URBAN DRAINAGE AND FLOOD CONTROL DISTRICT

FLOOD HAZARD NEWS

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The 1997 Floods in the District

by

Kevin Stewart, P.E., Project Engineer, Floodplain Management Program

The summer of 1997 will be long remembered for the devastating July 28 flash flood in Fort Collins which killed 5 people and caused millions of dollars in damage along Spring Creek and at Colorado State University. The following evening, storms on the eastern plains continued to threaten lives and destroy properties, inundating large areas surrounding the communities of Sterling, Atwood and Weldona. On August 1 President Clinton declared three Colorado counties (Larimer, Logan and Morgan) federal flood disaster areas. Ten additional counties were subsequently included.

This federal declaration was the first for Colorado since the 1984 western slope floods. While the extent of flooding and storm magnitudes varied among the 13 disaster counties, the Colorado Water Conservation Board reported that six counties (Larimer, Logan, Morgan, Elbert, El Paso, Lincoln) experienced storms with rainfall amounts exceeding 10-inches.

Upon first glance it might appear that the District "dodged-the-bullet," but a closer look reveals that the Denver area, while escaping "flood disaster status," did experience its worst flooding of the past decade. The remainder of this article is devoted to the more notable floods of 1997 occurring within the District.

Saturday, July 19:

At approximately 4:00 p.m., a severe thunderstorm in NE Denver and NW Aurora produced 3.83″ of rain in less than an hour, exceeding the official Denver one-hour record of 2.2″ set on August 13, 1921. This storm was accompanied by copious amounts of hail with stone diameters reaching 1.25 inches. It is interesting to note that although these observations were made by the National Weather Service (NWS) at their forecast office near Smith Road and Havana, the 1921 event retains its status in the record books because the "official" Denver rain gage, now located at DIA, only measured 0.59 inches.

Westerly Creek, a tributary to Sand Creek which enters the old Stapleton International Airport property from the south, flowed out of its banks and nearly overtopped Montview Blvd. The Montview culverts are designed to safely pass a 10-year flood, a project completed by Denver, Aurora and the District in 1980.

The Sand Creek ALERT gage at Brighton Road in Commerce City peaked at 3350 cfs exceeding its prior gage record of 2760 cfs (7/9/90). The new gage record set on July 19 was exceeded again on two separate occasions before the month's end by discharges of 4200 cfs of July 29 and 3690 cfs on July 30. The historic flood of record for Sand Creek (25,000 cfs) occurred on May 8, 1957, from a 4″ plus rainfall covering much of the . upper basin. The infamous 1965 flood resulted in a peak of 18,900 cfs.

The July 19 storm caused a roof cave-in at the Leather Factory Warehouse near 51st Ave. and Havana while another storm dropped 4″ of rain near the Interlocken Office Park in Broomfield, causing the closure of US Highway 36 where floodwaters overtopped the concrete median barrier.

In hindsight, July 19 was a precursor of things to come and a landmark day denoting the start of the Denver monsoon season, as it was preceded by 23 days of relatively dry weather where no heavy rainfall was predicted and followed by an 18-day period of significant flood potential. Henz Meteorological Services issued messages to local authorities on all but two of these days. Flash flood watches affecting the District were issued by the NWS for eight days in this period, and three flash flood warnings were also issued.

Sunday, July 27:

Between 3:00 and 4:00 p.m., Goldsmith Gulch in Denver was hit by heavy rains with 1.66″ falling at the Denver Tech Center (DTC). Downstream floodwaters approached 10-year levels causing the recently completed side-channel detention facility near Iliff Avenue to function. This flood control facility, constructed by Denver and the District in 1996 was credited with preventing damages downstream. Local residents were pleased with its performance. A minor glitch did occur, however, when the pump which drains the facility failed to start. Denver Wastewater Management Division officials corrected the problem the next day. This event received extensive media coverage and good photo documentation was obtained.

The Eastman Avenue ALERT gage peaked at 4 p.m. at a depth of 7.4' with an estimated discharge of 1670 cfs, exceeding its prior record of 1470 cfs (8/2/91). The Temple Pond gage at the

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1997 Professional Activities of District Staff

Scott Tucker, Executive Director

*Chaired program on Stormwater Management at National Association of Flood and Stormwater Management Agencies (NAFSMA) annual conference, in Orlando in November.
*Member of Board of Directors and Chairman of the Stormwater Management Committee of NAFSMA.
*Member of the Stormwater Phase II Advisory Subcommittee, formed pursuant to the Federal Advisory Committee Act to assist in developing the Phase II stormwater program.
*Presented a paper on "An Urban River Renewed – Denver's South Platte River," at Engineering Foundation Conference on Stormwater Management – Creating Sustainable Urban Water Resources for the 21st Century, in Malmo Sweden in September.
*Presented talk entitled "Flooding be Damned" at Conference Assessing the July 28 Flood in Fort Collins, CO at Colorado State University in Fort Collins in November.
*Speaker on Phase II Stormwater Regulation Requirements at the annual conference of the American Public Works Association (APWA) in Minneapolis in September.
*Presenter on Stormwater Phase II Regulatory Program on The Local Government Perspective, for the APWA Satellite Teleconference on "Strategies for Urban Wet Weather Management" in Stillwater, OK in December.
*Discussant at session on Planning and Design of Water Systems in Light of Changes in Climate, at Symposium on Climate Variability, Climate Change and Water Resource Management at Colorado Springs in October.
*Speaker on District activities at Colorado University student chapter of ASCE in April in Boulder.
*Speaker on South Platte River Rehabilitation Activities at University Hills Rotary Club in October in Denver.

Dave Lloyd, Chief, Design and Construction Program

*Co-authored, with Bill DeGroot, and presented "Integrating Flood Control and Recreation in Denver Area Projects" at ASCE's 24th Annual Water Resources Planning and Management conference in Houston in April.
*Co-authored and co-presented, with Chuck McKnight from Sellards and Grigg, Inc., "A Case Study of the Goldsmith Gulch Flood Control Project" at the same ASEC conference.

Bill DeGroot, Chief, Floodplain Management Program

*Chair of the Floodplain Management Committee of the National Association of Flood and Stormwater Management Agencies (NAFSMA), and chaired a session on Floodplain Management Issues at NAFSMA's annual meeting in Orlando in Nov.
*NAFSMA's technical advisor to the Technical Mapping Advisory Council.
*Member of ASCE's Technical Mapping Advisory Task Committee.
*Co-authored, with Dave Lloyd, "Integrating Flood Control and Recreation in Denver Area Projects."

Kevin Stewart, Project Engineer, Floodplain Management Program

*National Hydrologic Warning Council (NHWC) Representative for the Southwestern Association of ALERT Systems (SAAS).
*Member of the Colorado Natural Hazards Mitigation Council's (CNHMC) Dam Safety and Warning Subcommittee.
*Keynote Speaker at NHWC/SAAS National Conference and Exposition in St. Louis in Oct.
*Organized and hosted the first meeting of the NHWC Narrowband Radio Transitioning Committee in Denver in April.
*Member of Emergency Services Public Information Officers of Colorado, and participated in their workshop in Golden in Sept.
*Member of Colorado Emergency Management Association, and attended their annual conference in Breckenridge in Oct.
*Speaker at the 8th Annual Conference of the Colorado Association of Stormwater and Floodplain Managers in Vail in Sept.
*Participated in the FEMA and National Weather Service Hazardous Weather and Warning Coordination Pilot Short Course in Lakewood in July.
*Served on Colorado's FEMA Hazard Mitigation Grant Proposal Review Team.
*Attended "Conference on Assessing the July 28, 1997 Flood in Fort Collins, CO" held at CSU in Fort Collins in Nov.

Ben Urbonas, Chief, Master Planning & South Platte River Programs

* Serving on the French NOVATECH 98 conference's scientific group responsible for the evaluation of abstracts and the selection of conference papers.
*Principal co-investigator (Eric Strecker & Jonathan Jones principal co-investigators) for an EPA funded ASCE effort to develop Nationwide BMP Evaluation Data Management software and to accumulate and evaluate BMP data for performance and its relationships to design parameters.
*Co-authored a paper with Ian Lawrence of Australia, Jiri Marsalek of Canada and Brian Ellis of Great Britain on *Review of Stormwater Detention and BMPs* which was published in a special volume of the *Journal of the International Association of Hydrologic Research.*
*Organized and chaired a session on the topic of *BMP Selection and Design* at the Engineering Foundation Conference on *Stormwater Management, Sustaining Urban Water Resources in the 21st Century*, Malmo, Sweden, September, 1997.
*Continues to Chair the *Urban Gauging Networks Committee* of the Urban Water Resources Research Council of ASCE.
*Contributed to an effort by the International Association for Water Quality to develop an international *Urban Drainage Glossary* which will be published in 1998 in English, French, German and Japanese.

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Tucker-Talk

by L. Scott Tucker

Timely Comment from the District's Executive Director

Stormwater Phase II Proposed Rule

The Stormwater Phase II Proposed Rule was signed by EPA Administrator Carol Browner on Monday, December 15, 1997. The rule is scheduled to be printed in the Federal Register on January 9, 1998. A 90-day comment period will begin on the date it is published in the Federal Register, and comments on the proposed rule will be due on April 8, 1998. Following receipt of comments EPA will revise the proposed rule as they think appropriate and finalize it by March 1, 1999.

The proposed rule would expand the existing NPDES Stormwater Program (Phase I) which affects municipalities and counties with populations greater than 100,000 to smaller municipalities and construction sites that disturb one to five acres. Current regulations apply only to construction sites disturbing over five acres. It is estimated that there are some 3,500 communities under 100,000 in population, as well as many construction activities that will be affected by the proposed rule. Municipalities are encouraged to obtain a copy of the Federal Register dated January 9, 1998, review the proposed rule and submit comments to EPA. EPA plans to hold hearings on the proposed rule on the following dates: February 23, 1998 in Washington, DC; February 25, 1998 in Boston, Massachusetts; February 27, 1998 in Atlanta Georgia; March 2, 1998 in Chicago, Illinois; March 4, 1998 in Dallas, Texas; and March 6, 1998 in San Francisco, California. For further information regarding the proposed rule, contact Mr. George Utting, Office of Wastewater Management, Environmental Protection Agency, Mail Code 4203, 401 M Street, SW, Washington, DC 24460; 202-260-5816; SW2@epamail.epa.gov.

The proposed Phase II stormwater regulation is being promulgated pursuant to requirements in the Clean Water Act. The basic goal of the Clean Water Act is to improve the quality of the Nation's waters. This goal is one that is supported by most, if not all local governments. What is going to be initially required of local governments by the Phase II regulations is reasonable, but by no means trivial. There will definitely be a cost. To some the regulations may be a burden and cause some degree of difficulty. A few entities are already doing some or all of the required activities. As local governments we should support the Nation's effort to improve water quality. After all it is our citizens who have the most to gain.

Having said that, there are some things that you must understand. This is a mandate. You have no choice. You must comply. Non-compliance can result in penalties for your city or county, and citizens from your community or elsewhere can take you to court if they think you are not complying with your permit requirements. You will not be able to stop or change doing the things that will be in your permit unless you get your permit modified. If you are already doing some of the required activities, cost may not be a factor. However, those measures would no longer be discretionary. You will not be able to cut back if you want to shift efforts to another concern, say police protection, without approval from the NPDES permitting entity.

I make these comments not to be critical, but to be realistic. When reviewing the proposed regulations you must be thinking that we are starting a new way to do business in the public works field; one in which a permitting entity, either EPA directly or through the states, controls through regulation a segment of your public works activity, but you pay for it. The bottom line is that you will need a permit to discharge stormwater from your community and in order to get that permit you must do certain things. And unfortunately, it is a simple fact that when it rains, it discharges. Hopefully, these comments will help local governments understand what is involved with the Phase II stormwater regulations and how they may impact your city, county, or business.

Who needs a permit?

All municipalities under 100,000 population that are located within urbanized areas will be required to have permits. An urbanized area is defined by the Bureau of Census as comprising a place and the adjacent densely settled surrounding territory that together have a minimum population of 50,000 people. All cities and counties that are located within census defined urbanized areas would be required to obtain permits.

Application requirements

Basically all communities, with some minor exceptions, that are located within census defined urbanized areas must seek coverage under either an Individual or General Permit. For those seeking coverage under a General Permit, they will have to submit a Notice of Intent (NOI) to the permitting entity in order to be covered. The General Permit itself will explain the steps necessary to obtain coverage. The states will write the General Permits in about 42 states that have the authority to administer the NPDES Program, and EPA will write the General Permits that will apply to about 10 states. You must apply for coverage within three years and 90 days of the date the final regulation goes into effect which if it

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Design and Construction Notes

By
David W. Lloyd, P.E.
Chief, Design and Construction Program

1997 saw the design and construction program committing over $6.3 million to design and construction projects by year end. Most of this funding has gone toward construction as well as initiation of several new design projects.

The Dutch Creek project in the Town of Columbine Valley was completed this year at a cost of approximately $1.45 million. The project consisted of open channel improvements through the Columbine Country Club and a bridge replacement at Fairway Lane. The project has removed over 50 homes from the 100-year floodplain.

