URBAN DRAINAGE AND FLOOD CONTROL DISTRICT-69

FLOOD HAZARD NEWS

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SIZING A CAPTURE VOLUME FOR STORMWATER QUALITY ENHANCEMENT

by
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L. Scott Tucker, P.E., Executive Director

INTRODUCTION

Urban stormwater management is rapidly changing from a focus only on the control of damages resulting from storm runoff to now include water quality. Two basic issues are influencing this change. First is a fundamental heightening of environmental awareness and concern by the public. It is documented that urban stormwater, along with non-point runoff from non-urban sources, contributes pollutants to the receiving waters and efforts to do something about it are slowly picking up support and momentum.

The second factor causing a shift toward urban stormwater quality is the Water Quality Act of 1987 (WQA), which amended the Federal Water Pollution Control Act. How this WQA may impact the citizens, communities, local governments, industry, consultants and the water quality across the United States is yet to be seen. Nevertheless, local governments and industries are mandated by Congress to control pollutants in urban runoff to the "maximum extent practicable" (MEP). This hopefully means that Congress expects solutions to be practical, pragmatic, and economical.

In order to be practical and effective it is important that technologies for dealing with urban stormwater runoff be available. Several simple technologies are emerging (Urbonas and Roesner, 1986), (Roesner, Urbonas and Sonnen, 1989), which include detention and retention basins, infiltration and percolation at the source of runoff, wetlands, sand filters, and combinations of these techniques. It is clear from the references cited above that stormwater quality facilities first need to capture a certain volume of runoff in order to treat it. As a result, the size of runoff event to be captured is critical in the design of stormwater quality facilities. For example, if the design runoff event is too small, the effectiveness will be reduced because too many storms will exceed the capacity of the facility. On the other hand, if the design event is too large, the smaller runoff events will tend to empty faster than desired for adequate treatment to take place. We know that large detention basins designed to control peaks from larger storms will not provide the needed retention time for the smaller events, which are much more numerous than the larger storms.

A balance between the storage size and water quality treatment effectiveness is needed. Grizzard et. al. (1986) reported results from a field study of basins with extended detention times in the Washington, D. C. area. Based on their observations they suggested that these basins provide good levels of treatment when they are sized to have an average drain time for all runoff events of 24 hours. This equates to a 40 hour drain time for a brim-full basin. Beyond that, there remains little rationale for the sizing of the capture volume that results in reasonable pollutant load removal while providing reasonably sized facilities.

This paper will discuss one possible method to find a point of diminishing returns for the sizing of water quality capture volume. It utilizes rainstorm records as its base instead of synthesized design storms. An example based on the National Weather Service long term precipitation record in Denver will illustrate this methodology.

FINDING A POINT OF DIMINISHING RETURNS

In 1976 von den Herik (1976) suggested in Holland a rainfall data-based method for estimating runoff volumes which he called Rain Point Diagram (RPD). This was later modified to a Runoff Volume Point Diagram (RVPD) method which approximates continuous modelling without setting up a continuous model. The method requires combining individual recorded hourly or 15-minute rainfall increments in a given period of record into separate storm depths. Individual storms are defined by the time during which no rainfall occurs. Very small storms are purged from the record. Storm totals are converted to runoff volumes by multiplying each storm's depth by the watershed's runoff coefficient (C).

The use of the RVPD is illustrated in Figure 1, where the individual storm runoff depth is plotted against storm duration. The runoff capture envelope consists of the "brim-full" volume of the detention facility, plus the average release rate times its emptying time. In this figure the runoff capture envelope is based on a detention basin that has a brim-full capacity of 0.3 watershed inches which can be emptied in 12 hours. All the points above the

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Inside: The Urban Drainage and Flood Control District - The Second 10 Years

Professional Activities of District Staff

Scott Tucker, Executive Director

*Presented, "A Drainage District Perspective" at the Urban Stream Corridor and Stormwater Management Conference in Colorado Springs in March.

*Presented "Current Programs and Practices in Stormwater Management" at the APWA Centennial Conference on Water and The Cities in Chicago in June.

*Session chairman, "Status of EPA Regulation on Permitting of Urban Runoff Facilities" at the 1989 ASCE Water Resources Planning and Management Division specialty conference in Sacramento, CA in August.

*Presented "State and Local Government Programs to Reduce Hazards From Urban Flooding" and participated in a joint U. S. - Republic of China Workshop on Multiple Natural Hazard Reduction in Taipei, Taiwan in Sept.

*Presented "Stormwater Regulations From Local Governments View" at the Engineering Foundation Conference on Urban Stormwater Quality Enhancement - Source Control, Retrofitting, and Combined Sewer Technology held in Davos,Switzerland in Oct.

Mark Hunter, Chief, Maintenance Program

*Participated in a 3-day short course, "Optimizing Your Storm Drainage System" sponsored by the University of Wisconsin. Presentation was entitled, "The Storm Water Maintenance Plan to Optimize Your System".

*Presented a paper titled, "Storm Water Management Facility Maintenance" at a 4-day short course, "Understanding and Applying Storm Water Management Techniques" sponsored by the University of Wisconsin.

*Presented a paper entitled, "Identification Reduction, and Cost Accumulation of Long-Term Maintenance on Major Drainageways" at the 1989 ASCE Water Resources Planning and Management Conference in Sacramento CA.

Bill DeGroot, Chief, Flood Plain Management Program

*Elected Secretary/Treasurer of the newly formed Colorado Association of Stormwater and Floodplain Managers.

Kevin Stewart, Project Engineer, Flood Plain Management Program

*Lectured on major drainageway planning, study reviews and report preparation at a HEC-2 short course sponsored by the University of Colorado at Denver in January.

*Conducted Heavy Precipitation Workshop for hydro-meteorological staff from the National Weather Service, NOAA's Environmental Research Lab and Henz, Kelly and Assoc. in February.

*Presented "The Denver AWIPS-90 Experiment, A Federal-State-Local Partnership for Flash Flood Warning in the 1990's" at the 1989 conference of the Association of State Floodplain Managers in Scottsdale in May.

*Organized and participated in the Second Annual Conference of the Southwestern Association of ALERT Systems (SAAS) in Tulsa in Nov.

*Elected Vice-President of SAAS.

Paul Hindman, Project Engineer, Maintenance Program

*As Chairman of the Water Resources Group of the Colorado Section of ASCE, organized two seminars: A two day HEC-2 Users Conference in August and a three day Highway Drainage Design Short Course in October.

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

*Presented an invited paper titled "Hydrologically Optimizing Stormwater Quality Facilities" at the ASCE Specialty Conference and LIFE Symposium in June at the University of Delaware.

*Presented "Activities That Can Be Taken In Preparation for the EPA's Stormwater NPDES Program" at the APWA annual conference in Orlando.

*Presented a paper co-authored with Dr. James C. Y. Guo and L. Scott Tucker titled, "Optimization of Stormwater Quality Capture Volume" at an Engineering Foundation Conference held in Davos, Switzerland in October.

*Elected Chairman of the ASCE Urban Water Resources Research Council.

*Presented an invited paper titled, "Stream Stability Under A Changing Environment" at the Streambank Erosion Symposium held in Snowmass in August.

*Continues to serve as Chairman of ASCE's Subcommittee on Urban Gaging Networks sponsored by the USGS.

*Currently serving as Chairman of the steering committee of the Stormwater Task Force assembled by the Colorado Water Quality Control Division to explore issues and develop recommendations for the establishment of the state's Stormwater Quality Management Program.

AWARDS OF NOTE

In March, the Mined Land Reclamation Board recognized Cooley Gravel Company for the firm's outstanding reclamation efforts along the South Platte River in Adams County, north of 88th Avenue. Nominated by the District in the category of River Stabilization and Aquatic Habitat Enhancement, this is the second consecutive year that Cooley Gravel Company has been honored by the MLRB.

Little Dry Creek Flood Control Improvements in Englewood have received a number of awards this year. The project consists of 14 acres of sodded athletic fields which double as a side-channel detention area, a grass-lined channel with maintenance/recreation trail, and an artificial lake with fountains and waterfalls. The project was designed by a team of consultants led by McLaughlin Water Engineers, and constructed by the Englewood Urban Renewal Authority. The District participated financially in the construction of the detention facility and a portion of the grass-lined channel.

The awards include 1988 Colorado ASCE Civil Engineering Project of the Year, 1988 Honor Award from the Colorado Chapter of the American Society of Landscape Architects, 1989 Colorado Consulting Engineers Council Engineering Excellence Award, 1989 National Honor Award from the American Consulting Engineers Council, and the 1989 Award of Excellence from the Rocky Mountain Chapter of the American Concrete Institute.

VOC Helps District

On Saturday, April 8th, approximately 220 members of Volunteers for Outdoor Colorado assisted the District with plantings at three separate locations. About 75 people worked on revegetation near the new drop structure at 88th Avenue on the South Platte River, and about 70 people worked at a new pedestrian bridge over the South Platte south of Hampden Ave. Approximately 80 people worked on revegetation of portions of the Cherry Creek channel near downtown Denver.

The help of the Volunteers for Outdoor Colorado is very much appreciated by the District.

Tucker-Talk

by L. Scott Tucker

Timely Comment from the District's Executive Director

Maintenance and the Urban Infrastructure

Much has been written lately expressing concern over the status of the urban infrastructure. The conditions of our roads, streets, bridges, sewer systems, and drainage and flood control systems in many metropolitan areas seem to be in a state of decline. There are several facets to this problem including outdated design, overloading due to population increases, a lack of funds for upgrading the system, and lack of adequate maintenance. While much of the problem is caused by population growth, outdated designs, and limited resource availability, we should not be letting our facilities deteriorate because of a lack of regular maintenance.

The Urban Drainage and Flood Control District is fortunate to have a 0.4 mill levy that generates approximately $4,000,000 per year allocated entirely to maintenance of urban major drainageway facilities. Since the legislature first authorized this program with funding starting in 1981, the District has aggressively pursued an active program of maintaining major drainageway facilities in the Denver metro area. Working with the 36 cities and counties in the Denver metro area, the District establishes a work program each year that identifies maintenance priorities. Maintenance activities range from removing trash and debris from drainageways and routine mowings to restoration of drainageway facilities and major rehabilitation projects. Most major drainageway facilities are owned by the cities and counties with the District itself owning very few facilities. Consequently, the thrust of the District's program is to assist local governments in the maintenance of their major drainageway facilities.

Most major drainageways are multi-jurisdictional in nature, flowing from one local government into another, and it is important that maintenance of these facilities be addressed on a multi-jurisdictional level. The dedicated funding of the Urban Drainage and Flood Control District makes it possible to allocate resources on a dependable annual basis to address maintenance needs. It also enables long term planning of maintenance projects and permits some major maintenance efforts to take place over periods of several years. Another important factor is to have an agency that can focus on maintenance needs. This is the mission of the maintenance program of the Urban Drainage and Flood Control District and its primary reason for existence. This focusing is important as it provides a "hero" that can direct all of its attention to maintenance needs in a specific area.

We have taken to heart the old adage if you can't maintain it don't build it, and the District's maintenance program has become an indispensable component of our overall activities.

Urban Flood Control/Trails/Open Space/Wetlands/Recreation/Wildlife

What do all of these have in common? It turns out to be quite a lot. We are beginning to learn how to integrate urban flood control with other uses such as hiker/biker trails, open space, wetlands, recreation, and wildlife. Not all of these uses can be generally accommodated under the umbrella of one agency, so it takes an attitude among several different agencies and interests to look at their problems with broad vision rather than with narrow eyes of single interest groups. Rivers, streams, gulches, creeks, and lakes can serve as areas reserved for the passage and temporary storage of flood flows. Urban stream corridors can provide excellent locations for urban trail networks. Recreation, both passive and active, can be provided in detention and floodplain areas, and stream corridors can provide the habitat needed for wildlife enhancement.

