



FLOOD HAZARD NEWS

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DETENTION IN PARKS AND OPEN SPACE - GOOD, BAD AND UGLY

by

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and

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Introduction

Local governments are facing increasing demands for services (including parks, open space, recreation, drainage, flood control); increasing mandates from federal and state governments (including NPDES and 404 permits); and stagnant or diminishing revenues to meet these demands. The private sector is having similar problems. It is therefore imperative that innovative approaches be used to provide the services demanded within the resources available. One such approach is the multiple use of land for parks/open space and stormwater management/flood control detention. Multiple use facilities can spread the costs for land, design, construction and maintenance.

The Denver metro area has a long history of combining stormwater detention with parks and open space. These efforts include combining uses at the time of development of the land, as well as retrofitting one use into the other; either putting detention into an existing park or putting recreational facilities into an existing detention facility. If done well, the facilities become tremendous assets to the community. If not, they can cause real problems. The experiences and observations of the Urban Drainage and Flood Control District have been compiled into the design and implementation guidance given in the following paragraphs.

Basic Concepts

Detention facilities can be configured in two basic ways: on-line and off-line. On-line facilities pass the entire flood hydrograph through the facility. They are best suited for

joint uses which can tolerate fairly frequent inundation, such as open space, wetlands, wildlife habitat and stormwater quality enhancement features.

Off-line facilities by-pass frequent flows and divert only the upper portions of flood hydrographs into the detention area. The design frequency of diversion will vary, being dependent on factors such as downstream conveyance capacity, level of protection desired and available flood routing volume. They are flooded less frequently than on-line facilities and require a smaller detention volume. These facilities are superior for more intensive recreational uses such as play grounds, play fields and picnic areas.

Frequent Mistakes

The most common mistake is to put recreation facilities too near the

bottom of an on-line detention pond, which results in frequent flooding of the facilities. Other problems include inadequate drainage of the pond bottom due to lack of adequate slope or poor subsurface drainage, and placement of trickle or low flow channels such that the useable area of the pond bottom is reduced or chopped up.

There are also situations in which a small outlet, and consequently a long drain time, are required; in which case formal recreation facilities may simply not be appropriate. The design of a detention pond should always take into consideration the potential future use of the pond for recreational opportunities. Minor design adjustments can often have a large impact on the ability to install

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Figure 1. Playing soccer at Herbert Hosana Park, an off-line detention facility in Englewood.

1992 Professional Activities of District Staff

Scott Tucker, Executive Director

- *"Flood Control, Urban Stream Corridors, and Clean Water Strategies," presented at National Forum on Water Management Policy, American Water Resources Association, Washington, D.C., in June.
- *"Denver Area Floodway/Greenbelt Approaches," presented at Urbanization and the Riverine Environment: A Balancing of Values sponsored by U.S.E.P.A. and Harris County Flood Control Task Force, Houston, Texas in March.
- *Instructor for APWA Clinic on Understanding the Stormwater Permit Regulations, A Municipal Perspective, Syracuse, NY, in March.
- *"Stormwater NPDES," presented at APWA Institute for Municipal Engineers' Seminar, Breckenridge, CO, in May.
- *Chapter Delegate for Colorado Chapter of APWA.
- *Chairman, Stormwater Committee and member of Board of Directors of National Association of Flood and Stormwater Management Agencies.
- *Chairman, History and Heritage Committee, Colorado Section, American Society of Civil Engineers.
- *Received the 1992 Honor Award from the Colorado Engineering Council, which is given in recognition of meritorious and noteworthy service to science, engineering, or closely allied professions.

Bill DeGroot, Chief, Floodplain Management Program

- *Elected Region 8 Director of the Association of State Floodplain Managers (ASFPM).
- *"Detention in Parks and Open Space - Good, Bad and Ugly", coauthored with Dave Lloyd, presented at ASFPM annual conference in Grand Rapids, MI in May.
- *Secretary of the newly-forming Colorado Natural Hazards Mitigation Foundation.
- *Member of the Colorado Natural Hazards Mitigation Council.

Kevin Stewart, Project Engineer, Floodplain Management Program

- *President of Southwestern Association of ALERT Systems (SAAS), term ending November, 1992.
- *Member of Colorado Natural Hazards Mitigation Foundation's (CNHMF) Dam Safety and Warning Subcommittee.
- *Author of paper entitled: Exercising Flood Warning Systems and Storm Simulations.
- *Special outside consultant to the National Oceanic and Atmospheric Administration (NOAA) Disaster Survey Team investigating National Weather Service operations during the Texas flood disaster of December, 1991.
- *Presenter on formulation of National Advisory Council at Quarterly Meeting of the ALERT Users Group in Sacramento, CA in January.
- *Workshop instructor at CNHMF Conference in Colorado Springs in May.
- *Speaker at ALERT Users Group Annual Conference in Pacific Grove, California in May.
- *Speaker at two Dam Safety-Emergency Preparedness Workshops on Warning Systems for Early Detection, Pueblo and Golden in September.
- *Presided at Fifth Annual Conference of the Southwestern Association of ALERT Systems (SAAS) in Phoenix, Arizona in October.