The first phase of improvements along Drainageway A in the City of Louisville was completed this past year. This outfall project, consisting of 60-inch storm sewer, provided much needed upgrades in existing capacity at Highway 42 and the Burlington Northern Sante Fe Railroad. These improvements along with planned detention pond modifications at Lake Park and the Louisville Middle School, scheduled for 1998, will create a system capable of handling the 100-year event, thereby eliminating a large area of downtown Louisville from the 100-year floodplain.

Two projects completed in cooperation with Arapahoe County this year were a much needed drop structure along Cherry Creek upstream of Iliff Avenue; and Pond L-3, a regional detention and water quality pond along Lone Tree Creek.

The City of Lakewood and the District continue with much needed improvements along Dry Gulch. This year a detention pond along the North Tributary of Dry Gulch at 14th and Lamar was constructed to provide some relief to the existing undersized downstream conveyance system. Next year, Lakewood and the District intend to purchase the property needed for construction of yet another detention pond on the North Tributary of Dry Gulch at 16th and Dover.

STATUS OF DISTRICT DESIGN PROJECTS

Project	Participating Jurisdiction(s)	Status
Marston Lake N./Bear Cr. Park	Denver	45% Complete
Ralston/Leyden Feasibility	Arvada, Corps of Engineers	On hold
Van Bibber Final Design	Arvada, Corps of Engineers	90% Complete
Eastlake No. 3	Thornton	Complete
Goose Creek Phase 3	Boulder	15% Complete
Niver Creek Tributary L	Thornton	10% Complete
Lakewood Gulch	Denver	Complete
Tom Frost Detention	Broomfield	Complete
Little Dry Creek Phase C	Westminster	Complete
Little Dry Creek RR Crossings	Adams County	Complete
Massey Draw at Carr St.	Jefferson County	95% Complete
Jewell Wetland Detention	Aurora	95% Complete
Littles Creek	Littleton, Arapahoe County	95% Complete
Willow Creek	Arapahoe County	Complete
McKay Outfall	Adams County	10% Complete
Pleasant View Trib. to Lena	Jefferson County	75% Complete
Rangeview Gulch	Littleton	50% Complete
Westerly Cr. @ Expo Park	Aurora	20% Complete
Greenwood Gulch	Greenwood Village	Complete

STATUS OF DISTRICT CONSTRUCTION PROJECTS

Project	Jurisdiction(s)	Cost	Status
Cherry Cr. Drop at Iliff	Arapahoe County	$475,000	95% Complete
Lone Tree Cr. Pond L-3	Arapahoe County	700,000	95% Complete
I-25/46th & Pecos Ph. IV and V	Denver	1,200,000	95% Complete
Dutch Creek	Columbine Valley	1,450,000	Complete
Lena Gulch Schedule V	Wheat Ridge	585,000	Complete
West Evans Ph. 2	Denver	500,000	95% Complete
Monaco/Eastman Outfall	Denver	800,000	95% Complete
Big Dry Cr. at Windermere	Englewood	450,000	Complete
Dry Gulch at 14th and Lamar	Lakewood	350,000	95% Complete
Drainageway A	Louisville	760,000	95% Complete
Lower Ralston Cr.	Arvada	2,670,000	Complete
Bear Canyon Creek	Boulder	1,700,000	5% Complete

The District had an opportunity this past year to participate with two communities in the purchase of flood prone properties and the subsequent removal of structures located on those properties. The Boulder and Adjacent County Drainageways Master Drainage Plan identified a property at 1650 Alpine Avenue along Goose Creek as being particularly susceptible to flood damage. The District participated with the City of Boulder in the acquisition of this property and the removal of the structure. The City has since turned the property into a pocket park. Another flood prone property at 801 W. Powers Drive along Slaughterhouse Gulch in the City of Littleton was identified in the Slaughterhouse Gulch master plan which recommended removal. The District and City of Littleton cooperated in the acquisition of this property and the removal of all structures on the property. The District frequently cooperates with local governments and provides cost sharing for the acquisition and removal of flood prone properties

Dutch Creek through Columbine Country Club golf course.

Drop structure and pedestrian bridge across Cherry Creek in Arapahoe County.

along major drainageways within the District boundaries.

Several design projects were initiated this past year. Some of the more interesting design projects include Littles Creek in the City of Littleton and Arapahoe County, Willow Creek in Arapahoe County, Westerly Creek at Exposition Park in the City of Aurora, Niver Creek Tributary L in the City of Thornton and Marston Lake North at Bear Creek Park in the City of Denver.

The update to the District's "Storm Sewer Pipe Materials Technical Memorandum" is nearing completion. Copies of the updated manual should be available in early 1998.

Re-Greening Efforts Along the Platte

by
Ken A. MacKenzie, Engineering Inspector
South Platte River Program

The last phase of a typical restoration project is the revegetation of the disturbed area. Three factors greatly influence the success of this effort:

- The revegetation consultant's expertise in site review, soil analysis and planting strategy;
- The contractor's care in seeding, planting, and maintaining the site throughout the first critical season; and
- The cooperation of nature in providing adequate moisture.

For the most part, all three factors came together in 1997 for a year of very successful project revegetation.

One such success was the revegetation project upstream of 88th Ave. The east bank from 78th Ave. to 88th Ave. was the site of an early 1990's flood control project constructed in partnership with the City of Thornton. The previous revegetation efforts for most of this project were only marginally successful, and in 1997 we returned to the site in an attempt to establish a more diverse and better vegetative cover. With MDG, Inc. as the revegetation consultant, and Western States Reclamation as the contractor, we had great success in re-establishing native grasses, sandbar willows, rabbitbrush, and cottonwoods along this bank. A large effort was also put into the establishment of wildflower beds, however, the success of this effort may not be known for 3-4 years.

Other success stories include the west bank restoration project at 160th Ave., and the Rogers Co-op project on the west bank at 168th Ave. (Baseline Rd.). We enjoyed tremendous first year success at both locations with the sandbar willow stakings, and the native grass/wildflower mix. Also, at these locations we tried an experimental tree/shrub planting technique of grouping riparian species (plains cottonwoods, narrow leaf cottonwoods, hawthorns, etc.) and dryland species (sage, rabbitbrush, chokecherries, etc.) into planting "pods". This method proved very successful with the riparian species, and moderately successful with the dryland species.

Tree & strub planting near C470.

As a follow-up to the 1996 sanitary sewer buttressing project downstream of C-470 in Littleton, we worked with the South Suburban Parks and Recreation District to plant over 100 native trees and shrubs along the west bank in the immediate area of that project, which is inside South Platte Park. This was a barren area that now has the beginnings of a new riparian cover in this beautiful stretch of the river.

East bank of the South Platte River upstream from 88th Ave. before and after 1997 revegetation.

Check us on the Web

We will be putting this issue of *Flood Hazard News* on our Web page at www.udfcd.org. The advantage there is that we will have additional pictures, and most will be in color. Also available on our site is the District's *Activity Summary*, a status of current construction projects and a list of future projects.

South Platte River Program Notes

by
Ben Urbonas, P.E., Chief
South Platte River Program

Local Initiatives Along the Platte

City and County of Denver

We reported last year that the City and County of Denver launched a major South Platte River initiative. The Mayor of Denver set up a South Platte River Commission with a membership representing a variety of federal, state and local organizations with interests in technical, neighborhood redevelopment, political, fiscal, environmental and other issues. This initiative also involved a number of staff working groups that have addressed minimum river flows for a fishery and in-river recreation, trails and recreation along the river, water quality, wildlife, local flora and fauna, rafting and kayaking, aquatic habitat, open space needs, river stability, etc. As a result, the river's potential is being examined from a holistic perspective.

The District continues to support Denver in its efforts to improve the river and its various functions in the city. Much of the District's work revolves around routine and restorative maintenance and in assisting Denver with its capital improvement projects along the river. The details of several projects are reported later in this article.

Adams County

We also reported before that Adams County began a comprehensive look at the South Platte River corridor as an open space and recreational resource. Under a grant from GOCO the county has completed an inventory of the open space resource and recreational needs of the county and of the cities within the county. The county has also developed an open space and recreation plan for the river corridor, which is being finalized at this time.

Maintenance Activities

Routine Maintenance

In 1997 the South Platte River routine maintenance included an equivalent of

- 9 miles of tree trimming and pruning along the river trail,
- 59 miles of trail edge mowing, and
- 163 miles of trash and debris pickup and removal along the river.

Approximately 90 truckloads of trash and debris were removed and taken to a landfill. Local government personnel and volunteer groups picked up and removed additional trash from the river corridor. Trash is also removed from trash receptacles maintained by park personnel along all recreational trails.

Although this type of routine maintenance often is not noticed or recognized by the public, without it the South Platte River corridor within the District would have an entirely different "look" and "feel." This type of maintenance we believe is essential for the preservation of wildlife habitat, and provides the public with a more pleasant experience whenever visiting the many trail and pocket park facilities that now exist along the 41 miles of the South Platte River between Chatfield Reservoir and the Weld/Adams County line.

Restoration Maintenance

The restoration maintenance program in 1997 continued to repair erosion damage along the combined recreation and maintenance trail; repair the trail and maintenance access bridges; cut and remove large numbers of dead Siberian Elm and live Russian Olive trees; and stabilize, rehabilitate, and revegetate approximately 2000 feet of river banks.

We reported last year that we have completed the removal of infected dead Siberian Elm trees along the South Platte River through Denver and southern Adams County, with a total of 1,500 trees cut and chipped. In 1997 300 more dead trees were removed because of the continuing epidemic of Dutch Elm disease. In addition, at the request of South Suburban Parks and Recreation District and the Colorado Water Conservation Board (as a follow up on a request made by the U.S. Army Corps of Engineers), we have removed and chipped over 650 live Russian Olive trees that have invaded the riverbanks in Arapahoe County. We hope to introduce Plains Cottonwood live poles in many of the areas where the dead Siberian Elm and live Russian Olive trees were removed. Over time we hope to return the tree cover along the South Platte River to a more representative indigenous state, replacing many of the exotic, invasive, species now populating its banks.

One of the obstacles we face with the reintroduction of native riparian species along the river, such as cottonwood trees, is the overabundance of beaver. Outside of an urban area where there may be a much wider and abundant corridor for tree growth, the river corridor through this urban center is narrow and can only support a limited number of plants. Beaver, which have no known predators in this corridor, enthusiastically harvest our plantings for food and shelter. The only way we can keep new and old natives from being chewed off is by protecting them with wire mesh baskets, which add considerably to the cost of tree replacement. We continue to hope that the Sate of Colorado and the cities and counties within the District along the South Platte River begin some form of beaver control program. Since the river corridor is not the District's property, we do not feel it is appropriate for us to take a lead in such an effort.

The District is now financially assisting Denver Parks and Recreation Department (37.5% cost share) to replace two rapidly deteriorating timber pedestrian bridges. These timber bridges will be replaced in the spring of 1998 with wider steel ones that will need less maintenance and will be more resistant to vandalism. They will also meet ADA access requirements. Over the next three to five years we hope to continue to work with Denver to replace four more deteriorating timber bridges along the South Platte River.

The restoration project along the west bank of the river just downstream of 160th Avenue in the City of Brighton is complete. The City has preserved the riverbank as a relatively undisturbed natural area. Many of the large trees previously in danger of being uprooted by bank erosion are more protected by a stabilized bank.

Another restoration project constructed this year involved the

installation of weirs or jetties along the outside edge of an eroding river bend (see Alternative Bank Stabilization article in this issue). So far the project has been successful at arresting bank erosion and protecting against loss of riparian vegetation and wildlife habitat.

Cooperative Projects With Private Property Owners

In 1997 two more cooperative projects were completed. The first coop project involved bank restoration along 1,100 feet of property owned by Mr. and Mrs. Jack Rogers near 168th Avenue in Adams County. The project arrested bank erosion that threatened to breech the existing berm separating the river and the adjacent sand and gravel mining operation.

The second coop project completed in 1997 involved bank stabilization of 850 feet of badly eroded bank one-half mile downstream of Brantner Ditch diversion structure and adjacent to the Suburban Sand and Gravel pit operated by Aggregate, Inc. Part of the owner's contribution to this project included labor, equipment, and materials at a below-market price, in addition to the dedication of a flowage and maintenance access easement. The bank was seeded and mulched with native grasses. Live stake willow planting along the bank will take place in early spring of 1998.

Two new cooperative projects have also been started. One will clean up a river bank covered with broken concrete pipe, bed springs, car bodies – you name it! Albert Frei and Sons, the McIntosh Farm Company, and the District have agreed to jointly fund, by way of easement dedication and below-market equipment and material costs, over 1,400 feet of bank cleanup, stabilization with buried riprap and rubble, and revegetation with native grasses and willow.

As a follow up to the success with Aggregate, Inc. on the above-mentioned project, the District entered into another cooperative agreement with them. This one will restore 1,100 feet of eroded bank approximately one mile further downstream. We expect both of these new projects to be completed by the spring of 1998.