There are many examples of multiple uses of flood control areas throughout the United States. This is certainly the case in the Denver area where a comprehensive system of hiker/biker trails has been developed and is continuing to evolve along the stream corridors. Efforts are being made to preserve floodplains by open space groups, which is a highly compatible and desirable use from a flood control standpoint. And park and recreation agencies are utilizing urban stream corridors as lineal parks which in many cases link larger regional parks.

We are entering a period of less financial resources at the local level, and the multiple use of facilities becomes a way of being more efficient with limited dollars. Also the interest of the American public in the environment encourages the development of multiple use projects that incorporate open space and wildlife enhancement into the flood control and drainage system.

There seems to be a trend in the Denver area for many diverse agencies to communicate with one another and to work together to accomplish multiple goals for their projects. The Urban Drainage and Flood Control District supports and encourages this approach and we hope to see the trend continue to gain momentum in the future.

New District Area

The 1989 Colorado General Assembly passed legislation adding 408 square miles to the Urban Drainage and Flood Control District. A total of 180 square miles was added in Adams County, 120 square miles in Arapahoe County, and 108 square miles in Douglas County. Before the change in boundaries, the City and County of Denver and the cities of Aurora and Parker had portions of their cities located outside of the Urban Drainage and Flood Control District. Also the eastern north/south boundary of the District ran through the middle of the proposed new Denver airport. It was felt by the cities involved, and supported by the counties, that the cities should be located entirely within the District, which would enable the District to assist these entities in planning major

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PLANNING PROGRAM ACTIVITIES

by Ben Urbonas
Chief, Master Planning Program

PLANNING PROJECTS

As predicted last year, master planning program activity increased during 1989 and we expect the pace to further increase in 1990. See the accompanying table for what projects are under way and what we expect for 1990.

TECHNOLOGY TRANSFER

In the past, the University of Colorado at Denver and the District have either jointly or separately sponsored short courses on the use of CUHPE, UDSWM and UDSEWER, and seminars on urban drainage and flood control facilities design. If there is an interest in these types of short courses or seminars please write or call us to let us know. For further information on the types of short courses that will be offered in the future by UCD, call Dr. James Guo at 556-2849.

SOFTWARE

Adams County, Arapahoe County, Douglas County, Aurora, Boulder County, Greenwood Village, Littleton and the District are funding the development of PC software for all technical sections of the Urban Storm Drainage Criteria Manual. The University of Colorado at Denver is doing the software development and we expect the project to take another 18 months to complete.

STORMWATER QUALITY

When it became apparent that EPA will promulgate stormwater NPDES permit program regulations, the State of Colorado's Water Quality Control Division established a task force to study the stormwater quality issue and to recommend to the Division a stormwater management program for the state. The task force has more than 60 individuals representing municipalities, industries, citizen groups, engineers, biologists, chemists, lawyers and other areas of interest and profession. Scott Tucker and I are active participants and hope to report to you on stormwater quality technology and issues as they emerge.

To better deal with the wide array of issues the task force set up four committees. The Technical Committee was charged to investigate technical issues related to stormwater such as what constitutes a "representative" storm for monitoring, how to best monitor stormwater runoff events in Colorado, what needs to be studied to identify and quantify the impacts of stormwater on the receiving waters, etc.

The Municipal Committee is addressing how to deal with the institutional issues and how to apply the technical information in formulating stormwater management programs. Similar activity is taking place within the Industrial Committee, except it is addressing these issues from the industry's perspective. Last, but not least, is the Intergovernmental Committee that is focussing its efforts on building networks of the regulated and regulator communities to help shape practical, yet effective, stormwater management programs, laws and regulations.

STATUS OF PLANNING PROJECTS

Project	Sponsor(s)	Consultant	Status
Thornton Criteria	Thornton	WRC Engineering	In Review by City
Adams Co. Criteria	Adams Co.	WRC Engineering	Adopted by County
City of Boulder Criteria	Boulder	WRC Engineering	Project Terminated
Westminster Criteria	Westminster	WRC Engineering	In Review by City
Denver Criteria	Denver	n/a	Moved to 1990
Bear & Mt Vernon Creeks	Morrison, Lakewood, Jefferson Co.	Muller Engineering	Completed in 1989
Cottonwood Creek	Arapahoe County	Environmental Consultants	90% Complete
Dry Creek (ADCO) - North	Thornton, Adams Co.	Wright Water Engineers,Inc.	80% Complete
54th & Pecos to S.Platte & Clear Cr.	Adams Co.	Hydro-Triad, Ltd.	Completed in 1989
First & Irondale	Adams Co., Aurora, Brighton, Denver, Commerce Cty.	Wright Water Engineers, Inc.	95% Complete
Second & Third Cr.	Adams Co., Aurora, Brighton, Denver, Commerce City	Kiowa Engineering Corporation	95% Complete
Leyden Dam Feasibility Study	Arvada & Farmers Highline Canal & Irrigation Co.	McCall, Ellingson & Morrill, Inc.	Terminated in 1989
Little Dry & Piney Cr. Stability Plan	Arapahoe County	Greenhorne & O'Mara	Completed in 1989
Beebe Draw	FRICO, Brighton, Adams Co.	Wright Water Engineers, Inc.	30% Complete
Jackass Gulch	Littleton	Centennial Engineering	40% Complete
Sable & Granby Update	Aurora	Kiowa Engineering Corporation	30% Complete
Moon Gulch	Jefferson Co., Arvada	n/a	Scheduled for 1989
Weaver Cr. Trib.	Jefferson Co.	n/a	Scheduled for 1990
Western Hill Outfalls	Adams County	n/a	Scheduled for 1990
Brighton Basin Update	Brighton & Adams County	n/a	Scheduled for 1990
Bullhead Gulch	Lafayette & Louisville	n/a	Scheduled for 1990
Lewis Cemetery Creek	Colo. Parks, Aurora, Arapahoe Co.	n/a	Scheduled for 1990
Happy Canyon Creek	E. Cherry Cr. Val. Douglas County & Arapahoe County	n/a	Scheduled for 1990
Columbine Basin Outfalls	Arvada & Wheat Ridge	n/a	Scheduled for 1990
Upper Lena Gulch Update	Jefferson Co., Lakewood, Golden	n/a	Scheduled for 1990

FLOOD PLAIN MANAGEMENT PROGRAM NOTES

by
Bill DeGroot, Chief
Flood Plain Management Program

FLOOD WARNING SYSTEMS

Development reviews continued at a low level of effort through most of 1989, although the number of referrals began to increase in the latter part of the year. We took the time which in past years had been spent on development reviews to make major strides in our flood warning efforts. Kevin Stewart was asigned to spend about 95% of his time developing warning plans, and designing and installing flood detection networks using the ALERT technology.

During 1989, the District worked with Arvada, Jefferson County, Denver and Aurora in the installation of three rain gauges, one weather station and 12 combination rain and stream gauges in four drainage basins. We also installed a repeater which will give us direct access to 53 gauges in Boulder County which we have not been able to receive directly in the past. We will also be installing three new gauging stations along the South Platte river which are funded by that program. Finally, as the year comes to an end, we are finalizing an agreement with Jefferson County, Lakewood and Morrison to expand the system into the Bear Creek basin.

COAL CREEK IMPLEMENTATION

In 1987 the District and Boulder County completed a unique type of master plan for Coal Creek and Rock Creek in Boulder County, Louisville, Lafayette and Broomfield. The flood plains are mostly undeveloped, and what makes the plan unique is that it identifies those undeveloped areas where special efforts will be expended to keep them as prime open space, rather than allowing them to be developed in the typical fashion of channelization or filling fringe areas.

In 1989 we began implementation of the plan in Louisville. The first small piece, a 3000 ft. length of gravel maintenance/recreation trail. was completed in November. Final design is underway on two road crossings and a railroad crossing. They will be under construction in early 1990.

ACQUISITION EFFORTS

As we go to press the District has two land acquisition deals pending using funds from the District's preservation fund. The first involves the purchase of two houses, which contain a total of six apartments, which are located in the Boulder Creek floodway in Boulder. The city and the District are providing matching funds to buy the houses. They will be removed and the land used as an extension of the Boulder Creek greenway. By next spring we should have six fewer apartments in the floodway.

The other acquisition involves an attempt to acquire right-of-way for a future channelization project on Little Dry Creek. The owner has mined the property and is refilling it with construction debris. We want to acquire the property before it is completely refilled, which would put us in the position of having to remove the construction debris in order to construct the channel. In this case the preservation fund will pay for 100% of the purchase price, and the District's Board has reserved the option of requiring the construction project to reimburse the preservation fund at the time of construction.

CONFERENCE COMES TO DENVER

The third annual conference of the Southwest Association of ALERT Systems (SAAS) will be coming to Denver the last week in September, 1990. SAAS is composed of local and regional government users of the ALERT technology for flood warning systems in the eight state area of Arizona, Arkansas, Colorado, Kansas, Louisiana, New Mexico, Oklahoma and Texas.

For more information contact Kevin Stewart at the District.

COUNTY AND W/S DISTRICT FORM PARTNERSHIP

by
Kevin G. Stewart, Project Engineer
Flood Plain Management Program

On March 24, 1988, Arapahoe County and the East Cherry Creek Valley Water and Sanitation District (ECCV) entered into an agreement which defines the roles and functions of each for providing storm drainage planning, facilities and services within the ECCV District. The Urban Drainage and Flood Control District (UDFCD) applauds this significant accomplishment and acknowledges the efforts of the many individuals involved with negotiating the various terms and conditions of the agreement. This agreement provides a model for other local governments interested in achieving similar levels of cooperation between entities having over-lapping jurisdictions. The partnership which has been formed between Arapahoe County and ECCV represents one of the most comprehensive and efficient approaches to addressing multi-jurisdictional drainage problems.

State statute has provided ECCV with certain authority concerning storm drainage. Since both Arapahoe County and UDFCD also have authority over storm drainage, the over-lapping responsibilities greatly complicated development approval processes within ECCV. It became apparent that significant benefits could be realized if the roles and responsibilities of each entity were better defined. In addition, ECCV took the initiative to conduct master drainage planning studies which were officially adopted by both the County and ECCV in 1986. The master plans set forth a regional system of detention facilities to be implemented by ECCV and developers.

The 1988 agreement evolved through ECCV's active interest in implementing the adopted master plans and participating in development review processes. Through this agreement, procedures have been streamlined and flood plain management has become an integral part of each entity's review. Flood plains are being regulated in a manner consistent both with Arapahoe County and UDFCD flood plain regulations. In addition, UDFCD's maintenance eligibility requirements are recognized and incorporated in the planning, design and construction of each new facility. ECCV has accepted the responsibility for ownership, design, construction and maintenance of the "regional storm drainage system." Arapahoe County has accepted responsibility for "local storm drainage" facilities and services as well as the administration of flood plain regulations. The two entities have also coordinated on issues such as phosphorus control, fee assessments and arbitration.

UDFCD has been involved with development reviews in this area for a number of years. The partnership recently formed between ECCV and Arapahoe County compliments UDFCD's program and reduces the time required to complete reviews. UDFCD would like to express its appreciation to ECCV and Arapahoe County for their efforts in making this cooperative venture a success.

DESIGN AND CONSTRUCTION NOTES

by
B. H. Hoffmaster
Chief, Design and Construction Program

The District's 5-Year Capital Improvement Program (Program) continues to provide strong guidance to the Design and Construction Program. Each year, beginning in about August, the Program is reviewed, adjustments are made and a list of new projects added. After review by the Board of Directors, a preliminary Program is sent to all local governments for comment. On receipt of comments from the local governments, the Program is again reviewed and adjusted. The Program is presented to the Board of Directors again for comment and a month later is adopted as the District's Design and Construction Program for the next five years.

The District develops this program with a large amount of input from the local governments. Further, as the Program is carried out, the local governments must finance at least 50% of the project. The District has been fortunate to have excellent cooperation and good working relationships with the local governments. Each has been most cooperative and works hard towards the completion of the Program that benefits their area. At times there is more than one local government involved in a project and this increases the coordination effort.

Following authorization and agreement between the District and local governments, the District typically engages an engineer to design the project and prepare construction drawings and specifications. It is the consulting engineers who do most of the work after the District and local government(s) have signed an agreement. The engineer frequently is later retained for the construction management and inspection. In some cases, though, the construction management and inspection of the contractor's work is done by the local government if they have the available resources.

The District only maintains a management staff for the Design and Construction Program. Staff consists of the Chief and a Project Engineer. They are supported by a part time student and the District's secretarial and accounting personnel. The Board of Directors' policy is that the District contract out for all design work and, if

STATUS OF DISTRICT DESIGN PROJECTS

Project	Participating Jurisdiction(s)	Status
Goldsmith Gulch	Denver	Prelim. Design on Hold
Cherry Cr. to Dartmouth		
Gunbarrel Area	Boulder County	Prelim. Design Complete
Hays Lake Outfall	Arvada	Complete
Ralston Cr. to Oberon Rd		
Lena Gulch		
20th Ave. to Youngfield	Lakewood	30% Complete
Isabell Crossing	Jefferson County	Started
Little Dry Creek (ADCO)	Adams County	95% Complete
Clear Cr. to Lowell		
South Jefferson County	Arapahoe County, Nevada Ditch Co., Last Chance Ditch Company, Littleton	80% Complete
Lakewood Gulch	Denver	Prelim. Design Started
Van Bibber Cr.	Arvada, Corps of Engineers	Feasibility 20% Complete
Lower Hoffman Drainage	Thornton, Adams County	Started
Coal Creek Improvements	Boulder County, Louisville, Lafayette	20% Complete
Slaughterhouse Gulch	Littleton	90% complete
Powers Park to Littleton Blvd.		
4 Square Mile-Basins 2 and 3	Arapahoe County	75% Complete
First Ave Trib. Phase 1B	Lakewood	Started
Mississiippi & Jason	Denver	
Phase II		Complete
Phase III		95% Complete
West/Gay Lake Channel	Broomfield	50% Complete
University/Mexico Phase V	Denver	95% Complete
I-25/35th Av. Phase II	Denver	85% Complete
Tucker Gulch	Golden	Started
Sloan Lake North Trib.	Edgewater, Wheat Ridge	Preliminary Complete
Louisville Drainageway B	Louisville	30% Complete

STATUS OF DISTRICT CONSTRUCTION PROJECTS

Project	Jurisdiction(s)	Cost	Status
Clear Creek at Pecos	Adams Co., CO Dept. of Hwys	$124,000	85% Complete
Lena Gulch	Wheat Ridge	$262,800	To Start
Schedule V			
Little Dry Cr (ADCO) D3	Westminster	$1,143,751	Complete
Little Dry Cr.(ARAP)	Englewood, Co Dept. of Hwys	$500,000	45% Complete
Santa Fe to Cinderella City			
Parker/Mexico	Arapahoe Co, Aurora	$1,536,900	95% Complete
South Jefferson County	Jefferson County	$60,000	Complete
Drainage- North Trib.			
Weir Gulch 1st Ave. Tributary			
Sch. III	Denver	$313,200	Started
Schedule 1A	Lakewood	$900,000	Complete
Westerly Creek Dam	Denver, Aurora,	$12,100,000	30% Complete
Lowry AFB	Corps of Engineers		
Hays Lake Outfall	Arvada	$645,000	99% Complete
Upper Sloan Lake	Lakewood, Denver	$517,000	90% Complete
Schedule IV			
Mississippi/Jason	Denver	$1,167,600	45% Complete
Schedule II			
Spring Creek at Phillips Ave.	Arapahoe County	$180,200	Started
Coal Creek Improvements	Boulder County, Louisville	$342,000	7% Complete

possible, the local government(s) administer construction contracts.

Design projects that the District has participated in during 1989 are listed in the accompanying table titled "Status of District Design Projects." Some of the more unusual projects are discussed below.

The District, after entering into an agreement with the City of Arvada, entered into an agreement with the Army Corps of Engineers for a Project Feasibility Study for Van Bibber Creek. The Corps will determine whether a feasible project, both from an engineering and economic point of view, is possible. The study is being conducted by the Corps out of their District office in Omaha, Nebraska. Completion of the study is scheduled for July, 1990. This is one of the first studies of its kind for the Corps in the District since the Westerly Creek Dam Feasibility Study years ago.

The Corps has completed reconnaissance studies of Dutch Creek and Ralston/Leyden Creeks. A determination has been made that a feasibility study for both projects would be worthwhile. The District and Arvada anticipate proceeding with the Corps for the Ralston/Leyden Creek Feasibility Study shortly after January 1, 1990.

Projects that were in construction during 1989 are listed in the table "Status of District Construction Projects." A few of the more interesting are discussed below.

Little Dry Creek (ADCO) Phase D3 in Westminster was completed along with a portion of Shaw Heights Tributary. With the completion of this phase, the main residential 100-year flood potential along Little Dry Creek in Westminster has been eliminated. There is now only a short reach between 76th Avenue and Sheridan, about 280 feet, that will be completed in the next few months. The only reach left in Westminster to complete is between Lowell and Osceola in an industrial area.

The Corps of Engineers began construction of Westerly Creek Dam on Lowry Air Force Base in July of 1989. The District is the Local Sponsor representing the District, Aurora and Denver. Completion of this project is scheduled for June, 1991. To date, the relocation work has been completed, the fill for the dam started and embankment drains installed. Also, storm drain improvements downstream in Lowry Air Force Base have been completed by Denver, Aurora and the District. The contractor for the $12 million project is Tarco, Inc. The completion of this project will greatly reduce potential for flooding between Lowry Air Force Base and Stapleton Airport.

Restricted right-of-way necessitated the use of a rectangular concrete channel for Little Dry Creek-Phase D3.

Weir Gulch 1st Ave. Tributary Schedule 1A includes a reach of grass-lined channel with a tricklechannel composed of rock sides and a concrete bottom.

The Hays Lake Outfall project was started this year. A storm drain from Ralston Creek through Oberon Road in Arvada has been constructed. This will provide an outlet for a new spillway for Oberon Dam. The State Engineer has declared the dam unsafe because it could be overtopped and breached. It is hoped that an agreement can be reached shortly with the Denver and Rio Grande Railroad, which uses the crest of the dam as a railroad bed, Oberon Ditch Company, Arvada and the District so that the project may be completed before the next flood season.

Construction is now underway on Little Dry Creek (ARAP) from Santa Fe Drive to Cinderella City. The work is being done through the Colorado Department of Highways as part of the Dartmouth-Santa Fe Highway Improvement Project. This work includes an energy dissipater at the Cinderella City Shopping Center culvert outlet and a grass lined channel that will be incorporated into an adjacent city park. Completion of this reach of channel culminates improvements which have been made over the past nine years to reduce flooding in Englewood along Little Dry Creek.

ASFPM Coming to Denver In 1991

The 15th annual conference of the Association of State Floodplain Managers will be held in Denver, at the Hyatt Regency Hotel, from June 10 to 13, 1991. The Colorado Water Conservation Board (CWCB) and the District are co-hosting the event. The Conference Director is Bill Stanton from the CWCB. Program chair is Eve Gruntfest from the University of Colorado at Colorado Springs.

MAINTENANCE PROGRAM ACTIVITIES

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

PROGRAM DIRECTION

The 1989 Maintenance Program budget was $6,273,818. This was the largest budget the Maintenance Program has ever had and was primarily due to several large projects that were carried over from 1988. With each passing year, maintenance projects become more complicated and require more coordination with local governments, neighborhood groups, and federal regulatory agencies. Increased coordination is essential for a well-managed effort, yet the result is an extended time frame for each project. Use of a recently-developed 3-year rehabilitation project schedule will allow us to improve our large-project coordination.

ROUTINE PROGRAM

The routine portion of the Maintenance Program continues to expand each year. Based on total expenditures the level of work for 1989 was about 8% above that of 1988 and 1988 was 14.7% above 1987. This is as expected since the primary components of routine work (mowing, debris pickup, and silt removal) are on-going activities and additional drainageways needing routine service are added to the program each year.

RESTORATION PROGRAM

The restoration program completed more work in 1989 than in any previous year. Over $1.5 million worth of work was done compared to previous years in which the level has typically been at $1 million. More than 60 projects were done under this program in 1989. Better project documentation improved our management and efficiency for the year. Restoration work continues to be an efficient and timely way to accomplish local erosion repair, detention pond mucking, and low flow channel realignment.

REHABILITATION PROGRAM

Thirty-four projects were at various levels of activity during 1989. Those projects which were actively designed or constructed during the year are described in the accompanying table titled "STATUS OF MAINTENANCE PROJECTS". We will spend about $2.75 million on design and construction of rehabilitative projects this year. In prior years we have averaged just over $2 million annually. As mentioned above, this expenditure is primarily due to the larger than typical fund balance from 1988. Some of the unique projects for 1989 are discussed below.

STATUS OF MAINTENANCE PROJECTS

Project	Jurisdiction(s)	Cost	Status
ADAMS COUNTY			
Big Dry Creek-	Westminster	design- $20,844	100%
Cotton Creek.Trib.		const- $150,000	0%
Grange Hall Creek	Northglenn	design- $55,000	95%
		const- $250,000	0%-phase 2
ARAPAHOE COUNTY			
Little Dry Creekk	Cherry Hills	design- $28,454	100%
Drop Structures	Village	const- $181,000	0%
Big Dry Creek	Arapahoe Co.	design-by other	100%
		const- $96,000	100%
W. Toll Gate Creek	Aurora	design- $86,458	100%
Alameda		const- $211,120	100%-sch 1
W. Toll Gate Creek	Aurora	design- $58,888	95%
Summer Valley Ranch		const- $422,000	0% phase 1
Willow Creek	Arapahoe Co.	design- $41,809	100%
Spring Creek Trib.		const- $180,000	0%
Cherry Creek	Arapahoe Co.	design- $32,400	60%
Iliff Drop		const- $279,000	0%
Lee Gulch	Littleton	design- $18,934	60%
		const- $217,000	0%
Piney Creek	Arapahoe Co.	design- $21,430	100%
Smokey Hill Detention		const- $77,678	40%
BOULDER COUNTY			
Fourmile Canyon Creek	Boulder Co.	design- $33,193	95%
		const- $235,000	0%
Wonderland Creek	Boulder	design- $68,238	100%
		const- $270,000	95%
DENVER COUNTY			
Cherry Creek	Denver	design- $56,650	100%
Bank protection		const- $343,000	0%
Cherry Creek	Denver	design- $62,128	85%
Drops structures (University)		const- $421,000	0%
Cherry Creek	Denver	design-by other	100%
Dartmouth Trib.		const- $52,188	100%
Goldsmith Gulch.	Denver	design- $27,863	100%
Tamarac Drive		const- $262,325	85%
Goldsmith Gulch	Denver	design- $15,400	85%
Trash Rack		const- $46,000	0%
Lakewood Gulch	Denver	design- $26,000	10%
		const- $250,000	0%
DOUGLAS COUNTY			
Tallman Gulch	Parker	design-by other	100%
East Trib.		const- $55,946	100%
JEFFERSON COUNTY			
McIntyre Gulch	Lakewood	design- $61,000	75%
South Branch A (Alameda)		const- $431,000	0%
Ralston Creek	Arvada	design- $42,096	90%
		const- $338,000	0% phase 1
Big Dry Creek	Westminster	design- $20,790	95%
Ketner Trib.		const- $195,000	0%
S.J.C.D. North	Jefferson Co.	design- $72,316	100%
		const- $220,000	100%
Dutch Creek	Jefferson Co.	design- $60,709	100%
		const- $272,924	100% Sch 1