An example of a maturing restorative maintenance project is the project completed three years ago along the east bank of the river just upstream of 160th Street Bridge (Figure 1). At this location the bank and overbank were covered with concrete rubble and asphalt slabs. Although a few small Siberian Elm trees and other exotic vegetation established themselves in the rubble, the bank was very steep and offered virtually no wildlife habitat. Now the bank is much flatter and is covered by a healthy stand of new trees, shrubs and native grasses.

Capital Improvement Projects

Upper Central Platte Valley Project

During the last three years we have been working with Denver and the Public Service Company of Colorado (PSCo) to develop and design the Upper Central Platte Valley Project. PSCo, the owners of the Zuni Electric and Steam Generating Plant, has agreed to a concept of switching its cooling system from one-pass conductive cooling to a closed-loop, recirculating evaporative system. When this is done, only 10% of the water currently being diverted will need to be diverted in the future. This reduction will permit the use of an infiltration gallery for water diversions instead of a diversion dam and other associated surface structures.

After a year of testing a prototype system constructed within the river channel itself, we have concluded that an infiltration gallery will reliably provide the needed water. Water quality samples show that water from the gallery compares well with the surface water quality, and should provide little operational difference to PSCo in the future. Once the switch from surface diversion to an infiltration gallery is made, the options for river rehabilitation expand and allow for a more aesthetic "natural" appearance and much improved boating and aquatic and terrestrial habitat. This progress notwithstanding, funding the construction of this river restoration project remains a major challenge.

Globeville Area Project

The other ongoing capital project along the river is located in the Globeville neighborhood in north Denver. Phase I of the project covering 2,000 feet of South Platte River has now been completed (Figure 2). Despite the fact that this is a flood control project, the primary focus was on river bank and aquatic habitat rehabilitation. Improvements also included the construction of a recreational trail and better access to the river by the adjacent community. Construction of Phase II, encompassing another 5,000 feet of the river upstream of Phase I, is under way. We expect this construction to be completed by May of 1998.

Figure 1. Completed restorative maintenance project at 160th Ave.

The funding for the final phase (Phase III) of this project, which is immediately downstream of Phase I, has now been identified. Denver and the District expect to commit approximately $6,000,000 for this key link of this flood protection and recreational improvements project. A physical hydraulic model of Phase III is now under construction at the Colorado State University hydraulics laboratories, with the test scheduled to begin in March of 1998. We hope to have this phase of the project under construction in 1999.

Once completed, approximately 300 acres of existing inner city residential, industrial and commercial area will be removed from the 100-year regulatory floodplain. In addition, 7,000 feet of the river's channel will have been rehabilitated, a recreational trail separated from traffic and connected to the Adams County's trail system, and the community's access to the river and the environment for this old neighborhood of Denver will be significantly improved.

Other News and Projects

Early in 1997, Denver requested the District to take the lead in the design of low flow channel improvements between 15th Street and the downstream limits of the new Rockmont Park. The design includes aquatic habitat improvements through the use of low flow training jetties that simulate the appearance of rock outcrops occurring naturally in this reach of the river and low level grade control structures that provide pools and riffles. Denver will construct this project upstream of 19th Street in 1998 as part of its Commons Park construction. The District will build four grade control structures for Denver downstream of 19th Street using its restorative maintenance funds. These structures are needed to arrest continued degradation of the river's bottom, in addition to providing improved aquatic habitat and boatability of this stretch of the river. Work for these four structures will be completed by April of 1998.

Figure 2. Before and after views of the South Platte in Globeville.

Also in 1998, the District will head up a project to update the South Platte River Major Drainageway Plan through Adams County. This project is being cosponsored by Metro Wastewater Reclamation District, Adams County, City of Thornton, City of Brighton and Commerce City. It will examine the current plan and adjust to meet current needs and visions for the river. The project will rely heavily on the input of the project sponsors, state and federal agencies, and the public. We will look at water quality, aquatic and terrestrial habitat needs, open space needs, recreational needs, water resources development needs, gravel mining and its impacts on the river corridor, and many other issues that surround this very important river reach in Adams County. We hope to have the first phase of the plan completed in 1998 and the final plan completed in 1999.

Municipal Stormwater Permit Implementation Activities

by
John T. Doerfer, Project Hydrologist
Master Planning Program

The District continued to assist the cities of Denver, Aurora, and Lakewood in 1997 with planning activities related to implementation of their stormwater permits. A permit authorizes the holder to discharge runoff from its storm sewer system in accordance with approved stormwater management programs. The three cities proposed management programs in their permit applications submitted in November 1992. Permits were issued by the State of Colorado in May, 1996. The Clean Water Act requires that all permit requirements be implemented within three years of permit issuance. The permits define an implementation schedule that the three cities must meet for full compliance by June 10, 1999.

Some elements of the permits--such as street sweeping, inlet cleaning, and trash/debris removal from channels--existed prior to any permits. These are no longer discretionary activities and must be continued by the cities. The new programs required by permits and developed in 1997 by the three cities, with District assistance, include:

Annual Reporting and Cost Estimates. There are a variety of specific data to be reported each year. Early in 1997, the cities, with assistance from the District, developed databases, cost-estimating worksheets, and report templates to be used for each city's annual report.

Industrial Facilities Program. Although specific industrial sites must obtain an individual stormwater permit from the State, the three cities were required to implement a program to inspect and monitor certain industrial sites within their jurisdictional area as well. This program was approved by the State after extensive review and discussion in 1997.

Municipal *Facility Runoff Controls.* The cities operate certain facilities similar to those in the private sector--such as vehicle-maintenance yards--that require industrial stormwater permits. The Best Management Practices (BMPs) for use at these sites, and the list of sites and schedule for plan implementation before 1999, were approved this year.

Wet-Weather Monitoring Program. The permits also require the cities to develop a wet-weather monitoring plan that meets the State's and DRCOG's Total Maximum Daily Load (TMDL) study and planning needs. The District entered into agreements with the three cities and Arapahoe County to assist them with wet weather monitoring. The monitoring plan prepared by the District was approved by the TMDL Advisory Committee and State of Colorado in April. The U.S. Geological Survey has worked with the District to install monitoring equipment at five sites. Wet-weather monitoring will begin in the spring of 1998.

Dry-Weather Sampling Protocols. The cities sampled all of their major storm-sewer outfalls during dry weather as a requirement of permit applications. Permits require that these same outfalls, and additional ones, be sampled again once during the 5-year permit term. The District assisted cities in 1997 develop improved sampling protocols.

Other major programs currently in development include public education, new development planning procedures, and construction-site sediment control.

PLANNING PROGRAM ACTIVITIES

by
Ben Urbonas, P.E.
Chief, Master Planning Program

Planning Projects

The table "Status of Planning Projects" lists the projects that were under way or completed in 1997 and the ones we hope to begin in 1998. We will begin the consultant selection process for the 1998 projects as soon as the funding agreements are executed between the District and each project's local sponsors.

Master plans for the following watersheds were completed and reports for them published in 1997: Niver Creek, Grange Hall Creek, Brantner Gulch North Tributaries, Arapahoe and Magpie Gulches, and Big Dry Creek in Arapahoe County. At this time we are procuring mapping and are in the process of selecting consulting firms for the following four new master plans: select Big Dry Creek (ARAPCO) tributary areas, update of Broomfield and Vicinity master plan, Sulphur and Tallman Gulches, and the areas tributary to Quincy Reservoir.

STATUS OF PLANNING PROJECTS

Project	Sponsor(s)	Consultant	Status
Niver, Brantner & Grange Hall Cr. Updates	Thornton & Adams Co.	Kiowa	Completed
Basin 4100 Update	Thornton & Adams Co.	Kiowa	10% Complete
Arapahoe & Magpie Gulches	Golden & Jefferson Co.	WRC Engineering	Completed
Big Dry Cr. (ARAPCO) Update	Arapahoe Co., Douglas Co., Greenwood Village, Englewood, Littleton	WRC Engineering	Completed
Willow/Little Willow Cr.	Douglas Co.	ICON Engr., Inc.	60% Complete
Brighton Basin	Brighton & Adams Co.	WRC Engineering	60% Complete
Cherry Creek – Reservoir to County Line	Arapahoe Co., Aurora & Cherry Cr. Basin W.Q.A.	WRC Engineering	40% Complete
Academy Trib. to Bear Creek	Denver, Lakewood & Jefferson Co.	Kiowa	50% Complete
City of Englewood OSP	Englewood	Turner Collie & Braden, Inc.	50% Complete
Pleasantview Area OSP	Jefferson Co. & Lakewood	Turner Collie & Braden, Inc.	65% Complete
Lower Box Elder OSP	Adams Co.	n/a	Start in 1998
Areas SE of 54th & Pecos Trib to SPR	Denver & Adams Co.	Kiowa	5% Complete
Big Dry Cr. Tribs (ARAPCO)	Arapahoe Co.	n/a	Procuring Mapping
Broomfield & Vicinity MP Update	Broomfield & Westminster	n/a	Procuring Mapping
Quincy Reservoir Watershed Outfall Plan	Aurora	n/a	Procuring Mapping
Sulphur & Tallman Gulches Outfall Plan	Douglas Co. & Parker	n/a	Procuring Mapping
Holly Hills Trib. To Harvard Gulch	Arapahoe Co. & Denver	n/a	Start in 1998
Plum Creek OSP	Douglas Co.	n/a	Start in 1998
Cottonwood Area Catchment OSP	Parker & Douglas Co.	n/a	Start in 1998
Pinehurst Trib. to Bear Creek	Denver & Arapahoe Co.	n/a	Start in 1998

Technology Transfer & Education

Erosion Control Training

Red Rocks Community College is continuing to offer training in runoff quality management during construction. Red Rocks also can certify for the Colorado Department of Transportation that an individual has successfully completed the *Erosion Control Supervisor Training* program. A certified supervisor is now required on CDOT construction projects. Scott Olson at Red Rocks (telephone 988-6160, X-282) can provide you with more information. We encourage all municipal officials, consultants and construction contractors to take this class and to also obtain the CDOT certification.

Erosion Control Video

The Denver Regional Council of Governments (DRCOG) has completed a training video for the selection, design, installation and maintenance of stormwater quality management practices during construction. This work was done under a Section 319 grant to DRCOG. The District contributed approximately $40,000 in funds to provide a significant portion of the local match for this effort. This video addresses some unique conditions faced during construction in Colorado, especially within its semi-arid regions.

Software

The District and *Computer Software Library, Inc.* cooperated to upgrade the District's hydrologic software. Two packages, namely, *CUHPFPC* and *UDSWM386* are expanded versions of earlier software. *CUHPFPC* now provides for an option to account for the effects of hydraulically unconnected impervious areas and *UDSWM386* has corrected some of the reported problems and can now handle up to 1900 gutter/pipe elements. Both have been compiled using the Microsoft FORTRAN Power Station 32 bit compiler. Both programs have undergone considerable testing. These two programs and other District supported software can be obtained through the District's software distribution agent, *Computer Software Library, Inc.* P.O. Box 27517, Denver, CO, 80227, Tel. 303-947-3413, FAX 303-985-8882.

Criteria Manual

The District is starting a three-year effort to update its *Urban Storm Drainage Criteria Manual*. In 1998 the focus will be to complete and update *Volume 3 – Best Management Practices*. When it was first published in 1992, it contained chapters that were set aside for future completion. This effort will complete these sections and will update and improve other chapters in response to the comments received from manual users since its initial publication. Most of the experience so far has been positive, however it needs clarification on how to select, use and

combine BMPs for stormwater quality management.

To help with this effort, the District is establishing a 10-member technical advisory group. We hope to have representatives from large and small cities, counties, CDOT, and other organizations. The membership will not be restricted to communities within the District and will attempt to include representation from other Front Range communities as well.

January 23, 1998 BMP Seminar

On January 23, 1998 the District is sponsoring a one-day seminar on the topic of stormwater structural best management practices. The program will include the showing of the new video produced by DRCOG on construction activities management, a short training segment on the selection and design of structural BMPs, a panel discussion on the experience by local governments in the use of *Volume 3 – Best Management Practices*, and an audience participation segment on suggested needs on how to improve *Volume 3*.

Stormwater NPDES Activities

New EPA Initiatives

EPA will publish proposed regulations for Phase II of the stormwater program (i.e., affecting municipalities with less than 100,000 in population) in January. EPA is under court order to have these promulgated by 1999 (*see Tucker Talk and a related article by John Doerfer*). We will distribute copies of the draft Phase II regulations to local governments when they are available and will schedule a meeting to discuss them in January or February of 1998.

On June 2, 1997 EPA published proposed regulations for reissuance of general permits for construction-site stormwater discharges. They include provisions intended to protect threatened and endangered species and sites of archaeological significance. After EPA adopts these, the State will most likely need to modify its construction general permit conditions to be in line with EPA's requirements.

Denver, Aurora, and Lakewood Permit Implementation Activities

Following issuance of permits in May of 1996, the District continued to work with Denver, Aurora, and Lakewood as they takes steps to implement the requirements of their stormwater permits. See the article by John Doerfer about this and other stormwater related permit efforts of the District.

Arapahoe County Phase I Application

Arapahoe County was notified in 1996 by the State that it had an unincorporated urban-area population of over 100,000 and this put them into the Phase I category for municipal stormwater NPDES permitting. Three special districts within the County meet the regulatory definition of "owner of municipal separate storm sewer system" and need to be permitted as well. These are East Cherry Creek Valley Water and Sanitation District, Arapahoe County Water and Wastewater Authority, and Inverness Water and Sanitation District. The County and the three special districts agreed to become "co-permittees" and submit a single, combined permit application. Although individual descriptions were needed where the entities differ, overall efficiency and consistency were gained using this approach.

The District assisted these co-permittees with their preparation of Part 1 application submitted in July, 1997. Part 2 of the application is planned for completion in July, 1998. The co-permittees used the protocols developed by the Joint Task Force when the initial permit application requirements were being defined for the largest three cities.

Offer of Assistance

Should your city or county within the District's service area decide to work toward preparing information that may be eventually used to support a permit application, or is taking an initiative to develop its own stormwater quality management program, or simply wants to develop a stormwater system inventory, call us. We can provide you with advice and a fully developed set of consistent protocols and data management tools that can help make your job easier and consistent with others in this region, thereby qualifying your community for further support and assistance as you enter the world of stormwater permitting.

Welcome To New Staff Members

Ken MacKenzie has joined the District as an Engineering Inspector in the South Platte River Program. A student intern with us since early 1995, Ken graduated *summa cum laude* from the Metropolitan State College of Denver in May, earning his bachelor's degree in Civil Engineering Technology. Ken is an active member in the American Society of Civil Engineers. His prior life experience includes nine years in the aviation industry, where he achieved a position of a supervising airframe and power plant mechanics with Continental Express/Rocky Mountain Airways. As a lifelong front range resident, Ken brings to the District much knowledge and understanding of this region.

Sandra Gonzalez has joined the District as Administrative Secretary. Prior to joining the District she was an Executive Secretary with the San Bernardino County Public Works Group for 14 years. Sandy obtained an Associate Degree in Business at San Bernardino Valley College, California, which she has supplemented over the years with several courses working toward a bachelor's degree. Sandy is also a volunteer member of the Denver Center for Performing Arts Kindred Spirits Council and a Board member of the CU Boulder Parents Association.

David Mallory has joined the District as a Project Engineer in the Floodplain Management Program. David has a B. S. Degree in Civil Engineering from Colorado State University and is a registered P.E. in Colorado. His previous experience has been in the private sector, most recently with RG Consulting Engineers, Inc.

We are delighted that Ken, Sandy and David have joined the District and we look forward to working with them.

Hydraulic Design of Sand Filters for Stormwater Quality

Ben R. Urbonas, P.E

Introduction

This article is an abbreviated version of a full paper submitted for publication in a professional journal. It was modified to fit the Denver area's meteorology and the space available in this *Flood Hazard News*. The original paper is based on research efforts by the District, including filed data collection and analysis, of the hydraulic performance of sand filters under field conditions. Local data were combined with data from others in the U. S. to suggest pollutant removal by sand filters.

Design Hydrology and *TSS* Load

Because of the temporal variability of stormwater runoff, a media filter needs a detention volume upstream of it to equalize the runoff rates during a rainstorm. This detention volume has be drained out (i.e., fully evacuated) in a reasonable amount of time to provide room for the next runoff event. Urbonas and Ruzzo (1986) suggested a water quality capture volume (*WQCV*) equal to ½ inch of runoff from impervious surfaces in the tributary watershed. Subsequent studies of rainfall records in the United States and field performance of BMPs now suggest that this *WQCV* needs to be based on runoff somewhere between an average (i.e., *mean*) storm depth (Driscoll, *et al.*, 1989) and the *maximized* depth (Guo and Urbonas, 1996). Equation 1 is now suggested (Urbonas, *et al.*, 1996a) for making the first order estimate of *WQCV*.

$$P_o = a \cdot C \cdot P_6 \qquad (1)$$

$$C = 0.858 i_a^{\,3} - 0.78 i_a^{\,2} + 0.774 i_a + 0.0 \quad \text{where } (r^2 = 0.72) \qquad (2)$$

In which,

A = coefficient for the *maximized* or *mean* runoff volume from Figure 1

C = catchment's runoff coefficient found using Equation 2

P_6 = average runoff producing storm depth (0.43 inches in the Denver Area)

P_O = *WQCV* in inches

$i_a = I_a/100$

I_a = percent of the total area covered by impervious surfaces

The average annual load of total suspended solids (*TSS)* in runoff can be estimated using:.

$$L_a \quad 0.2265 \quad A_c \quad n \quad P_6 \quad E_s \qquad (3)$$

In which,

L_a = average annual *TSS* load from the tributary catchment in pounds

A_c = area of tributary catchment in acres

P_A = average annual total stormwater runoff from the catchment in inches

n = average number of runoff producing storms per year (n = 30 in Denver)

E_s = average event mean concentration (*EMC)* of *TSS* in stormwater in mg/l

This annual load of *TSS*, along with the removal rates by the upstream detention/retention and by the filter determines the size of a media filter.

Filter Configurations

Figure 2 schematically illustrates three basic arrangements of upstream *WQCV* and the filter media. The upstream *WQCV* equalizes stormwater runoff rates to match the filter's flow-through capacity. When this capture volume is exceeded by a large storm, the excess runoff ponds on the surface upstream of the filter, or it bypasses the filter. In Case 1 the filter is preceded by an extended detention basin. In Case 2 the filter is preceded by a retention pond with a surcharge extended detention above the permanent pool. For both cases the detained volume is evacuated through an outlet designed to empty out the volume over a desired time period, namely its *drain time*. If the outlet is oversized, the drain time is governed by the flow-through rate of the filter itself. This is the design condition shown as Case 3, where at least a part of the detention volume is directly above the filter's surface.

The detention/retention basin upstream of the filter removes some of the *TSS* in the runoff. We need to estimate how much *TSS* is removed this way to know how much *TSS* is left for removal by the filter. The intent of these estimates is to use reasonable, somewhat conservative rates that will result in a realistic filter size. Table 1 provides the suggested *TSS* removal rates for designing media filters.

For Cases 1 and 2 defined in Figure 2 the concentration of *TSS* leaving the filter facility can be estimated using Equation 4.

$$E_{sfr} = E_s \cdot \left(\frac{R_T - R_D}{100} \right) \qquad (4)$$

In which,

E_{sfr} = the change in suspended solids concentration through the filter in mg/l

R_T = total system's average percent removal rate of *TSS* (95% recommended)

R_D = the percent removal rate for the retention or detention basin upstream of the filter bed from Table 1

For Case 3 the above analysis needs to be modified. The water column that is above the filter's surface receives no pretreatment and all the *TSS* in this water is subject to removal by the filter. Thus, for Case 3 reduction in the *EMC* of *TSS* by the filter installation can be expressed by

$$E_{sfr} = E_s \cdot \left[\frac{R_T - r_R \cdot R_D}{100} \right] \qquad (5)$$

In which,

$r_R = [A_R/(A_R+A_f)]$, ratio of the retention basin's surface area to the total system's surface area (When all detention storage is above the filter, $r_R = 0$ and all the *TSS* load is removed by the filter)

A_R = surface area of the retention pond's permanent pool in square feet

A_f = surface area of the filter bed in square feet

Filter's Flow Through Rate

The classic relationship for water percolating through uniform soil media, such as sand, breaks down for a slow sand filter when fine sediment accumulates on top of its surface. Field observation and laboratory tests (Neufeld, 1996; Urbonas *et al.*, 1996b) show that the flow-through rate for a sand filter (and other media as well) quickly becomes a function of the sediment being accumulated on the

filter's surface. This relationship for a sand filter (i.e., Figure 3) appears to be not sensitive to the hydraulic surcharge on the filter's surface and can be expressed by Equation 6.

$$q = k \cdot e^{-c \cdot L_m} \quad (6)$$

In which,
K = empirical flow-through constant (see Figure 3)
c = empirical exponential decay constant (see Figure 3)
L_m = *TSS* load accumulated on the filter's surface in pounds per square foot

TSS Load Removed By The Filter

Recognizing that not all runoff during any given year will pass through the filter installation, the average annual load removed by the filter facility can be expressed by Equation 7.

$$L_{afr} = b \cdot \frac{E_{sfr}}{E_s} \cdot L_a \quad (7)$$

In which,
L_{afr} = average annual *TSS* load removed by the filter in pounds
B = the fraction of all average annual runoff volumes that is treated by the filter facility (i.e., not bypassed)

The fraction of all runoff volume from the tributary area that will be treated through the filter facility is, in part, a function of the *WQCV* upstream of the filter. Depending on whether the basin is bypassed or overtopped will also determine the amount of treatment provided to the excess volumes during large storms. If the *maximized* capture volume is provided, approximately 80% to 90% of all runoff volume can be treated by the filter installation. If, however, the *mean* capture volume is used, approximately 65% to 70% of the total annual runoff volume will be fully processed through the filter.

The filter will also need to be maintained to stay in operation. The contaminated and clogged layers will need to be removed and replaced with new media and eventually (say after five to ten surface cleanings) the entire media filter will need to be replaced. Equation 8 can be used to estimate the *TSS* load removed by each square foot of the filter during each maintenance cycle.

$$L_m = \frac{L_{afr}}{A_{fm} \cdot m} \quad (8)$$

In which,
L_m = average *TSS* load removed by each square foot of the filter during each maintenance cycle in pounds per square foot per maintenance cycle
m = number of times per year the filter is cleaned and reconditioned. Use a fraction (i.e., 0.5) if more than one year between cleanings
A_{fm} = surface area of the filter based on annual *TSS* load removed in square feet

Sizing The Filter

Equation 8 can be rearranged to estimate the filter's area based on *TSS* removed.

$$A_{fm} = \frac{L_{afr}}{L_m \cdot m} \quad (9)$$

Equation 10 can be used to estimate this area based on the desired *drain time* of *WQCV*.

$$A_{fh} = \frac{P_o \cdot A_c \cdot 43{,}560}{q \cdot T_d} \quad (10)$$

In which,
Q = the design flow-through rate through the sand filter's surface in inches/hour
T_d = the time it takes volume P_o to drain out at rate q in hours
A_{fh} = surface area of the filter based on hydraulic sizing in square feet

The designer now has to find the filter area that comes close to satisfying both conditions and the following design procedure to accomplish this:

Design Procedure

1. *Determine E_s, the average EMC of TSS for the tributary catchment.* Use local *TSS* data when available. In absence of local data, use the closest regional averages reported in the Nationwide Urban Runoff Evaluation final report (EPA, 1983).
2. *Calculate the average annual TSS load in stormwater runoff from the design catchment.* Use Equation 2 and Equation 3 to estimate L_a.
3. *Select filter-detention/retention configuration and preselect its desired drain time.* Cases 1 and 2 are suggested for catchments with more than one acre of impervious surface, while Case 3 is suggested for smaller sites.
4. *Estimate E_{sfr}, the reduction in the EMC of TSS provided by the filter itself.* Based on Case 1, 2 or 3 with a value for r_R select a value from Table 1 for the removals by the detention or retention portion of the facility and use it in Equation 4 or 5.
5. *Estimate the average annual TSS load removed by the filter.* Use Equation 7 to calculate a value for L_{afr} (assume b = 0.90 if $WQCV = P_o$).
6. *Determine the filter's annual maintenance frequency.* Typically one cleaning per year is suggested as a starting point.
7. *With the aid of Figure 3 select the desired unit TSS load removed, L_m per each cleaning.*
8. *Set the WQCV for this installation.* It is recommended that, as a minimum, a volume equal to the runoff between the *mean* storm and the *maximized* volume be used for design. Use equations 1 and 2.
9. *Make first estimates of the filter's area.* Calculate the filter's area, A_{fm}, using Equation 9 and Equation 10.
10. *Compare the two filter areas calculated in Step 9.* If the two calculations differ by more than 20%; average the two areas; calculate a new value for the unit load removed by the filter, L_m; find a new q using Equation 7 and repeat Step 9. Otherwise use the larger surface area of the two.

Design Examples

Example 1. At a commercial site in Denver the media filter will be preceded by an upstream extended detention basin. The known site conditions are:

Step 1:
Tributary Area, A_c = 1.5 acres
Expected *EMC* of *TSS*, E_s = 225 mg/l
Average storm depth, P_6 = 0.43 inches
Average number of runoff storms per year, n = 30
Catchment's total imperviousness, I_a = 85%

Step 2: Using Equation 2 find its runoff coefficient:
C = 0.66
Using Equation 3 calculate the annual *TSS* load from the catchment:
L_a = 651 *lbs*

Step 3: Since the filter will be preceded by an upstream extended detention basin, we have Case 1 configuration. The *WQCV* will drain in 12 hours.