Lee Gulch. A short but steep reach of Lee Gulch in the City of Littleton is currently being designed by J.F. Sato and Associates. The goal of this project is to arrest the erosion in this 660 foot long reach and to field test

(Continued on page 15)

South Platte River Program Notes

By
Ben Urbonas, Chief, and
Barbara Benik, Project Engineer,
South Platte River Program

Maintenance of South Platte River

This was another productive year for the South Platte River maintenance program. Our routine work included mowing and tree trimming along the trail, as well as debris and trash removal, from the South Platte Park boundary (at Brown's Ditch) on the south to Niver Creek (78th and Steele) on the north. Debris removal also was continued through the Cooley property north of 88th Avenue. One unique project by our routine maintenance crew involved dismantling an old railroad boxcar located in the floodway and within a critical wildlife habitat area of South Platte Park. This boxcar was part of the debris deposited by the 1965 flood. The Park's rangers assisted by backpacking the dismantled beams out of the area.

Restoration maintenance activities included drainage improvements and trail repairs in Denver; scour protection for a bridge in Commerce City; 700-feet of bank restoration and revegetation in Englewood; and 800-feet of bank restoration and a boulder "riffle type" grade control structure in Commerce City/Adams County.

Most of these restoration maintenance projects required 404 Permits. The General Permit we were issued in 1987 has greatly facilitated the 404 process. The average turnaround time under the General Permit has been less than ten days, with the longest period being fourteen days and the shortest six days.

Cooperative Activities

Previous issues of this newsletter have discussed the cooperative projects undertaken by the District with property owners. This year we successfully completed the Cooley Gravel Company, Albert R. Frei and Sons, Inc., and Esther Miller cooperative projects. We also executed two more cooperative agreements with Pershing Van Scoyk and with Mr. and Mrs. Edward Getz in Adams County. These two new cooperative agreements added about 10 acres of flood conveyance and maintenance easements dedicated to the District. The Van Scoyk project has been completed, and the Getz project will be completed by the end of this year.

Capital Improvement Activities

The Central Platte Valley preliminary design study we discussed in our last newsletter has been completed. The study calls for major flood control improvements that will remove the 100-year floodplain from this area and enable development and redevelopment of the area between 8th Avenue and Cherry Creek. It is likely that final design for portions of the recommended improvements will begin in Spring of 1990.

This year we began a project with Denver and Adams County to prepare a preliminary design of the South Platte River for an area known as "Globeville and Areas north." We expect this project to be completed in 1990. Just downstream of this reach there is a need for several grade control checks along the River. As a result, Adams County and the District are negotiating with the Colorado Highway Department to construct a check structure downstream of Highway 224.

The maintenance/recreational trial between 8th and 13th Avenues in Denver is badly deteriorated and in need of replacement. Denver and the District have funds set aside for this work and are waiting for the right-of-way issues to be resolved between Denver and the Burlington Northern Rail Road. We hope that construction can begin in 1990.

Typical bank erosion damage.

The restored bank at the Frei property.

Frei Cooperative Project Recognized

By
Barbara Benik
Project Engineer, South Platte River Program

Located across from the Adams County Regional Park north of 124th Avenue, the Albert R. Frei and Sons, Inc. (Frei) gravel pit has been one of the less-attractive sights on the South Platte River. At one time, mining activity included dredging along the river, and the banks had concrete rubble and debris dumped on them for erosion protection.

Last year, Frei and the District negotiated a cooperative agreement to clean up the banks, bury all exposed rubble, place riprap armoring over this rubble, construct two "riffle type" boulder check structures, and re-establish vegetation on the restored bank areas. Frei performed all of the construction. The District paid for the installation of the two check structures and for the cost of the rock used along the banks. Frei contributed the equipment and labor to reshape and restore the banks, and to place all topsoil and riprap.

The District followed up the construction by having one of its maintenance contractors plant golden willows, cottonwoods, yellow clematis, sandbar willows, and a mixture of native grasses over the project site. A temporary irrigation system was installed, with water supplied by the owner's water rights. This irrigation system really paid off during the record high temperatures in June and July. The plants on the Frei property have suffered very little compared to other non-irrigated sites this year, and the overall vegetation success on this site has been impressive. This site now presents an attractive view with stabilized slopes and the beginning of a cottonwood grove characteristic of the South Platte River. We wish to thank Al Frei and recognize his efforts and contribution toward this successful cooperative project.

URBAN DRAINAGE AND FLOOD CONTROL DISTRICT THE SECOND 10 YEARS

INTRODUCTION

July 1, 1989, marked the 20th birthday of the Urban Drainage and Flood Control District. During that time the District has gradually increased its capabilities, in a carefully planned manner, to a current staff level of 17 employees and 1989 expenditures of $12,043,200. The December, 1979, issue of *Flood Hazard News* contains a description of the origin and evolution of the District, for those readers who might be interested in how the District came to be. The purpose of this article is to look at changes which have ocurred over the last ten years, and to take a look at some unique and interesting District projects.

All District activities are carried out through one of its five programs: Master Planning, Flood Plain Management, Maintenance, Design and Construction, and South Platte River. Revenues are derived from four property tax mill levies. The District can levy a maximum of 0.1 mill for the general fund which includes office expense and support staff in addition to the Master Planning and Flood Plain Management Programs. The District can also levy maximums of 0.4 mill for each of the Design and Construction and Maintenance Programs; and 0.1 mill for the South Platte River Program (excluding the Boulder County part of the District).

SIGNIFICANT DEVELOPMENTS OF THE LAST 10 YEARS

Maintenance Program takes shape. The Maintenance Program was in its infancy in 1979, but has grown to be a vital part of the District's overall effort. The 1989 maintenance service expenditures were $4,798,200; and maintenance activities were provided in three categories of effort: routine, restoration and rehabilitation. Routine maintenance consists of mowing, weed control, debris pickup, silt removal, etc. Restoration activities require a higher level of effort and include projects like detention pond mucking, tree thinning, local erosion repair and revegetation. Rehabilitation projects are major construction projects meant to reclaim and rejuvenate existing facilities which are experiencing serious problems. Rehabilitation projects require engineering design and go through a bidding process on a project-by-project basis. Routine and restoration contractors are chosen annually through a selection process which considers unit costs, past experience and past performance.

Newest Program. The newest District program, the South Platte River Program, was authorized by the State Legislature in 1987. This program is involved in planning, design, construction and maintenance of projects along the South Platte River. The impetus for creating the program was the completion of a master plan for the 40 miles of river from Chatfield Dam to the downstream District boundary. That master plan is now being used to aid in decisions concerning construction and maintenance projects along the river.

Annexation. In 1989 the State Legislature added 408 square miles to the District's area to include newly developing areas in Denver, Adams and Arapahoe Counties around the proposed Denver International Airport, as well as in northern Douglas County. The District now covers an area of 1608 square miles.

New Board Members. At the same time the Legislature added a provision to the District's statute which gives each city with a population over 100,000 a seat on the Board of Directors. The immediate effect of the legislation was to give seats on the Board to Aurora and Lakewood. The Board now totals 17 members.

INTERESTING AND UNIQUE PROJECTS

The District has completed many drainage and flood control projects, and a number of them have had interest or value beyond their flood control benefit. Some of those projects are described below.

Boulder Creek Flood Warning. In 1977 the District, Boulder and Boulder County completed an investigation of flood warning alternatives for Boulder Creek. As a result of that investigation, the sponsors chose to install the ALERT technology (radio reporting rain and stream gages) in the Boulder Creek drainage basin. The District also decided to hire a private meteorological service (PMS) to provide forecasts of flood potential tailored to the District area.

Now,the District has completed its 11th year with a PMS, and the ALERT system has been expanded to three additional basins in Boulder County and six basins in Denver and surrounding suburban areas. A total of 49 gauging stations are now in place with 24 more planned for 1990.

As a side benefit, the Denver Water Board is using the rainfall data collected by the ALERT gages to assist them in developing their daily ET (evapotranspiration) ratings for their water conservation program. Similarly, the City of Aurora is using the rainfall data to schedule watering in its parks, and has projected significant savings using the data.

Cherry Creek. In 1977, Denver, Glendale, Arapahoe County and the District completed a master plan for Cherry Creek from the South Platte River to Cherry Creek Dam. Part of the plan called for the rehabilitation of the three mile reach of channel between the river and the Denver Country Club, which is contained between two vertical concrete retaining walls.

The rehabilitation, which included construction of a concrete maintenance trail in the walled section and a series of access ramps to the trail, was completed in 19xx. The trail has become perhaps the most heavily used recreational and commuting trail in the Denver Area, offering three miles of grade-separated trail.

Littles Creek/Littleton RR Depression. When the City of Littleton and the Colorado Department of Highways (CDOH) depressed the mainline railroad tracks through the city, the depression had to cross Littles Creek, and it also had to have a drainage system. Also, Littles Creek had been obliterated by development between the railroad corridor and the South Platte River.

Littleton, CDOH and the District joined forces to construct a flood control channel for Littles Creek which also was compatible with the depression. An enlarged channel was constructed from the South Platte to the downstream side of the railroad corridor, where a large, stepped drop structure was constructed. A triple box culvert was then constructed over the depression and connected to the top of the drop structure. Finally, a 48" reinforced concrete pipe was constructed under and adjacent to the channel until it could daylight into the channel to provide drainage for the depression.

The completed project allows trains to travel through Littleton without tying up traffic as they did in

the past, and the channel has taken a number of properties out of the flood plain. It has been an overall success.

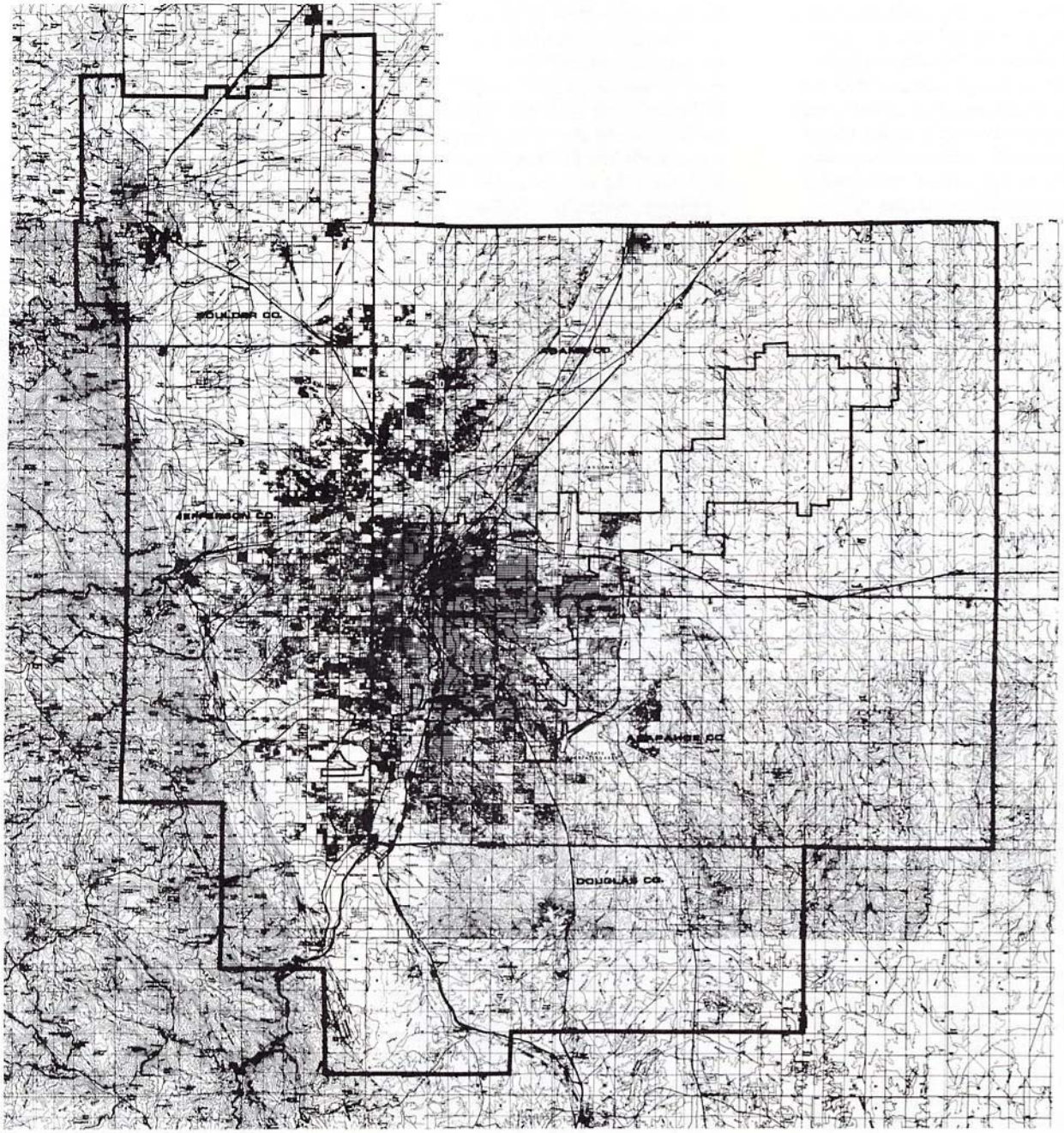
Central Platte River/Elitch's. Denver voters recently approved a bond issue of $14 million to provide infrastructure improvements which will open the Central Platte Valley to new development such as a relocated and expanded Elitch Gardens amusement park. The District and Denver have been developing the preliminary design of the needed flood control improvements. Elitch Gardens is viewed as the "killer amenity" necessary to start development of the Central Platte Valley.

Implementation of the preliminary design will provide a number of recreational and wildlife habitat opportunities as well as flood control. It will also improve boater safety at the existing boat chutes at Confluence Park and the Zuni power plant.

1st/2nd/3rd/Irondale Master Plans. Two District master planning projects (First Creek and Irondale Gulch and Second Creek and Third Creek) were begun fortuitously, at just the right time. The master planning process had just begun when the decision to build the new Denver International Airport in a large portion of the subject drainage basins was made. Because the studies were underway, and all the affected local governments were already involved, the drainage master planning for the airport and surrounding areas was handled much easier than it might have been. An earlier start on the master plans would have resulted in plans that no longer reflected the projected development in the basins, and a later start would have had us scrambling to catch up.

THE FUTURE

No one can predict the future, but, based on the requests for assistance the District continues to receive, it appears that the future will be both busy and rewarding.



The new District boundaries are shown on this map.

Tucker Talk *(from page 3)*
drainageway facilities as the new airport is constructed and associated development takes place.

The City of Parker, located in Douglas County in the southern part of the District, was incorporated after the Urban Drainage and Flood Control District was created in 1969. That incorporation and subsequent annexations have resulted in Parker being located partly in and partly out of the District. In addition, this area of Douglas County has been experiencing considerable development in recent years. It was felt that District support for drainage and flood control planning, construction, and maintenance assistance in these developing areas in Douglas County was needed.

Much of the annexed area, particularly in Arapahoe and Adams Counties, is undeveloped at this time. It will be important to provide good drainage and flood control planning and implementation as development takes place and construction of the new airport proceeds. The goal in areas impacted by new development will be to prevent development in the floodplains that can lead to potential flood damages in the future.

New Directors Added

The 1989 Colorado General Assembly also added a Director to the District's Board consisting of the Mayor or Mayor Pro-Tem of any city in the District with a population in excess of 100,000. The cities of Aurora and Lakewood have populations of approximately 225,000 and 125,000 respectively, and each of those cities are now represented on the Board. The total number of Directors on the Board was increased from 15 to 17.

The representation on the Board of Directors of a regional organization is important in terms of how it functions. This legislation will insure that two of the largest cities in the Denver metro area will always have representation on the Board.

Present makeup of the Board of Directors consists of the Mayor or Deputy Mayor of the City and County of Denver, three Denver City Council members appointed by the Denver Council; one County Commissioner from each of the five counties of Adams, Arapahoe, Boulder, Douglas and Jefferson, appointed by the respective Boards of County Commissioners; a mayor appointed from each of the counties of Boulder, Arapahoe, Jefferson, and Adams by the Governor; the Mayor or Mayor Pro-Tem of any city over 100,000 population, which now includes Aurora and Lakewood; and two professional engineers appointed by the other Board members. While seventeen is a fairly large number to have on a board, it is not unmanageable, and it does provide for balanced representation.

The District Response to proposed EPA Regulations for Municipal Stormwater Discharges.

Since 1985 I have commented each year on the proposed regulation of municipal separate storm sewer discharges. This year is no exception. In response to the 1987 Clean Water Act (CWA), the EPA published on December 7, 1988 proposed permit application regulations for stormwater discharge permits. The comment period was open until March 7, 1989. EPA received over 400 comments incorporating some 3000 pages. This was a high level of response and it indicated the concern over the impact of the proposed regulations. EPA has indicated they expect the final regulations to be promulgated by August 1990.

Considerable concern was expressed to EPA regarding the unrealistic requirements of their proposed two-part regulations and the inflexibility of the proposed regulations in some areas. The EPA is being pressured and even threatened to show no quarter in their regulatory requirements. Local governments, on the other hand, are pleading for reasonable and flexible requirements that can be implemented within an affordable cost framework. The regulations that will be promulgated by EPA will become the minimum requirements for state administered programs and the requirement in EPA regulated states.

The regulations that have been proposed by EPA include both good and bad features from a local government perspective. EPA has taken the common sense approach that end-of-pipe treatment in most cases is not appropriate for the urban storm sewer problem. Municipal storm sewer permits will not be like industrial discharge permits. One EPA official explained it this way: "These are not permits in a normal sense we expect them to be, these are actual programs. These are permits that go far beyond the normal permits we would issue for an industry because they in effect are programs for stormwater management that we would be writing into these permits."

EPA stated in the preamble to the proposed regulations that the basic approach being recommended is a shift from an end-of-pipe approach towards comprehensive stormwater quality management programs to reduce the discharge of pollutants from municipal separate storm sewer systems. In rationalizing this approach EPA noted that discharges from municipal storm sewers are highly intermittent and are usually characterized by very high flow rates occurring over relatively short time intervals. This results in a high number of storm sewer outfalls within a given municipality. Traditional end-of-pipe controls are limited by material management problems that arise with the high volume intermittent flows that typically occur. EPA also noted that municipal storm sewers tend to discharge runoff drained from land used for a wide variety of activities. Given the material management problems with end-of-pipe controls, management programs directed at pollutant sources are more practicable than relying on end-of-pipe controls. Another factor recognized by EPA is that water quality impacts from storm sewer discharges depend on a wide range of factors including the magnitude and duration of rainfall events, the time period between events, soil conditions, the percentage of land that is impervious to rainfall, land use activities, the presence of non-stormwater connections, and the ratio of stormwater discharge to receiving water flow. EPA stated that in enacting the 1987 Clean Water Act Congress recognized that permit requirements for municipal stormwaters should be developed in a flexible manner to allow site specific conditions to reflect the wide range of impacts that can be associated with these discharges.

Consistent with the intent of Congress, EPA has stated their goal to develop permit application requirements that are sufficiently flexible to allow the development of site specific permit conditions. This approach is important to local governments in that management programs can be developed that recognize particular characteristics of each local government and region. EPA's thrust in their proposed regulations is to force the development of stormwater quality management plans and programs in the urban areas of the United States. The management plans can be tailored according to local situations.

Unfortunately, the application requirements as proposed by EPA will be difficult, if not impossible, to accomplish in the two year permit application period. Areas of particular concern are the field screening analysis and characterization plan requirements in Part 1 and the characterization data, proposed management plans (for residential, commercial, and industrial activities), assessment of controls, and fiscal analysis required in Part 2. The requirements as written will result in hurriedly collected and compiled sampling data of questionable usefulness, and there will be little time to prepare well-documented and meaningful estimates of loads. Management plans will have to be quickly thrown together instead of receiving the needed thinking and varied input at the local level that such plans deserve. It is unrealistic to think that legislative changes at the state level can occur within the two year time frame of the proposed two part application period.

The Urban Drainage and Flood Control District supported the proposal of the National Association of Flood and Stormwater Management Agencies (NAFSMA) that recommended a one-part application process be substituted for EPA's two-part proposal. The suggested one-part process recognized the futility of attempting to develop all the information, legal authority and quality data within the two-part, two-year application period proposed by EPA. The NAFSMA proposal recommended that the application period be reduced to 18 months, requiring initial system identification work to take place during the application period, with monitoring, planning and characterization assessment to take place on an agreed-upon schedule during compliance. A one-part application, followed by compliance activities as outlined in the NAFSMA proposal, would result in a more orderly development of stormwater management programs while allowing for quick implementation of efforts to eliminate illicit discharges and initiation of proven best management practices. Allowing for this orderly development of programs will save time in the long run and will be more cost effective. The proposed 18-month one-part application process would not eliminate any of EPA's required work items, but only rearrange them. Also permits could be more easily administered and quickly issued because permit requirements would be reduced. An important aspect of the NAFSMA proposal is that urban stormwater management program development that EPA is trying to encourage can be more readily adapted to local conditions because the sequence of events will allow a building block approach.

Whether or not EPA modifies the final regulations to incorporate a one-part application process remains to be seen. In any event, local governments must start thinking in terms of responding to the permit requirements. Regardless of how the final regulations turn out, many cities will soon be required to initiate the permit application process. EPA's regulations as proposed will initially apply only to municipalities in excess of 100,000 people, but the 1987 Clean Water Act requires that regulations also be adopted for other municipal storm sewer discharges by October of 1992. Smaller cities and unincorporated urban areas will follow close behind the larger cities.