Step 4: Using T_d = 12 hours, Table 1 suggests R_D = 50%. Assuming 95% overall removal rate for the detention-filter system, estimate using Equation 4

the reduction in *TSS* produced by the filter itself.
E_{afr} = 101 *mg/l*
Step 5: Using Equation 7 estimate the average annual *TSS* load removal by the filter.
L_{afr} = 263 *lbs*
Step 6: Determine the filter's annual maintenance frequency. Assume m = 1 (i.e., once per year).
Step 7: To keep the size of the filter small while not imposing a very frequent maintenance schedule we choose to design the filter to drain at approximately 2.0 inches per hour. This means L_m = 0.32 pound/square foot in Figure 3.
Step 8: Using T_d = 12 hours and C = 0.66 from Step 2 and a from Figure 1 in Equation 1, find the *maximized WQCV*:
P_o = 0.32 *watershed inches* = (1720 ft^3)
Step 9: Using Equations 9 and 10:
A_{fm} = 822 ft^2
A_{fh} = 871 ft^2
Step 10: The two areas are within 20% of each other. Choose the larger of the two.
A_f = 870 *sq. ft.* (after rounding off)

Example 2. Same as Example 1 except use a filter inlet, namely Case 3, with r_R = 0.5.
Steps 1 through 3 are the same as in Example 1.
Step 4. Using Equation 5 for a "retention basin" with a 12-hour drain time find:
E_{afr} = 124 *mg/l*
Step 5. Using Equation 7 we find
L_{afr} = 322 *lbs*
Step 6. Assume m = 1.
Step 7. Using the same reasons stated in Example 1 we find: L_m=0.32 lbs/ *sq. ft.*
Step 8: Same as in Example 1 @ T_d = 12 *hrs.*: P_o=0.32 inches (1,720 *cu. ft.*)
Step 9: Using Equations 9 and 10:
A_{fm} = 1006 ft^2
A_{fh} = 871 ft^2
Step 10: The two are within 20% of each other. Use the larger of the two.
A_f=1,000 ft^2. (after rounding off)

Expected Water Quality Performance

Figure 4 illustrates two cases during larger storms, namely overflow of the excess and the bypass of the excess. To make a valid assessment of the average annual *EMC* for any constituent reaching receiving waters, to flow-weight the concentrations of the effluent and the excess runoff from all the storms that occur, on the average, any given year. For Case 1 shown in Figure 4 this is given by Equation 11

$$E_c = (k_T \cdot k_D \cdot E_i) \cdot (1 - r_{pf}) + E_f \cdot r_{pf} \quad (11)$$

and for Case 2 by Equation 12

$$E_c = (k_T \cdot E_i) \cdot (1 - r_{pf}) + E_f \cdot r_{pf} \quad (12)$$

In which,
E_c = average annual *EMC* downstream of the filter facility, in mg/l
E_i = average annual *EMC* in the runoff inflow to the *WQCV*, in mg/l
E_f = average annual concentration in the filter's effluent, in mg/l
r_{pf} = fraction of the average annual runoff volume that flows through the filter
k_D = fraction of the original *EMC* in the runoff that remains in the water after overflows
k_T = coefficient of the *EMC* that represent the post "first-flush" fraction of the average *EMC* in stormwater runoff

If the *maximized* coefficients in Figure 1 are used, one can expect r_p = 0.8 to 0.9. If, however, the runoff from the *mean* storm is used, one can expect r_{pf} = 0.65 to 0.7.

Currently it is not possible to suggest definitive values for k_D and k_T, which coefficients depend on the constituent being considered and the actual design. However, a literature review by the author suggests the following tentative ranges for *TSS*:

k_D=0.3 to 0.5 k_T=0.7 to 0.9

Table 2 summarizes, after screening out the outliers, the findings of filter tests at four cities in the United States, namely, Alexandria, VA; Austin, TX; Anchorage, AK; and Lakewood, CO. Data for the first three were consolidated by Bell *et al.* (1996) and the data for the Lakewood site were obtained by the Urban Drainage and Flood Control District in 1995. Note the high variability in the influent concentrations for all constituents and that the ratios between the high and the low concentrations are significantly less for the effluent. The variability in the influent quality accounts for most of the range in the reported removal percentages.

In Example 1 an extended detention basin was used upstream of the filter. It is relatively easy to design this arrangement so that all runoff will pass through the detention basin and the excess runoff will overtop the pond. Let's further assume that k_D = 0.35 and k_T = 0.75 and as a first order estimate assume that 80% of the average annual runoff volume will pass through the basin and the filter. Using an average effluent *TSS* concentration of 16 mg/l (Table 2), the average annual *EMC* of *TSS* downstream of the filter installation is
E_c = 25 *mg/l*
Comparing this to the average *EMC* for *TSS* in stormwater runoff at that site (i.e., 225 mg/l), this installation will have 82% average annual removal efficiency for *TSS*.

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Table 1. Suggested Removal Rates by Retention and Detention Upstream of a Media Filter

Detention Volume, P_o, Drain Time T_d in hours	Suggested Percent Removal - R_D	
	Detention	Retention
48	60	90
24	55	85
12	50	80
6	40	75
3	30	70
1	20	50

Table 2. Field Measured Performance Ranges of Sand Filters

Constituent	In or Out	Concentration *mg/l*			Percent Removed		
		Low	High	Mean	Low	High	MCR*
TSS	In	12	884	160			
	Out	4	40	16	8%	96%	80-94%
TP	In	0.05	1.4	0.52			
	Out	0.035	0.14	0.11	5%	92%	50-75%
TN	In	2.4	30	8.0			
	Out	1.6	8.2	3.8	(-130)%	84%	30-50%
TKN	In	0.4	28	3.8			
	Out	0.2	2.9	1.1	0%	90%	60-75%
TC_u	In	0.030	0.135	0.06			
	Out	0.016	0.035	0.025	0%	71%	20-40%
TZ_n	In	0.04	0.89	0.20			
	Out	0.008	0.059	0.033	50%	98%	80-90%

*MCR - Most Common Data Range

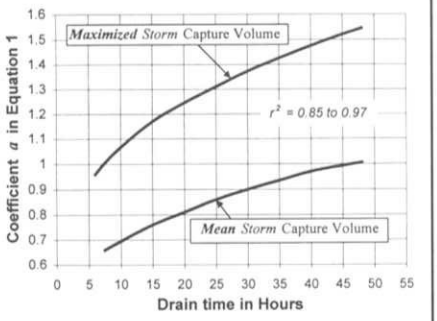


Fig. 1 – Values of coefficient a in Equation 1.

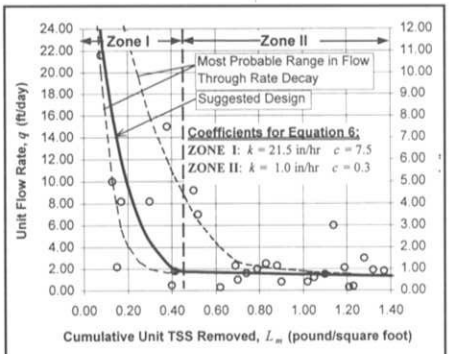


Fig. 3 – Flow through rate of sand filter as a function of TSS removal.

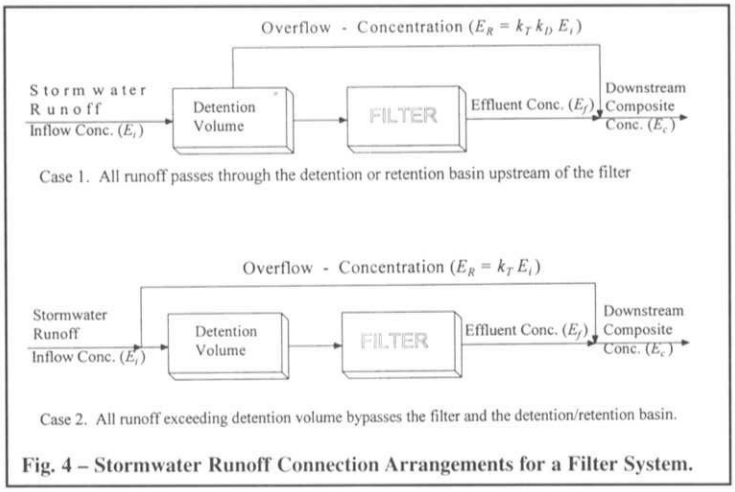


Fig. 4 – Stormwater Runoff Connection Arrangements for a Filter System.

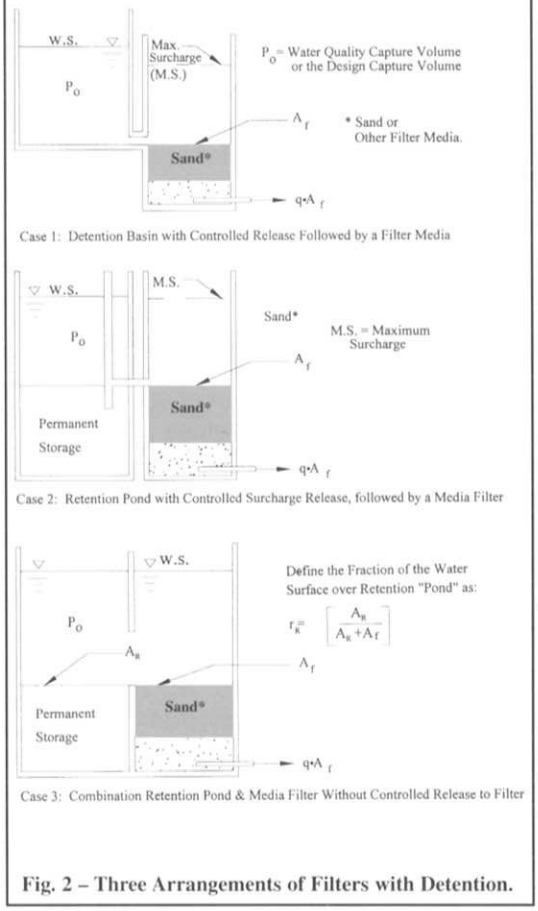


Fig. 2 – Three Arrangements of Filters with Detention.

MAINTENANCE PROGRAM ACTIVITIES

by
Mark R. Hunter, P.E.
Chief, Maintenance Program

Routine Maintenance

Through the routine maintenance program $716,500 was spent in 1997 for mowing and debris pickups on approximately 210 different sections of drainageways within the District boundaries. This equates to a total of nearly 100 miles of drainageways in the Denver area that were given routine maintenance.

The amount of money spent on routine work this year is up substantially over last year. This is the result of an increased frequency of mowing on certain drainageways. Some of the more urban drainageways now receive four to five mowings per year. Three to four mowings per year was inadequate for effective weed control and for overall appearance.

Other drainageways we maintain are more rural in character. On portions of some of these drainageways we have taken the opportunity to reduce or eliminate our mowing activities. This has been done to encourage habitat and leave a more natural character in the drainageway corridor.

Restoration Maintenance

In 1997 the restoration program completed $841,000 of work. Restoration projects typically address isolated drainage problems where the solution involves small scale construction. Ninety-four individual activities were completed during the year.

In last year's *Flood Hazard News* we described a site on **Lena Gulch** at the confluence with **Clear Creek** where, through natural processes, Clear Creek had captured the lower 300 feet of Lena Gulch. The result was a 50-foot wide pool of slow-moving water in Lena Gulch that has experienced some sedimentation and has contributed to insect populations and to uncontrolled vegetation. On the other hand our assessment has been that the changed conditions on Clear Creek and Lena Gulch have not elevated the 100-year floodplain. Thus, there has been little incentive to move rapidly to reconstruct the confluence of these two creeks.

In contrast to the Lena Gulch site described above two other sites have also had increased sediment and vegetation, but they have also experienced a loss of flood-carrying capacity. **Tucker Gulch** in Golden was improved about five years ago. Through earlier land-use decisions the channel was already limited to a confined right-of-way pinched between streets and residences. During the design the project participants made the decision to not expand the right-of-way. That resulted in a narrow concrete-lined channel with little or no surplus flood-carrying capacity. When sediment accumulated and vegetation took root it became necessary for maintenance crews to remove to material to restore the intended capacity to the creek.

The other similar site is on **South Boulder Creek** on the east side of Boulder, Colorado. As with Tucker Gulch, South Boulder Creek has experienced sedimentation and dramatic vegetation growth in the 20 years since it was improved. The resultant flooding threat was recognized by nearby landowners and city officials. To restore the channel capacity a plan was developed to remove the sediment and vegetation.

The excess material needed to be removed from the channel cross-sections of both Tucker Gulch and South Boulder Creek in order to maintain them in a manner that was consistent with the intent of their original designs. Accomplishing this maintenance work caused some discomfort for the involved parties. First, it was a time-consuming process to acquire federal permits to carry out this kind of local maintenance work. A second issue was that some of the neighbors objected to the removal of the material. To them the vegetation was a welcome addition to otherwise stark drainage channels.

Rehabilitation Maintenance

Twenty-eight projects were at various stages of design or construction during 1997. Those projects are listed in the accompanying table titled "STATUS OF MAINTENANCE REHABILITATION PROJECTS". Rehabilitation projects usually take the form of consultant-designed repairs that are intended to address severe problems that have occurred on a previously improved drainageway. By the end of 1997 the District will have spent about $2,178,000 on rehabilitative design and construction for the year. A few of the unique projects are discussed below.