Local governments should be preparing themselves for the application process. Items that can be initiated at this time are identification of the drainage system, drainage basins, outfall points, storm sewer sizes, location of industrial facilities, and location of landfill sites; delineation of the various land uses; and definition of any on-going activities that would tend to reduce the pollutants in stormwater discharges. Local governments should start the process of educating their upper management, city councils, and county commissioners on the upcoming requirements for stormwater discharge permits. It is only a matter of time and the attitude should be how to most efficiently and effectively respond to the permit requirements.

NWS,DISTRICT TO TEST MODERNIZATION PLAN

Officials from the National Weather Service (NWS) Headquarters in Silver Spring, Maryland have agreed in concept to cooperatively fund a pilot project with the District to test and evaluate the capabilities of their Advanced Weather Interactive Processing System for the 1990's (AWIPS-90). The prototype for the AWIPS-90 hydro-meteorological workstation is being developed at the National Oceanic and Atmospheric Administration's Environmental Research Labs in Boulder, Colorado. This forecaster operated workstation employs the use of the most advanced weather data sources available including hydrological and meteorological models, sophisticated Doppler weather radars, vertical wind profilers, automated surface observing systems, a variety of satellite-based products and other tools.

In addition to involving local governments in an operational test of the new AWIPS-90 technology, the existing communications infrastructure of the District's Flash Flood Prediction Program (F2P2) will provide an initial framework to further improve dissemination capabilities. The F2P2 has just completed eleven years of successful operation providing direct meteorological support to Denver area emergency managers, thus making this program a logical starting point for evaluating both new and existing forecast products.

Through this cooperative effort, two-way communications will be enhanced for exchanging weather-related information between the NWS, the District, state disaster officials and emergency managers and response organizations from 35 local governments within the Denver Metropolitan Area. This project will represent one of the first operational tests of the NWS's proposed one billion dollar nation-wide modernization plan.

By including the emergency management community in this project, a government-helping-government approach can be demonstrated as a national prototype and a forum will be provided for addressing policy issues, implementation strategies and dissemination procedures. Through this process, the NWS modernization plan and the AWIPS-90 operations concept will undergo a strategic test with the evaluators being those individuals responsible for making critical decisions when life-threatening weather conditions occur.

DISTRICT HONORED

The District was honored for cooperative and financial help in the development of drainageways in the South Suburban Park and Recreation District at the Park Board's public meeting on July 12. The District was cited for joint projects which have been very successful in providing attractive and safe trail corridors and other areas of open space which have recreational value and are designed to remain free from flood damage for the citizens of the two overlapping districts.

Incipient Runoff Value of Rainfall in the Denver Region

by

Paula W. Makar, Student Intern
and
Ben Urbonas, Chief, Master Planning Program

INTRODUCTION

Between rainfall and runoff on any urban catchment, a series of losses occurs, including evaporation, evapotranspiration, interception, depression storage, and infiltration. Many investigators, including Tholin and Kiefer (1959), Schomaker (1966), Holtan (1961), Viessman (1967), Hicks (1944), Turner (1967), Urban Drainage and Flood Control District (1982) and others have reported how to approximate these losses when estimating the portion of rainfall which becomes surface runoff. As we began to investigate the potential runoff using an entire record of continuous rain gages, it became apparent that it was not clear at what rainfall depth surface runoff actually became measurable.

An investigation was conducted to gain insight into the rainfall depth at which incipient surface runoff occurs in urban watersheds in this semi-arid region. Data was used from the following three urban watersheds in the Denver region: 1) Harvard Gulch, located in south Denver; 2) a tributary to Irondale Gulch, located in north Denver; 3) a tributary to Sanderson Gulch located in Lakewood. Simultaneous rainfall and runoff data were collected by the U.S. Geological Survey during 1988 and provided the basis for the investigation.

Harvard Gulch is a fully urbanized watershed with a basin area of 3.08 square miles. A mix of residential and commercial land uses and soils of SCS type B results in an average imperviousness of 39%. The time of concentration is 105 minutes. There is a rainfall/runoff gage located at the mouth of the watershed and four auxiliary rainfall gages are located throughout the basin.

Sanderson Gulch tributary is a completely developed residential watershed with an average imperviousness of 44%. The 0.38 square mile basin has type B soils and a time of concentration of 39 minutes. The rainfall/runoff gage is located at the basin mouth and an auxiliary rainfall gage is immediately west of the basin.

The watershed for the Irondale Gulch tributary has had changing land uses. In 1988 the upper half of the basin was undeveloped with the exception of a small group of farm buildings and does not contribute runoff from the smaller storms important to this study. The lower half is fully developed residential with an average imperviousness of 40% and time of concentration of 69 minutes. The soils are type B. The rainfall/runoff gage is located at the basin mouth and an auxiliary rainfall gage is located immediately north of the basin.

The pervious areas within all three basins (excluding the upper portion of the tributary to Irondale Gulch) are irrigated on a regular basis. As a result, it was safe to assume that the irrigated portions do not accumulate a significant moisture deficit.

INVESTIGATION OF FINDINGS

Each basin was analyzed separately. The data were collected continuously in five minute increments and later checked for synchronism between the gages within each basin. The continuous data were separated into individual storms by checking for periods without rainfall. Trial separation periods of one hour, three hours, six hours, and 24 hours without rainfall were used, resulting in four sets of storm data for each watershed. Runoff was assigned to a particular storm if it occurred after the start of that storm and before the start of the next storm. Base flow was defined as the average of the stream flow before and after the storm runoff, which was subtracted from each runoff increment to determine storm generated surface runoff.

An example of the pattern observed in the rate of runoff as a function of rainfall is shown in Figure 1. Harvard Gulch and Irondale Gulch tributary exhibited the clearest pattern. The Sanderson Gulch data did not present such a clear pattern. There were ten events which deviate from the pattern observed at the other two watersheds. After studying all known factors, it was possible to explain the occurrence of runoff from low rainfall for all but two of the storms.

As a result, these two events were not used at this time in evaluating the incipience of runoff for the Sanderson Gulch tributary. The data scatter in the Sanderson Gulch watershed also suggests that some rainfall contributing to runoff from the basin may not be represented reliably by the rainfall recorded at the two gages.

FIGURE 1. HARVARD GULCH

1988 – 6 HR STORM SEPARATION

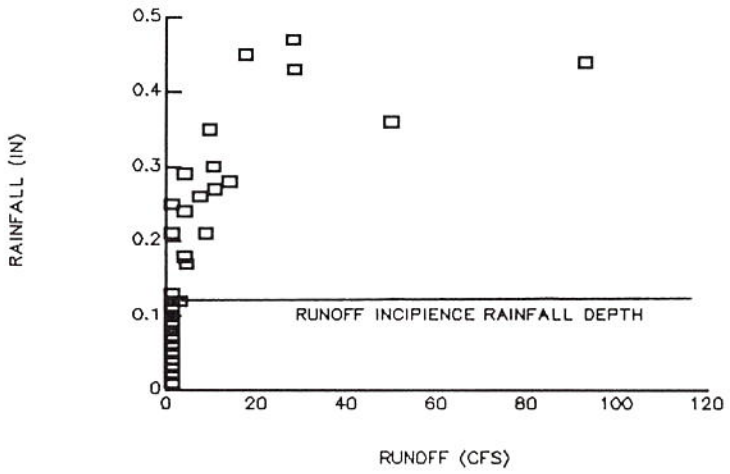


Table 1. NUMBER OF STORMS (1988)			
	HARVARD GULCH	SANDERSON GULCH	IRONDALE GULCH
ALL STORMS	193	112	71
RAINFALL ≥ 0.1 INCH	29	29	26

CONCLUSIONS

Runoff was measurable in the Harvard Gulch watershed for rainfalls of 0.12 inches or more. Irondale Gulch tributary required at least 0.11 inches of rain to start runoff. The rainfall required for runoff incipience in the Sanderson Gulch basin was 0.06 inches. The average of the three incipience levels is 0.10 inches. When a minimum rainfall of 0.10 inches is used to delete storms from the record for data analysis, the number of storms to be analyzed is reduced by at least 60% as shown in Table 1.

The use of a minimum rainfall to filter the storms for rainfall/runoff research can decrease the amount of data analysis very significantly. We are continuing this investigation and hope to add data from other years which will help solidify conclusions on runoff incipience levels.

Raft the Platte

On July 21, 1989, 109 hardy souls ventured forth in rafts on the District's fifth annual "Raft the Platte" tour. The objective of the trip is to familiarize elected and appointed officials with different reaches of the river and the types of problems and opportunities that exist along the river.

This year the rafters put in at Grant Frontier Park upstream of Evans Ave. at about 1:30 and finished at Confluence Park at about 6:30. The afternoon was topped off with a buffet supper at Zang Brewing Company, hosted by the City and County of Denver, Littleton, Englewood, and the District.

Traveling through the boat chute at the Florida Ave. dam.

Maintenance *(from page 8)*

several soil reinforcement grids/blankets and precast interlocking concrete products for erosion control effectiveness and durability. Hydro Dynamics, Inc is providing technical consulting for the field test activities. Construction should be in early 1990. South Suburban Parks and Recreation District will participate in the construction of this project.

Cherry Creek. Rapid degradation of the Cherry Creek channel bottom in southeastern Denver has exposed a 24 inch water main which crosses the creek at Iliff Avenue. Four feet of degradation led to the failure of the sheet pile drop structure which was protecting the water line. The erosion continued upstream and eroded around the Iliff Avenue bridge piers and undermined several storm sewer outlets. The District, Arapahoe County, and The East Cherry Creek Water District are cooperating on building a new drop structure with construction expected in early 1990.

McIntyre Gulch. Paralleling Alameda Parkway in Lakewood is a reach of McIntyre Gulch that is sandwiched between the parkway and a frontage road. The overall grade varies from 3% to 4% with more than 70 feet of elevation loss in a reach length of 1900 feet. The design approach of using drop structures and stable open channel between the drops resulted in a preliminary design which called for more than 20 drop structures each being three feet high. The design was limited to small drop structures becuase of safety and floodplain considerations. With the given constraints the construction cost to replace the existing deteriorated structures would have been prohibitive. We are now re-evaluating the design and are considering a pipe and swale system or a fully hard-lined installation.

Fourmile Creek. This creek is in an undeveloped natural condition with the exception of two existing drop structures. The drops need to be replaced but the rest of the channel is to be left as natural as possible. Boulders and a minimum of concrete will be used for the drop structures. Some tree removal will be done, yet at the same time bio-technical erosion control techniques will make use of native plant materials to stabilize the channel between the drops. We are coordinating closely with open space and trail planning representatives for this project on the north side of Boulder, Colorado.

Wonderland Creek. This project was completed in November, 1989 and is a unique Maintenance Program effort in its application of a low flow channel made up of a wetland bottom with vertical concrete sides. An article detailing this project can be found elsewhere in this issue of *Flood Hazard News*.

Concrete bottom trickle channel at Middle Branch Hylands Creek.

SOFT BOTTOM LOW FLOW CHANNEL

by
Paul A. Hindman
Project Engineer, Maintenance Program

The District's Maintenance Program was established to assist Denver area local governments in maintaining their major drainageways in the condition to which they were originally designed, or to improve them to current engineering standards. The City of Boulder requested such assistance on Wonderland Creek which has a basin area of approximately 1.35 square miles and a 100-year discharge of 1190 cubic feet per second (cfs). The reach of drainageway which required improvements is approximately 1350 lineal feet and is contained within a highly developed residential greenbelt area. The thalweg was heavily overgrown with cattails which the local maintenance crews complained were growing in the area from year to year. In the past the District's solution to this problem would have been to install a hardlined trickle channel to pass the minor discharges. Because of the environmental concerns and the increased awareness of non-point pollution, a concrete bottom was not desirable in this situation.

With the assistance of Love and Associates, Inc., a design was developed which satisfied all the engineering aspects of the project as well as environmental concerns. In general, the design consists of three boulder drop structures and an eight foot wide trickle channel, which contains 3% of the 100-year discharge. The vertical sidewalls are sandblasted concrete with a soil/cattail bottom (see Figure 1). The boulder drops are a semi-circular design that have a concrete stilling basin with rock cobbles imbedded into the surface. The grade of the trickle channel was designed at 0.30% to 0.62%. With this grade the velocity in the channel is only 3 feet per second during the design storm of 35 cfs. The Manning's "n" for the trickle channel was .054.

To accelerate the cattail growth following construction the bottom of the channel was replaced with the original organic material. In the future it is anticipated that the cattails will retain a portion of the sediment flowing downstream. Because of this, brass monuments which designate the amount of allowable aggradation of the channel bottom were installed at several locations along the channel on top of the concrete walls.

It is the District's hope that it will only be necessary to remove this sediment once every five years. This is an estimate based on our past experience with other drainageways. When it is necessary to remove the sediment, a small Bobcat or similar machine will be used. The maintenance/bike path was designed to be only three feet from the trickle channel to allow a maintenance truck to be close enough to the channel to be easily loaded by the Bobcat.

The project cost was $228,000 for construction with about $20,000 of additional landscaping. The unit cost was approximately $185 per foot. The construction did include a 10 foot wide maintenance/bike path. As a comparison, the District recently completed a similar project that had a concrete trickle channel instead of a soft bottom. The unit cost for that project was $155 per foot. The construction time needed to complete the project was 90 days which is equal to other trickle channel projects.

Future maintenance costs will have to be determined, but all of the project sponsors, as well as the local citizens, are optimistic that this type of channel improvement is appropriate for this type of location.

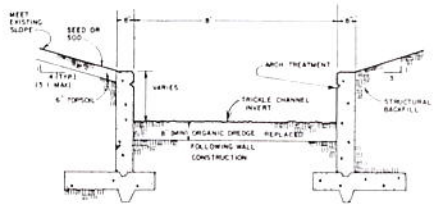


Figure 1. Cross section of the low flow channel design.

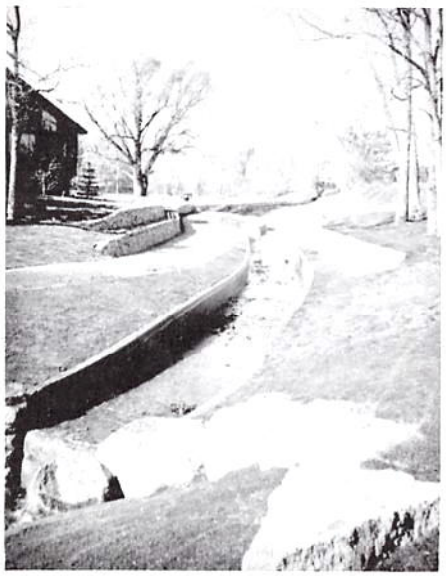


Figure 2. The low flow channel as it existed shortly after construction.

MEET THE NEW BOARD MEMBERS

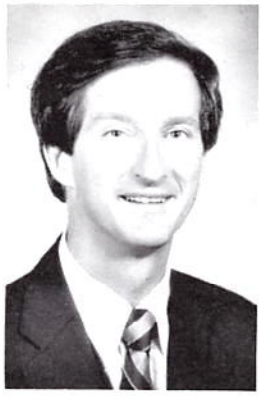
KATHY STAPLETON

Mayor Pro-Tem, City of Lakewood

Kathy Stapleton was recently elected Mayor Pro-Tem and assumed one of the newly created positions on the District Board. She has been a member of the Lakewood Board of Adjustment for nine years.

Kathy is seniorRide Coordinator at the Regional Transportation District, a service she created. She is the recipient of the "1987 Outstanding Service Award" from the Colorado Gerontological Society.

Kathy and her husband John have five children. She is active in community and church activities.



STEVE HOGAN

Mayor Pro-Tem, City of Aurora

Steve Hogan is a two-term member of the Aurora City Council, and is currently Mayor Pro-Tem. As such he has assumed one of the newly created positions on the District Board.

Steve served as a State Representative in 1975-76, and later ran for the U. S. Congress. He is self-employed and currently assisting in fundraising for Boys Club of Metro Denver. His past experience includes advertising manager for a large industrial supply firm and a program manager in the Governor's office.

Steve received a B. A. in 1970 from the University of Denver.

Capture Volume *(from page 1)*
capture envelope line represent individual storms that have sufficient runoff to exceed the available storage volume (i.e., brim-full volume) of the detention facility. A software package was developed to perform this analysis and to report the results after testing a variety of capture volumes.

in which, P_r = relative pond size normalized to P_m,
P = pond size being tested
P_m = maximum runoff volume (i.e., 99.9% probability).

The search for the point of diminishing returns, sometimes called "maximized point," incrementally increases the relative (i.e., normalized)

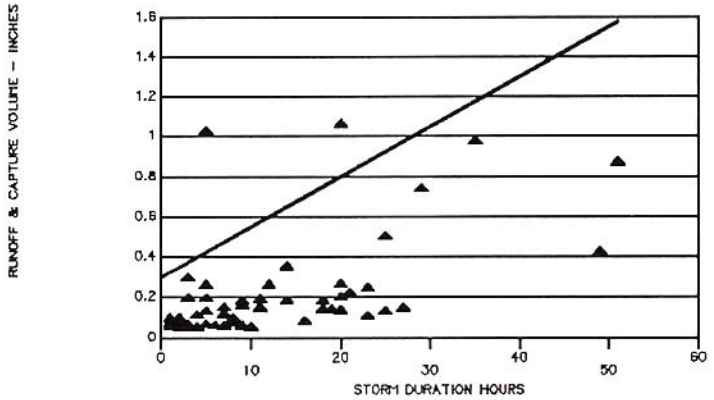


Figure 1. Runoff Volume Point Diagram and Capture Volume Envelope. (1-inch = 24.5 millimeters)

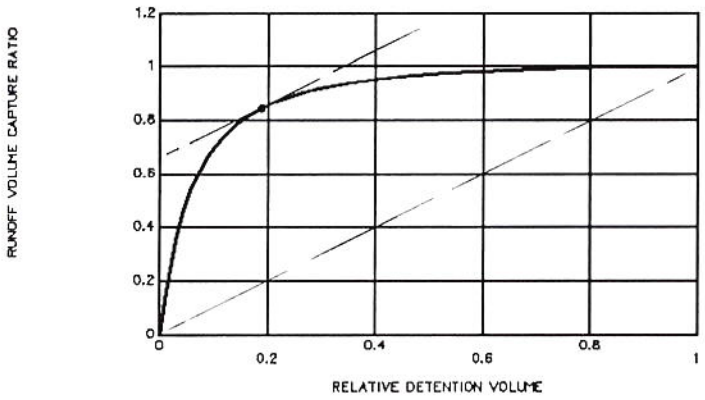


Figure 2. Maximizing Capture Volume.

For the storm events in a given record there is a capture volume that will intercept all runoff within the record. For practical reasons this maximum pond volume, P_m, was defined to be equal to the 99.9 percent probability runoff event volume for the period of record. For the Denver rain gauge period of record studied (1944-1984), P_m is equal to the runoff from 3.04 inches of precipitation, or 6.9 times the precipitation of an average runoff producing storm for this same period of record. This value of P_m was then used to normalize all pond sizes being tested using the following equation:

$$P_r = P / P_m \qquad (1)$$

pond size and calculates runoff volume and the number of events. Figure 2 illustrates an example of the results of such an analysis for the following conditions: storm separation criteria is 6-hours, emptying time for the brim-full basin is 12-hours, and the runoff coefficient for the watershed is C = 0.5.

The maximized pond size occurs where the 1:1 slope is tangent to the runoff capture rate function. Before this point is reached the capture rate increases faster than the relative capture volume size. After this point is reached the increases in the capture rate become less than corresponding increases in relative capture volume size. In other words, when the point of maximization is passed, diminishing returns are experienced if the capture volume is increased any further. In Figure 2 example, the maximized point occurs when the relative capture volume is equal to 0.18, which converts to 0.27 watershed inches.

A statistical summary of rainfall characteristics for all storms that exceeded a total of 0.1 inch at the Denver Rain Gauge is given in Table 1. A 0.1 inch "filter" was used to eliminate from the record the very small storms, which are not likely to produce runoff (see "Incipient Runoff Value of Rainfall in the Denver Region" in this issue of *Flood Hazard News* concerning the point of incipient runoff in the Denver area).

You can see from this summary that the rainfall exhibits a skewed statistical distribution. More than two-thirds of the storms have less precipitation than the average storm. Apparently in the Denver area the average runoff producing rain storm depth is a relatively large event.

Once the precipitation and runoff probabilities were understood, an attempt was made to find a simple yet reasonably accurate, relationship for approximating the maximized capture volume for water quality facilities. The final result for the Denver rain gauge data is illustrated in Figure 3. This figure relates the maximized capture volume to the watershed's runoff coefficient. Separate relationships are shown for the brim-full storage volume emptying time of 12-, 24- and 40-hours.

The capture volume found using these curves will result in 86 percent of all runoff events being totally captured and processed by the facility. It is the frequency of the shock loads that has the greatest negative effect on the aquatic life in the receiving streams. On the other hand, the very few large storms in the record are responsible for all of the flooding damages. Even during these larger events some degree of capture and treatment occurs, even though it may be at somewhat reduced efficiency.

SENSITIVITY OF PROCEDURE

An attempt was made to test the sensitivity of the capture volume as a surcharge above a permanent pool level on the removal rates of total suspended solids. For lack of local data on sediment settling velocities, the data given by EPA (1986) were use for several capture volume sizes. Estimates were made of the dynamic removals during the runoff events and

TABLE 1. Denver Rain Gauge Hourly Data Summary For Storms Larger Than 0.1 Inches In Depth

Separation Basis For New Storm (Hours)	Number of Storms	Average Depth (Inches)	Average Storm Duration (Hours)	Average Time Between Storms (Hours)	Percent of Storms Smaller Than Average
1	1131	0.39	7	267	70.9
3	1091	0.42	9	275	71.7
6	1084	0.44	11	275	70.7
12	1056	0.46	14	280	70.8
24	983	0.51	23	293	69.8
48	876	0.58	43	310	70.0

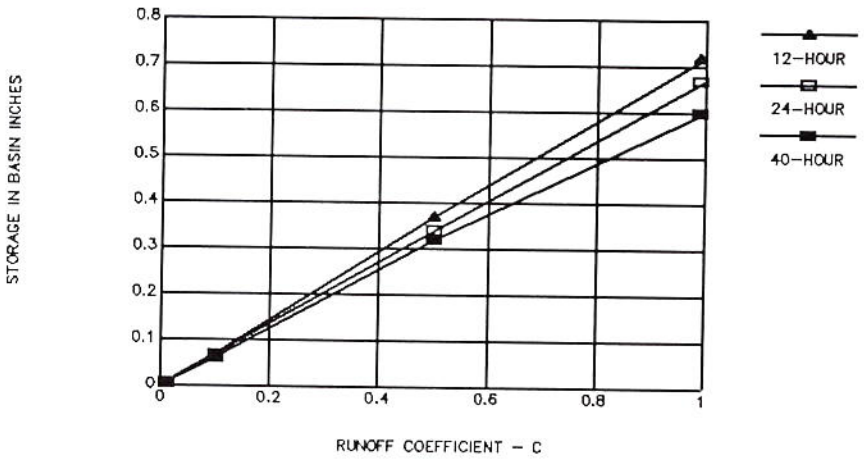


Figure 3. Maximized Capture Volume for Water Quality, Denver Rain Gauge 1944-84 Period.