East of Irma Drive at 104th Avenue in Northglenn there is a detention pond on **Grange Hall Creek.** The pond serves as both stormwater detention and as a surface water re-use program run by the City of Northglenn. The existing 108-inch outlet passes under an unused 30-foot high railroad embankment. The outlet pipe had deteriorated to the point that it was being held up with railroad timbers. Through a combined project with the District's construction program and the City of Northglenn the pipe and outlet systems are being replaced. The contractor is laying the pipe in an open cut and is backfilling

Before and after views of Lena Gulch in Wheat Ridge.

STATUS OF MAINTENANCE REHABILITATION PROJECTS

Project	Jurisdiction	Cost		Status
ADAMS COUNTY				
Clear Creek-I-25 to Broadway	Adams County	Design	By others	100%
Repair three drop structures, partic.		Const.	$60,000	0%
Grange Hall Creek-east of Irma	Northglenn	Design	23,064	100%
Detention Pond/outlet repairs, partic.		Const.	230,000	40%
Westerly Creek-north of Montview	Aurora	Design	48,743	100%
Replace pipe with open channel		Const.	113,139	100%
Niver Creek-S.Platte to Steele St.	Adams County	Design	By others	95%
Replace pipes,repair channel, partic.		Const.	242,500	0%
ARAPAHOE COUNTY				
Greenwood Gulch-east of Holly	Greenwood Village	Design	130,000	100%
Erosion repair/drop structures, partic.		Const.	550,000	0%
Little Dry Ck.-West of Colorado	Arapahoe County	Design	38,745	95%
Drops and channel repair		Const.	next year	0%
West Harvard Gulch	Englewood	Design	118,706	100%
Replace pipe w/ open channel, partic.		Const.	501,840	100%
W. Toll Gate Ck.-Delaney Farm	Aurora	Design	81,689	100%
N.E. of Alameda and Chambers		Const.	395,860	0%
Willow Creek-S. of Dry Creek Road	Arapahoe County	Design	29,600	95%
Sediment trap		Const.	next year	0%
BOULDER COUNTY				
Bear Canyon Creek-in Martin Park	Boulder	Design	$28,371	85%
Repair drops and channel		Const.	next year	0%
Coal Creek-Drainageway #7	Lafayette	Design	23,034	75%
Louisville and Lafayette		Const.	260,000	Delayed
Fourmile Canyon Creek	Boulder	Design	35,680	95%
West of Broadway at Lee Hill		Const.	290,000	Delayed
Fourmile Canyon Creek	Boulder	Design	28,900	20%
East of Broadway		Const.	120,000	Delayed
South Boulder Creek	Boulder	Design	19,085	95%
N.E. of Arapahoe Ave. and 55th		Const.	40,000	0%
DENVER COUNTY				
Bear Creek	Denver	Design	$49,610	100%
Raleigh to Sheridan		Const.	388,000	0%
Cherry Ck - Babi Yar	Denver	Design	34,865	95%
Drops, bank repair		Const.	167,000	Delayed
Goldsmith Gulch	Denver	Design	150,819	100%
Bible Park low flow channel, partic.		Const.	400,000	0%
Goldsmith Gulch	Denver	Design	78,436	75%
Cook Park low flow channel		Const.	240,000	0%
Lakewood Gulch-Federal to Knox	Denver	Design	78,432	100%
Channel repair phase 3		Const.	next year	0%-
South Platte River-Westside Trib.	Denver	Design	43,868	95%
N.E. of 6th and I-25. Install pipe.		Const.	153,000	Delayed
Weir Gulch	Denver	Design	by others	100%
Barnum Park detention		Const.	177,841	0%
DOUGLAS COUNTY				
Cherry Creek-N. of Cottonwood Dr.	Parker	Design	by others	100%
Trail and bridge participation		Const.	$28,147	100%
East Dad Clark Gulch	Douglas Co.	Design	52,498	100%
Improve existing drop		Const.	149,734	100%
Sulphur Gulch,U/S of Cherry Creek	Parker	Design	by others	100%
Trail construction, participation		Const.	155,000	0%
JEFFERSON COUNTY				
Dutch Creek	Jefferson County	Design	$30,768	30%
N.E. of Pierce and Coal Mine Road		Const.	next year	0%
Lakewood Gulch-Bayaud Tributary	Jefferson County	Design	33,121	100%
Green Mtn. drainage		Const.	110,943	100%
McIntyre Gulch	Lakewood	Design	31,128	50%
West of Holland St.		Const	next year	Delayed
Ralston Creek	Arvada	Design	27,400	80%
Upstream from Brooks Drive		Const.	200,000	0%

the conduit with products called "flash fill" and "flow fill" to prevent water movement along the pipe.

Since we reported on it last year our project on **Niver Creek** in Adams County near the South Platte River has made slow but steady progress. Adams County was successful in acquiring enough land to expand the Niver Creek trail-head park. The design is now 95% complete. With funding in place from several different sources this project will soon begin construction. Deteriorated pipe, concrete lined channel and eroded channel will be replaced with a new bridge over Niver Creek, a restored open channel for Niver Creek and a trail-head park facility.

In Arapahoe county, just south of Dry Creek Road, **Willow Creek** has cut a 25-foot high vertical bank. About 2,000 feet downstream the creek enters the flood detention pool behind Englewood Dam. The flood pool has been experiencing aggradation for several years. The District's construction program has a design underway to solve the severe erosion problem. Coupled with that design the maintenance program is having the same consultant design a sediment trap upstream of the flood pool. This will reduce the amount of large sediments being deposited in the detention pond and improve the quality of the stormwater. The sediment trap should also help reduce the on-going muck removal that has been necessary to keep open the pedestrian trail under Dry Creek Road.

To the west of Holly Street in Greenwood Village **Greenwood Gulch** flows through a wide area of wetlands. East of Holly Street the gulch has eroded a steep and narrow channel behind several homes. The maintenance program has combined with the District's construction program and the City of Greenwood Village to fund a single project to address these problems. The wetland is soon to be re-established using low grade control structures. The eroded channel will be rehabilitated with grouted boulder drop structures. Extensive vegetation

(Continued on page 24)

Floodplain Management Program Notes

by
Bill DeGroot, P.E.
Chief, Floodplain Management Program

New Staff Member

The Floodplain Management Program has added a second project engineer. David Mallory, most recently with RG Consulting Engineers, Inc., has been appointed to this new position. David's initial assignment will be in the areas of development review and District maintenance eligibility.

Armstrong Appointed

Mike Armstrong, who was Region 8 Director for the Federal Emergency Management Agency for four years, has been appointed by President Clinton and confirmed by the Senate as FEMA's Associate Director for mitigation. I've known Mike for a long time, and am pleased to see someone of his quality, and past local government experience, in this important position.

NAFSMA Notes

I have spent the last two plus years as chair of the Floodplain Management Committee of the National Association of Flood and Stormwater Management Agencies (NAFSMA). Following two committee meetings to identify the issues most important to our member agencies, I drafted a position paper setting forth our issues with regard to FEMA's administration of the National Flood Insurance Program. (NFIP). The NAFSMA Board of Directors adopted the position paper and forwarded a copy to FEMA Director James Lee Witt with a request for a meeting to discuss the issues with him.

While we were not successful in meeting with Witt, we did receive an audience with Mike Armstrong. NAFSMA President John Beyke, Executive Director Susan Gilson and I met with Mike and a number of his senior staff in September. I think we were successful in articulating our concerns to Mike, and I am hopeful that our concerns will be better understood and recognized in the future.

The three of us also met with the Technical Mapping Advisory Council the same day. The Council was established by Congress to advise FEMA on mapping issues. Our main concern with the Council was that they did not have any member representing local government, and we suggested that a NAFSMA representative should be added to the Council to provide the local point of view. We learned, however, that the membership was specified in Federal legislation and could not be changed without an amendment to the legislation.

The Council did extend an invitation to NAFSMA to nominate a technical advisor to the Council, and I was appointed to fill that role. I attended my first meeting in that capacity in Minneapolis in December. I was impressed by the hard work put in by the Council members at that meeting. I also felt that my input was seriously considered by the Council members. If you have any input or issues regarding FEMA's maps, please let me know and I will bring it to the attention of the Council.

NAFSMA's 20th anniversary annual meeting will be held in Denver at the Brown Palace Hotel, September 22-26, 1998. This will be a great opportunity for Denver area flood and stormwater managers to attend one of the premier meetings on these subjects for just the cost of registration. Mark your calendars now and plan to attend. We will have more information on the program and registration as the date gets closer.

FEMA Mapping Initiative

FEMA has begun a comprehensive planning effort to address numerous problems with their Flood Insurance Rate Maps; including updating old maps and the distribution of maps. They have published a report, "Modernizing FEMA'S Flood Hazard Mapping Program, A Progress Report," dated November, 1997; and have under internal review reports assessing the benefits and costs of the recommendations in the above report.

There are a number of positive recommendations in the report. Once the benefits and costs have been sorted out, and decisions made as to if and how much funding to request in President Clinton's budget, we should know more about FEMA's revised mapping efforts in early 1998.

Random Thoughts

The *Denver Post* has a daily phone-in poll feature called "Q&A" which they say "is not a scientifically designed poll, and therefore no claims are made as to the validity of its results." Nevertheless, the August 10 results to the question "Should new housing be allowed in floodplains?" are encouraging. A whopping 94.1% of the callers said no. I wish those folks would all show up at a public hearing the next time we see a proposal to build a new subdivision in a floodplain.

It is popular in some floodplain management circles these days to be anti-structural flood control. However, a *New York Times* article printed in the May 3 *Denver Post*, describing Winnipeg's experience with the flood which had earlier devastated Grand Forks had this to say: "The main difference between the destruction in Grand Forks and the relative calm in Winnipeg is a huge floodway built around the eastern half of the city after a disastrous flood in 1950." It might be interesting to learn more about how Winnipeg handled that flood.

Floods (Continued from page 1)

DTC had a maximum water depth of 8.2' and a peak outflow of 470 cfs.

Almost immediately after the Denver storm had ended, and while Goldsmith Gulch flooding was at its worst, another storm developed in central Jefferson County over the headwaters of Lena Gulch. This second storm produced a 1.85" downpour near the intersection of US Highways 6 & 40 in Golden. At 4:35 p.m., the NWS issued a flash flood warning for Lena Gulch, affecting Golden and Pleasant View where the Mountainside Mobile Estates entrance road was inundated by 2 to 3-feet of water. Fortunately the storm was isolated and only resulted in minor flood damages and temporary inconvenience for motorists.

Monday, July 28:

As mentioned at the beginning of this article, July 28 will be marked in Colorado history as the day of the Fort Collins Flash Flood of 1997. The Denver area was under a similar weather threat all day, but fortunately our number did not come up, at least not in the disaster category. Some significant flooding did occur, however, with Goldsmith Gulch being hit hard for the second consecutive day, exceeding the prior day's peak at Eastman Avenue by one foot and setting a new record of 2040 cfs at 6:30 p.m. Upstream at Temple Pond, Goldsmith floodwaters pooled to a depth of 9.5' releasing 500 cfs. Downstream of Eastman at Yale Ave. the peak flow was estimated at 1850 cfs and classified as a 10-year event. According to the Goldsmith Gulch design hydrology model, the discharge at Eastman approached the 50-year mark. As with the previous day's storm, the Iliff detention facility and improved channel reaches performed as designed preventing significant damages. By 9:00 p.m., Goldsmith Gulch floodwaters had combined with Cherry Creek flows causing the Market Street gage in lower downtown Denver to measure its new record peak of 3200 cfs. The Cherry Creek gage at Steele Street also set a new record at 2350 cfs. Heavy rains in other parts of Denver and Aurora caused localized flooding of many roads, parking lots and basements. In Aurora, road washouts occurred in the upper Sand Creek basin along Coal Creek at Gun club Road, Picadilly Road and Jewell Ave. Some homes in the Coal Creek floodplain also sustained damage. Unofficial rainfall estimates of up to 6" were reported in local Denver newspapers the next day.

Table 1 shows the rain intensities and totals measured by the ALERT system for Goldsmith Gulch on July 28. In contrast, the disastrous Fort Collins storm occurred later in the evening and produced more than 11" over a 4-hour period.

Tuesday, July 29:

Late evening rainfall on July 28 caused the Sand Creek ALERT gage to measure a new record flow of 4200 cfs at 2:47 a.m. (see July 19 discussion). At Sand Creek Park near its crossing with I-225, the pedestrian trail crossing was overtopped by 4.4 feet, and the discharge was estimated at 3480 cfs, another ALERT gage record. While the search for victims was continuing in Fort Collins, readers of the July 29 *Rocky Mountain News* were greeted by a front page photograph of a 12-year-old girl and a car floating in a flooded parking lot at Quebec St. and Leetsdale Dr. in Denver.

Wednesday, July 30:

At 3:25 p. m. a flash flood warning was issued by the NWS for Boulder Creek and for small streams in northern Jefferson County. Some landslides occurred in the mountains along South Boulder Creek and localized street flooding was widespread in the warning area. Fortunately, the heavy mountain rains did not cause any major stream flooding.