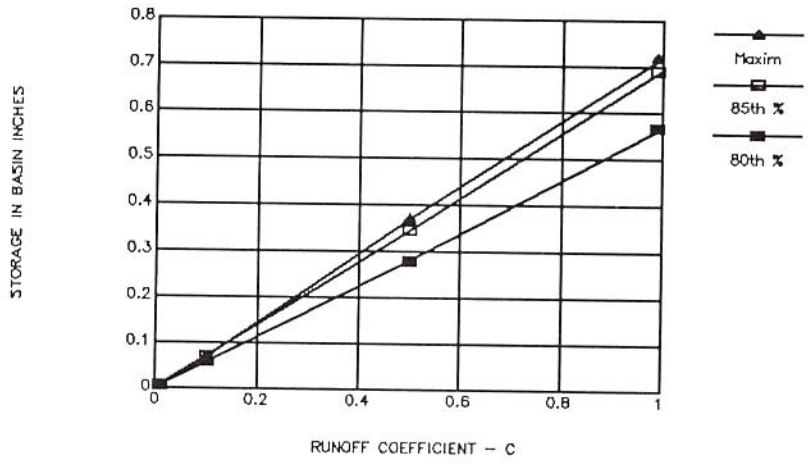


Figure 4. Surcharge Volumes for a 12-hour Drain Time and Several Runoff Event Capture Probabilities - Wet Pond.

the quiescent removals in the pond between storms.

Using a capture volume equal to 70 percent of the maximized volume, the annual removal of TSS was estimated at 86 percent. This compares to an estimated rate of 88 percent annual removal of TSS when using the maximized capture volume, and to a 90 percent removal rate when using twice the maximized volume. In other words, the removal efficiencies are very insensitive to increasing the capture volume beyond the capture of a 70th percentile runoff event.

It thus appears possible to use a lesser capture volume above the wet detention pond water surface than the maximized volume and have virtually no effect on the TSS removal efficiency. Currently we suggest that the design volume could be based on the capture of an 80th percentile runoff event instead of the maximized volume. Obviously this suggestion needs further testing. In the meantime, Figure 4 may be used to size the surcharge capture volume for ponds with permanent pools of water and Figure 5 may be used to size a capture volume for a detention facility that drains completely.

On the other hand, if the removal of dissolved nutrients, such as phosphorous or nitrates, is desired, the designer has to consider using wet ponds or a marsh. Biologic activity is responsible for the removal of dissolved constituents. The effectiveness of these processes is primarily the function of residence time within the permanent water pool. Increasing the capture volume above this pool will have little effect on the removal efficiencies of dissolved compounds. On the other hand, dry ponds have little effect on the removal of dissolved materials, since their primary removal mechanism is sedimentation (Grizzard, et. al., 1986; Schueler, 1987; Roesner, et. al., 1988; Stahre and Urbonas, 1988).

DETERMINATION OF RUNOFF COEFFICIENT

In 1982 EPA published data as part of the NURP study on rainfall depth vs. runoff volume. Although EPA did acknowledge some regional differences, much of the United States was found to be well represented by the data plotted in Figure 6. The

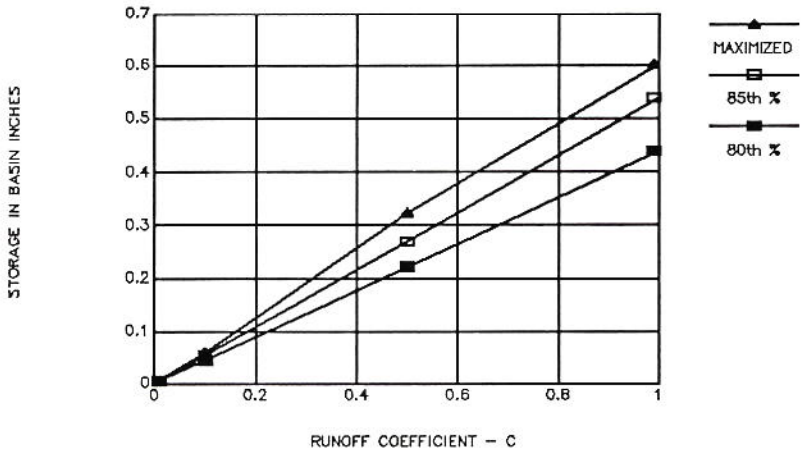


Figure 5. Capture Volumes for a 40-hour Drain Time and Several Runoff Event Capture Probabilities - Dry Detention Facility.

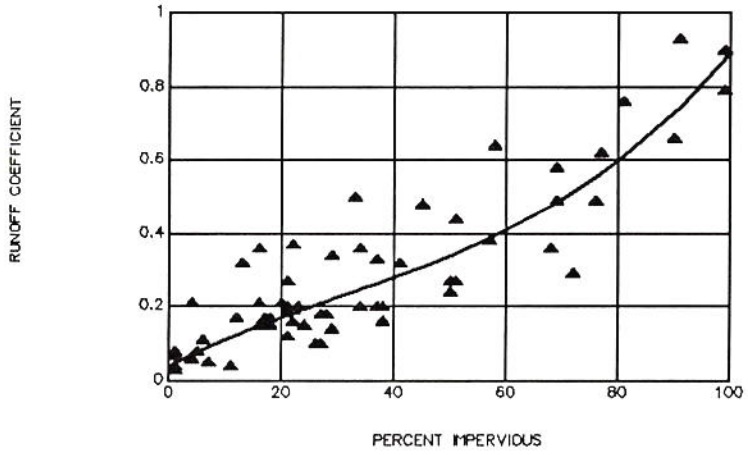


Figure 6. Runoff Coefficient Based on NURP Data for 2-year and Smaller Storms.

curve in this figure is a third order regressed polynomial with the regression coefficient $R^2 = 0.79$. This value of R^2 implies a reasonably strong correlation between the watershed imperviousness, I, in percent and the runoff coefficient, C, for the range of data collected by EPA. Since the NURP study covered only two year period, in our opinion this relationship is justified for 2-year recurrence probability and smaller storms.

CONCLUSIONS

An investigation of sizing stormwater quality facilities for maximized capture of stormwater runoff events and their performance in removing settleable pollutants revealed that simplified design guidelines are possible. These guidelines can be developed using local or regional rain gauge records. Preliminary suggestions for such guidelines are illustrated in Figures 4 and 5 for the Denver area and areas having similar rain and snow storm patterns.

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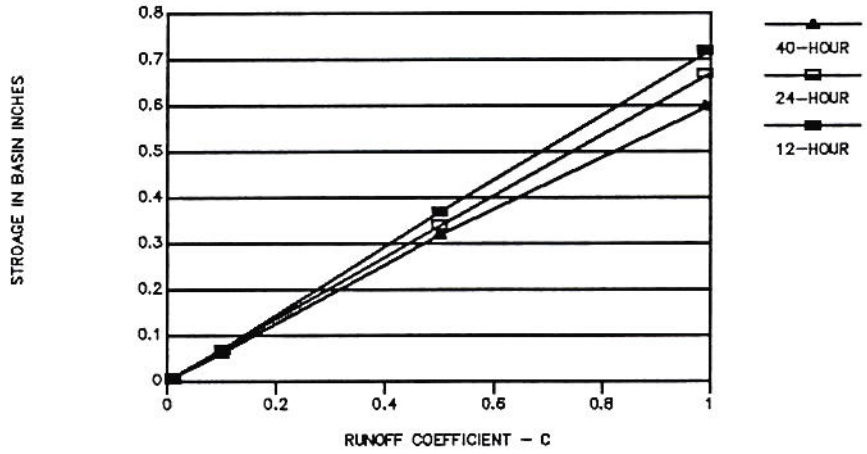
This article is a condensation of a paper presented at an Engineering Foundation Conference in Davos, Switzerland, in October, 1989. The full paper will be printed in conference proceedings to be published by the American Society of Civil Engineers in 1990.



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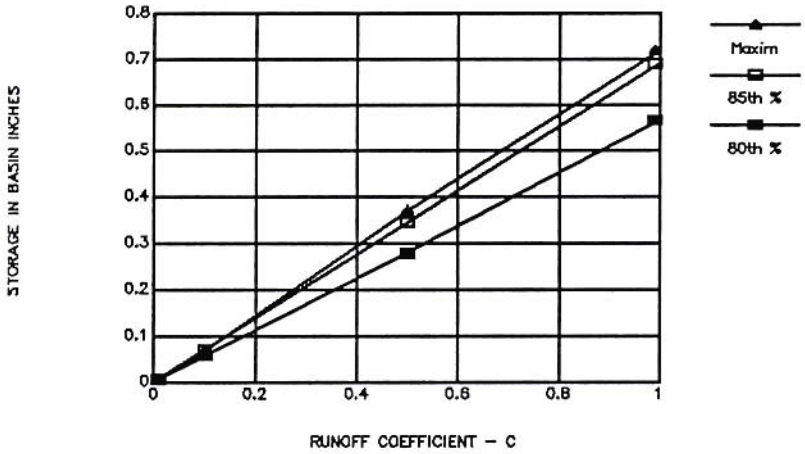

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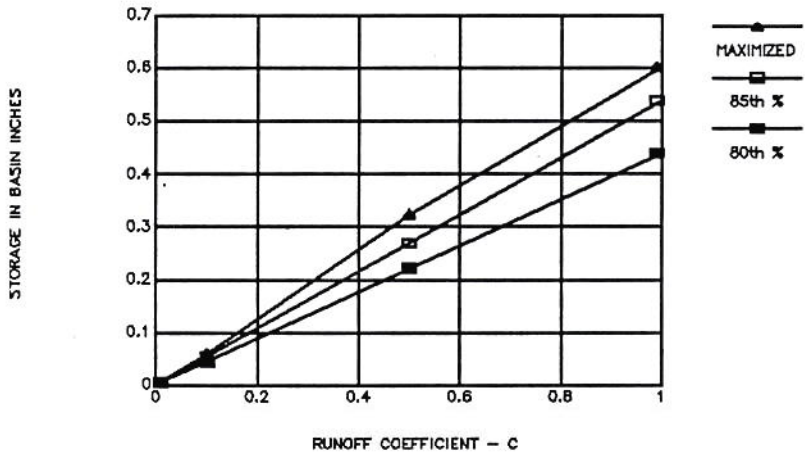

Figure 5. Capture Volumes for a 12-hour Drain Time and Several Runoff Event Capture Probabilities - Wet Pond.

MEET THE NEW BOARD MEMBERS

JOHN J. NICHOLL

Commisioner, Arapahoe County

John Nicholl is really not a new Board Member, having previously served on the Board for 11 years, including five as Chairman. He rejoined the Board earlier this year after an eight year absence.

John is a Colorado Registered Land Surveyor, and has served as manager, owner and operator of Arapahoe Surveys at different times. He is a member of the Board of Directors of First Federal Savings Bank of Colorado, a member of the 18th Judicial District Victim Compensation Board, and Chairman of the 6th Congressional District Artistic Discovery Art Council.

He has been active in the Republican Party since 1962. He is serving his fifth term as County Commissioner, where he serves as Finance Officer, and coordinator of Highways/Transportation and Road and Bridge, Planning, Building and Public Safety.

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