Evening storms in Aurora caused the Utah Park detention pond in the upper Westerly Creek basin to overflow onto adjacent streets, making headline news for local television stations. Precautionary sandbagging was performed by public works officials along Peoria Street between Mexico and Florida, safely conveying floodwaters back to Westerly Creek. Aurora officials estimate that flood levels at this location approached the 100-year threshold. The ALERT system measured more than 3 inches of rain in the drainage basin above Utah Park. At 8:05 p. m. the NWS issued a flash flood warning for Westerly Creek in coordination with officials from Aurora and the District.

The Granby Ditch detention basin at East 6th Ave. ponded floodwaters 11 feet deep and came within 2 feet of overtopping the street. This facility is designed to handle 100-year developed runoff. During the event, the ALERT gage at this location gave Aurora officials confidence that an emergency response at this location would not be needed.

Thursday, July 31:

Heavy rains in Arapahoe County and Littleton caused new ALERT gage depth records at Holly Dam (15 feet) on Little Dry Creek, and at the Grant Street detention basin (5.3 feet) on Slaughterhouse Gulch.

Monday, August 4:

Little Dry Creek in Adams County flooded causing damages to public facilities and homes in its lower reaches below Lowell Blvd. The fireplace store upstream of Lowell, frequently damaged in past floods, was spared this time by the 1986 construction of a new bridge. The bridge superstructure was partially inundated, but no road overtopping occurred here. Downstream at Grove Street, the KCNC-Channel 4 News helicopter rescued a man who drove his pickup into the floodwaters. Fire rescue crews were unable to safely reach the victim. Pedestrian bridges in this area were shifted along their foundation by as much as 3 feet by the force of the water and debris.

Table 1 - July 28 Peak Rainfall for Goldsmith Gulch (inches)

ALERT Station	10-min	30-min	60-min	Total
Temple Pond at DTC	0.74	1.42	1.54	1.61
Goldsmith at Eastman	0.67	1.34	1.46	1.85

In Arvada, flooding upstream of Pomona Drive and Wadsworth came very close to damaging homes while low area flooding west of the intersection made the street impassable. At the former site of the Valley Mobile Manor where 56th Ave. crosses Ralston Creek, some of the old concrete slab channel wall panels collapsed. The relocation of this mobile home park in 1996 by Arvada and the District clearly prevented damages here. Arvada residents reported rainfall amounts of 3 to 3.25″ from this storm.

In Columbine Valley, Drainageway 'E' overtopped Platte Canyon Road.

Monday, August 11:

Insurance companies, affected homeowners and gardening enthusiasts will remember this day. Hail depths of up to 2 feet, driving rains and high winds caused an estimated $150-million in damage in Lakewood and Denver. A rainfall amount of 1″ in 10-minutes was measured by the Cherry Creek gage in downtown Denver, and after the hail melted, the total measured precipitation exceeded 2 inches. Cherry Creek flowed wall-to-wall at a depth of approximately 5 feet and a peak discharge of 2640 cfs. This was the second highest measurement for Cherry Creek this year, exceeded only by the July 28 event.

Thursday, September 4:

Not withstanding the October 24 snow storm, this day may have been the last hurrah for heavy precipitation in Denver for 1997. Cherry Creek flowed wall-to-wall once again as captured by late evening news reports. Steve Paulson, Meteorologist for KMGH-Channel 7 News, opened the evening news broadcast with a report concerning Denver's weather. Data obtained from the ALERT system was reported while the event was still in progress. Five rain gages had alarmed (1″ in less than 1-hour) by 9:45 p.m. The locations and amounts were accurately reported to the public at the start of the 10 p.m. broadcast. Live video of Cherry Creek was shown later during the program's normal weather segment and Steve made excellent use of the ALERT stream gage data to describe current flow conditions. The District appreciates the cooperation of our local news media and the working partnerships that have developed.

Some statistical facts:

The official July rainfall total for Denver of 5.60″ made 1997 the second wettest July in Denver's 126-year record, with the average for the month being just under 2 inches. The wettest July was in 1965 with an official amount of 6.41 inches. Six ALERT rain gages in Denver and Aurora exceeded the 5.60″ official total measured at DIA. The maximum ALERT rainfall for July (6.38″ at Granby Ditch) occurred in Aurora near Buckley Air Force Base.

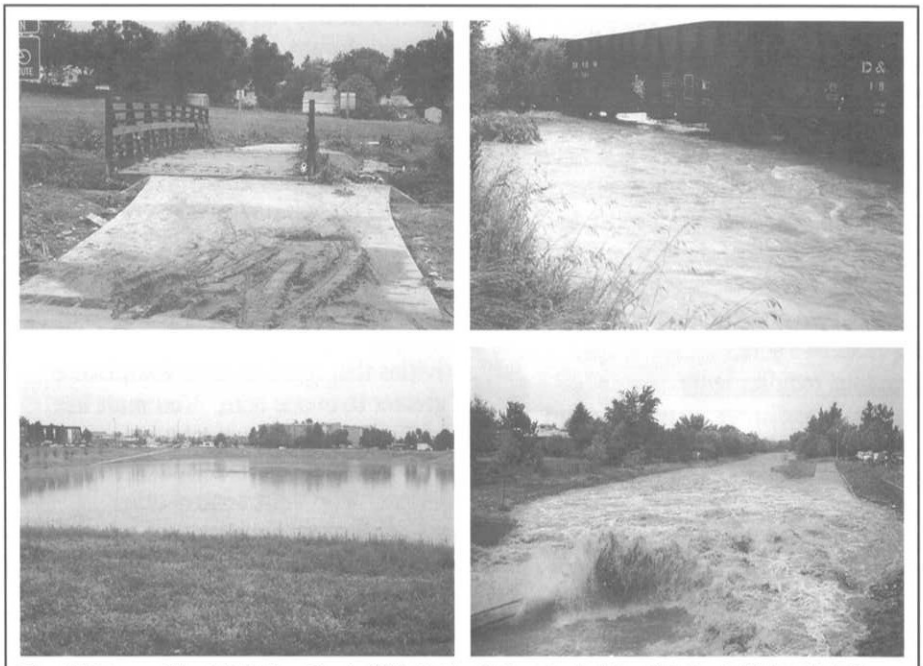
Denver's wettest August was 1979, with a record total of 5.85 inches. The official 1997 August total was 3.52″ and the maximum ALERT rainfall of 4.53″ was measured in Aurora. Nine other gages in the network also recorded amounts exceeding 4 inches (Table 2). Denver's average rainfall for the month of August is 1.65 inches.

Recalling that six counties in Colorado experienced storm rainfalls exceeding 10″ in 1997, it is interesting to note the total rainfall for the wettest 30-day period measured by the ALERT system.

Table 2 - 30-day rainfall totals ending August 17, 1997 (inches):

LOCATION	AMOUNT
Aurora (6th & Buckley)	10.0
Aurora (Utah Park)	8.2
Broomfield	7.5
Denver (Southeast)	7.9
Denver (downtown)	6.9
Lakewood	6.4
Arvada	5.2
Louisville	5.2
Boulder Co. (Gross)	5.2
Golden	5.1
Boulder Canyon	4.9
Wheat Ridge	4.7
Commerce City	4.5
Morrison	4.2
Thornton	4.1
Boulder	3.8

An article elsewhere in this *Flood Hazard News* contains additional information about the ALERT system, the 1997 Flash Flood Prediction Program, and other related activities. Flood documentation is a routine function of the District's Floodplain Management Program and the information gathered is available for public inspection upon request.



Flood Pictures: Top Little Dry Creek (8/4): Left – Pedestrian bridge dislodged. Right: Mainline railroad tracks threatened. Bottom Goldsmith Gulch (7/27): Left – Iliff detention pond. Right – Downstream from Yale Ave.

Tucker **(Continued from page 3)**
goes into effect on March 1, 1999, would be June 1, 2002.

What is included in a Notice of Intent?

The Notice of Intent must include at a minimum the following:

1. The best management practices (BMPs) you choose to implement for each of six "minimum measures" categories.
2. Measurable goals for each of the minimum measures.
3. The month and year each minimum measure will be started and completed or the frequency of action.

The measurable goals will not be a condition of the permit until EPA or the state has issued a menu of measures they think to be cost effective.

What is required in a Permit?

An Individual permit would require the same information required in the Notice of Intent, plus the square miles served by the storm sewer system; a listing of all permits or construction approvals received or applied for; a topo map covering one mile beyond the boundary showing all discharge structures, hazardous waste facilities, surface water bodies, and drinking water wells; and any additional information the NPDES authority requests.

It should also be noted that local governments would need separate NPDES permits pursuant to the Phase I requirements for any municipal-owned industrial facilities. These would include hazardous waste treatment facilities, landfills and dumps that have received industrial waste, steam electric power generating facilities, airport de-icing facilities, sewage treatment facilities that have a capacity greater that 1 mgd, and construction activity greater than one acre.

Performance requirements

The basic performance requirement is to develop, implement and enforce a program to reduce the discharge of pollutants in stormwater to the maximum extent practicable (MEP) and to protect water quality. Your stormwater program must satisfy technology requirements including reduction of pollutants to the MEP standard; water quality based requirements of the Clean Water Act; any more specific conditions or limitations to meet water quality standards as may be defined in a total maximum daily load study (TMDL); and reporting requirements.

The major requirement of the program is implementation of management practices in each of six categories of "minimum measures" which are described as follows:

1. Public education and outreach. This will require implementation of an education program to distribute material to your community or conduct outreach about stormwater impacts on water bodies and the steps your citizens can take to reduce stormwater pollution.
2. Public involvement and participation. This requires that you comply with all applicable public notice requirements.
3. Illicit discharge detection and limitation. It requires you to develop a storm sewer system map showing the location of major pipes, outfalls and topography, as well as areas of concentrated activities likely to be a source of stormwater pollution. You must prohibit through ordinance, order, or similar means, illicit discharges into your storm sewer system and implement appropriate enforcement procedures and actions. You must implement a plan to detect and address illicit discharges including illegal dumping into your system. Finally, you must inform public employees, businesses and the general public of the hazards associated with illegal discharges and improper disposal of waste.
4. Construction site stormwater runoff control. This minimum measure will require you to develop, implement, and enforce a program to reduce pollutants in stormwater runoff to your municipal storm sewer system from construction activities that result in land disturbance of greater than one acre. You must use an ordinance or other regulatory mechanism that controls erosion and sediment. You must control other waste at construction sites such as discarded building materials, concrete truck washout, and sanitary waste. Finally, your program must include requirements for construction site owners or operators to implement BMPs, provisions for pre-construction review of site management plans, procedures for receipt and consideration of information submitted by the public, regular inspections during construction, and penalties to ensure compliance.
5. Post construction stormwater management. To comply with this measure, you must develop, implement, and enforce a program to address stormwater runoff from new development and redevelopment projects that result in land disturbances of greater than one acre and that discharge into your storm sewer system. This program must include site appropriate and cost-effective structural and non-structural BMPs and you must ensure adequate long-term operation and maintenance of the BMPs. Your program must ensure that controls are in place that would prevent or minimize water quality impacts.
6. Pollution prevention and good housekeeping for municipal operations. This minimum measure will require you to develop and implement an operation and maintenance program with the goal of preventing and reducing pollutant runoff from municipal operations. The program must include local government employee training to prevent and reduce stormwater pollution from government operations such as park and open space maintenance facilities, fleet maintenance planning, building oversight, and stormwater system maintenance.

Full implementation of your stormwater program will mean doing the six minimum measures and meeting the reporting requirements. Doing this shall constitute compliance with the standard of "reducing pollutants to the maximum extend practicable." You will have five years from the date of issuance of your permit to fully develop and implement a program. Based on June, 2002 as a deadline for permit applications, local governments could have up to June, 2007 to fully implement their programs.

Measures of Permit Compliance

Once this program becomes implemented a portion of your public works activity will then be mandatory. You will have to implement the six minimum measures included in your

Notice of Intent. You will be required to evaluate program compliance, appropriateness of your six minimum measures, and progress toward achievement of your measurable goals. Monitoring may be required by your NPDES permitting authority, but it is not required as part of the proposed EPA regulations. However, reference is made to the potential of monitoring. You must keep records for at least three years. You must submit the records only when specifically asked and you must make records available to the public. It is not clear in the proposed permit what will constitute adequate record keeping.

You must submit an annual report to the NPDES permitting authority for the first permit term. For subsequent terms, you must submit reports in years two and four unless the NPDES authority wants them more often. Your report must include: 1) status of compliance with permit conditions, assessment of appropriateness of your identified BMPs, and progress toward achieving the measurable goal for each of the six minimum control measures; 2) results of information collected and analyzed including monitoring data, if any; and, 3) summary of what stormwater activities you plan to undertake during the next reporting cycle and changes in any identified measurable goals that apply to your program elements.

NPDES permits are federally enforceable. Violators are subject to enforcement actions and penalties of the Clean Water Act. Compliance with the NPDES permits issued under the authority of this rule will be deemed to be in compliance with the Clean Water Act. For the time being, do what you say you will do and you will be okay.

Concerns and Unresolved Problems

This is just the beginning. While EPA is recommending in the proposed rule that no additional requirements beyond the six minimum control measures be imposed on small regulated municipalities, until they review and evaluate the program, there is a caveat. When adequate information exists in an approved TMDL study to develop more specific conditions or limitations to meet water quality standards, additional requirements can be imposed. There is currently a lot of pressure to conduct TMDL studies. The NPDES permitting system will be used as an enforcement mechanism to implement TMDL recommendations.

There is a concern that the NPDES permitting system will eventually be used to regulate the flow rate and volume of stormwater which in turn translates to land use control. In other words, the NPDES permit may become a vehicle for federal land use control. Local governments should, on their own, attempt to regulate the flow rate and volumes of stormwater, but it should not be a subject of NPDES permitting control.

Your public works program will forever be linked to the federal government and/or state through a regulatory program. They will have the power and authority to force local governments to do what they think is required to meet water quality standards.

The NPDES permitting program is fundamentally a point source program. It is designed for the control and permitting of point sources such as waste treatment plant effluent. Stormwater is a diffuse source of discharges and does not lend itself to point source control. The Clean Water Act needs to be revised to reflect the realities of stormwater.

It is hard to develop partnerships in a command and control environment such as with the NPDES permit system. It is like being a partner with an 800 lb. gorilla. One partner has a definite advantage. Local government is not the gorilla in this case.

There is concern that eventually cities and counties will be forced to meet numerical effluent limitations at the end of their storm sewers. This would be an impossible requirement and would cost local governments a lot of money trying.

In summary, I urge all of you to get a copy of the proposed regulations and comment on them. If you have concerns or suggestions to improve the proposed regulations, let EPA know in writing. What we can all agree on is the goal of reducing pollutants in stormwater. The mechanism congress has chosen, command and control through the NPDES permitting program, may eventually cause problems for local governments. Review the proposed regulations carefully, think in terms of how your local government can respond to the requirements and comment accordingly.

Student Intern Program

Since the late 1970's, the District has hired students on a part-time basis to assist staff with various activities. The students have come mostly from the University of Colorado at Denver Civil Engineering Program, and the Metro State University Civil Engineering Technology Program. We started with one student in the late 1970's. At the present time, we have six interns. Three students work in the Maintenance Program, one student is splitting duties between the Construction Program and Floodplain Management Program, and two students are assisting with research, and data collection and evaluation activities. Some 30+ student interns have worked for the District since the program began.

Students typically join the District in their junior year and remain with us for one to two years. The students work about twenty hours a week during the nine months of the school year and up to 40 hours a week during the summer months. As soon as the student graduates, they are no longer eligible for employment at the District under our intern program.

It has been satisfying indeed to see a number of young people join the District as student interns, work productively for the District, graduate, and then enter the work force. Many of the former student interns are now pursuing successful careers and working with local consultants or municipalities throughout the Denver metropolitan area and elsewhere.

This program has been a plus for both the students and the District. The students gain from the experience and contacts they make while they are at the District, and the District gains by employing competent people at reasonable rates.

Flood Warning & Preparedness

by
Kevin G. Stewart, Project Engineer
Floodplain Management Program

Prediction & Notification

The District's Flash Flood Prediction Program (F2P2) issued messages on 48 days in 1997 falling three short of last year's record. The number of flash flood watch (Message 2) days did, however, set a new record this year at 12 days, two of which (July 27 and July 30) resulted in flash flood warnings (Message 3) also being issued in the District. Henz Meteorological Services (HMS) provided the weather forecasting for the F2P2 and were responsible for notifying local governments of impending floods.

As suspected, the October 1, 1996 loss of the FSL Mesonet had an adverse impact on flood forecasting capabilities in 1997 (ref. 1996 *Flood Hazard News).* By mid-July three Boulder County ALERT weather stations had been strategically relocated which, according to HMS forecasters, had a the very positive net effect as the Colorado monsoon rains began soon thereafter. One additional Boulder County weather station will be relocated by spring of 1998, along with the installation of three new weather stations in Douglas County. The Mesonet Loss Impact Study draft report, completed early in 1997, is being revised to reflect the past year's operational experience and to revisit the recommendations for locating additional weather stations.

ALERT System News

The District's ALERT base station logged 5511 modem connections during 1997 representing over 1640 hours of remote use and exceeding the previous year's "high-water mark" of 3871 logins. This record-setting use year is indicative of the 1997 flood season (see cover story). It should be noted that these statistics do not represent total system usage since the District Base is one of eight existing base stations.

The District provides it's local government partners and certain other cooperators with free access to the base station. In addition to ALERT data displays, a full suite of weather products is also available including watches, warnings and advisories from the National Weather Service; and heavy precipitation outlooks, quantitative precipitation forecasts and internal message status reports from HMS.

Having just completed two years of adjusting to a substantial operating system upgrade along with its associated "improved" database management and display software, it is nice to report that system stability has finally been achieved. In other words, the bugs now appear manageable. More custom reports and graphics tools are available then ever, making the interpretation of ALERT data more friendly.

Also, a new windows-based software package known as STORM Watch™ is becoming the system of choice for many. The District's ALERT system maintenance contractor, DIAD, Inc. of Lyons, Colorado, is the author of this Microsoft Access™ driven program. The District began running STORM Watch as part of their ALERT base station operations this year, having participated with Boulder County in its initial concept development and testing. This parallel utility provides a very nice visual addition to the multiple-PC District Base Station environment as well as providing backup data collection and analysis.

ALERT data requests and local government interests continue to fuel demands for Internet access. The District is currently considering a proposal with the City of Aurora to support a dedicated "Server" for ALERT, making data from the system widely available.

Record year for breaking gage records

During 1997 the ALERT system logged a record number of 53 rainfall rate alarms (1"/hr amount exceeded) on 11 days (May 29; June 6; July 19,27,28,30,&31; August 4,5,&11; September 4). The table lists the ALERT stream gages which set new records in 1997.

1997 Record Flows

Location	Peak (cfs)	Date/ Time
Cherry Creek at Market St.	3200	July 28 20:56
Cherry Creek at Steele St.	2350	July 28 19:47
Cub Creek above Evergreen	180	June 7 18:02
Goldsmith Gulch at Eastman Ave.	2040	July 28 18:26
Lena Gulch at US Highway 6	510	July 27 N/A
No Name Creek at Quincy Ave.	530	July 28 19:07
Sand Creek at Brighton Road	4200	July 29 02:47
Sand Creek Park near I-225	3480	July 29 N/A
Toll Gate Creek at E. 6th Avenue	1760	July 30 19:21
Westerly Creek at Montview Blvd.	1200	July 19 N/A

Gages on three detention basins also measured record levels this year: Granby Ditch on East 6th Ave. in Aurora (11.0' on July 30 at 21:47); Holly Dam on Little Dry Creek in Arapahoe County (15.0' on July 31 at 17:52); and Slaughterhouse Gulch/Grant Street detention basin in Littleton (5.3' depth on July 31 at 16:34).

ALERT data is currently available from 130 gaging stations comprising 113 rain gages; 62 water level sensors and 8 weather stations. Anyone interested in obtaining ALERT data from the District may contact Kevin Stewart at 303-455-6277.

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Mark Hunter	mhunter@udfcd.org
Kevin Stewart	kstewart@udfcd.org
The District	udfcd@udfcd.org

Professional Activities (Continued from page 2)

John Doerfer, Project Hydrologist, Master Planning Program
*Chairman of the Stormwater Quality Committee, Colorado Association of Stormwater and Floodplain Managers (CASFM).
*Chairman of Awards Committee, 1997 CASFM Annual Conference.
*Instructor on "Stormwater Systems" at Collection and Distribution Systems Short Course sponsored by Rocky Mountain Chapter of Water Environment Federation and APWA in Boulder in November.

Mark Hunter, Chief, Maintenance Program
*Member of International Erosion Control Association (IECA) standards committee on riprap, standards committee on articulating blocks, and the by-laws committee.
*Secretary of the Board of Directors for the IECA-Mountain States Chapter.

Paul Hindman, Project Engineer, Design and Construction Program
*Received Master of Science degree in Management from the University of Colorado at Denver in May.
*Treasurer of the Colorado Chapter of APWA.

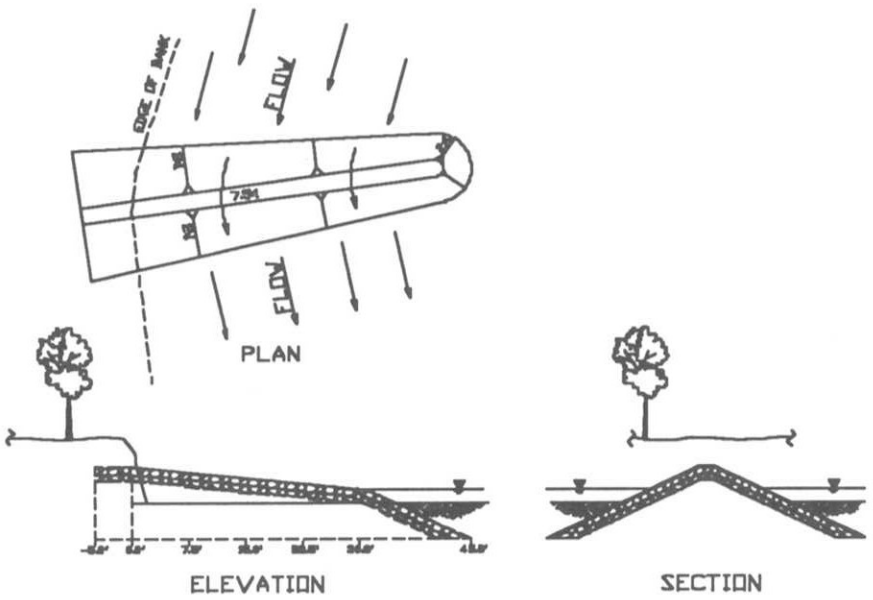
ALTERNATIVE BANK STABILIZATION ON THE SOUTH PLATTE RIVER

By
Bryan W. Kohlenberg, P.E., Project Engineer
South Platte River Program

Actively eroding banks along the South Platte River are typically vertical with minimal amounts of vegetation along the toe. The traditional method for stabilization involves laying back to a 2:1 slope and armoring the slope with riprap. In the last 10 years the District has modified this by providing a flatter slope and using buried revegetated riprap to enhance the riparian habitat. Recently the South Platte River program has tried using bendway weirs (i.e., rock jetties) to arrest bank erosion.

In a typical river bend, surface water currents tend to move toward the outer bank, concentrating flow and higher velocities along the bank edge, resulting in severe bank erosion. The traditional rock riprap revetment installation resists this increased bank velocity. The bendway weir method, however, involves redirecting the bank velocity away from the bank towards the middle of the bend. With a series of weirs angled upstream along the outside of a bend, the current is redirected through the bend and into the downstream crossing.

For the last four years, a bending reach of the South Platte River in Adams County was observed to have moved 50 feet laterally, endangering several mature cottonwood trees. Since the traditional method required removal of the trees, the weir concept was tried for bank stabilization.



IN-STREAM WEIRS

At a cost equivalent to the bank lining method, the District installed a series of five jetties along the outside bend of this river reach at approximately 152nd Avenue in Adams County. The jetties are essentially small berms of 12 inch (d_{50}) riprap keyed into the existing bank, extending into the low flow channel approximately 40 feet and angled 5 to 15 degrees upstream (See Figure). The rock was mixed with in-situ soils and revegetated with willows and native grass where possible.

Since construction early this year we have observed:

- Sediment deposition between jetties and adjacent to the vertical bank.
- New scour holes at the jetty points (great fish habitat).
- Erosion along the vertical bank has stopped.
- Woody debris can be placed between jetties with little or no anchoring needed.

The District will try additional installations such as this and will continue to monitor them over the next few years. We will report our findings in future issues of *Flood Hazard News.*

Maintenance (from page 16)

planting will complete the project.

In last year's *Flood Hazard News* we reported that two large projects were underway on **Goldsmith Gulch** in the City of Denver. Both projects are situated on park land and both have benefited from a design partnership with participants from nearby neighborhoods, the Denver parks department, the consultant and the District maintenance program.

Within Bible Park Goldsmith Gulch has eroded a vertical-sided channel ranging from three to ten feet deep. The gulch flows through a broad natural area. This allowed the design partnership the opportunity to recreate a relatively natural riparian corridor for the stream. The rehabilitation project has recently been bid and will create a meandering stream which will repair the erosion damage and make the stream more accessible and aesthetically pleasing to the park users.

Within Cook Park the erosion in the low flow channel of Goldsmith Gulch has created a steep-sided channel three to six feet deep. Although this is not as severe as in Bible Park the setting in Cook Park is an improved blue-grass multi-use area. This dictates that the channel configuration for Goldsmith Gulch be rehabilitated to be less of a threat to existing facilities such as pedestrian bridges and play areas. The design for this project is well underway. Construction will be in 1998.

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