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

- *Chairman, ASCE Urban Water Resources Research Council's Urban Gaging Networks Committee.
- *Described District's approach in drainage and flood control projects at a Stormwater Training Seminar, Barcelona, Spain, in May.
- *"A Joint Effort to Prepare Part 2 of NPDES Application," coauthored with L. Scott Tucker and John Doerfer, presented at the 1992 APWA Convention, Boston, MA in August (a summary of this paper is in this issue).
- *Presented a summary of the stormwater management plans, fiscal analysis and proposed monitoring approach submitted with Denver's, Lakewood's and Aurora's NPDES Part 2 Applications to the annual meeting of the National Association of Flood and Stormwater Management Agencies, Sacramento, CA in December.
- *Published by Prentice Hall a book coauthored with Peter Stahre of Malm, Sweden: *STORMWATER - Best Management Practices and Detention*.

John Doerfer, Project Hydrologist, Master Planning Program

- *"Site-Selection Criteria for Monitoring Stormwater Quality in the Denver Metropolitan Area, Colorado," coauthored with Ben Urbonas, presented at the Colorado Water Engineering and Management Conference, Aurora in March.
- *Coauthored article with Ben Urbonas and Scott Tucker in *APWA Reporter* in April.
- *Speaker at the Colorado Association of Stormwater and Floodplain Managers workshop, Breckenridge in June.
- *Presented description of the District's new BMP manual to the Institute of Water Resources of the Colorado Chapter of APWA, Denver in December.

Mark Hunter, Chief, Maintenance Program

- *Member of ASCE Task Committee on Urban Drainage Rehabilitation Programs and Techniques.
- *"Trickle Channel Rehabilitation," presented at the ASCE Water Forum '92, Baltimore in August.
- *Member of International Erosion Control Association standards committee on riprap ;and articulating blocks.

Paul Hindman, Project Engineer, Design and Construction Program

- *Chairman of the Institute of Water Resources of the Colorado Chapter of APWA.

Tucker-Talk

by L. Scott Tucker

Timely Comment from the District's Executive Director



Mandate Mania

To mandate or not to mandate has not been the question in recent years. Congress has found a way to pass problems down to state and local governments without having to face the responsibility of justifying their requirements directly to those that have to pay. Congress has been particularly busy with mandates in the environmental area addressing such problems as hazardous waste handling, asbestos abatement, clean water, clean air, land acquisitions for endangered species habitat, removal of underground storage tanks, mitigation of wetland development, etc.

Mandates have a subtle but suffocating effect and are difficult for local governments to fight. For example, a Clean Water Act (CWA) amendment dealing with stormwater permits was passed by Congress in 1987. A few local governments tried in vain to warn Congress that the impact would be expensive and that no one could define the effectiveness of the program, but it sounded good and felt good and the CWA was passed. So, where is the pain? Nothing much happened immediately. The Environmental Protection Agency (EPA) went through a period of promulgation of the regulations that will implement the CWA, and a few local governments commented on the proposed regulations expressing concern about the cost impact it will have on their communities. By and large their objections and concerns were ignored and the regulation freight train continued down the track, so far without costing local governments a great deal of money.

Eventually, in November, 1990, EPA adopted regulations that set forth requirements for the preparation of stormwater permits for cities and counties over 100,000 in population. Like it or not, need it or not, these some 200-plus cities and counties started preparing applications for NPDES permits for their stormwater systems. Now the cities started facing some costs. In the Denver metropolitan area, for

example, the Urban Drainage and Flood Control District coordinated the permit application development effort with Denver, Lakewood and Aurora; and the total cost of preparing permits for the three cities was \$2,000,000. Again, concerns were expressed to Congress but to no avail. This scenario repeats itself in community after community across the United States and in many other areas in addition to stormwater.

With regard to environmental mandates, Congress has placed cities in the difficult position of being depicted as "anti-environment" if they show any hesitation to enthusiastically implement them. A basic issue is that environmental problems vary considerably from community to community and local governments are in many cases faced with addressing many problems regardless of the risks involved. There is no way for them to prioritize the mandates and address only the most serious problems with their limited resources.

The frustration of mayors is expressed in comments made by Knoxville, Tennessee, Mayor Victor Ash, at a Houston workshop when he said, "It is wrong for Congress to create programs it is unwilling to fund...and to force local tax increases on Americans and expect someone else--mayors, for instance--to take the blame. It is a back door tax increase that will sap from our cities the ability to make our own decisions and solve them with our own resources. If members of Congress want to be city councilmen, then they should run for city council." The mayors are indeed becoming frustrated.

Local officials understand the cost issue but they have had difficulty convincing members of Congress and federal agencies of the magnitude of the costs of unfunded mandates. Cities are beginning to develop detailed estimates of the cost of the mandates.

First to address the cost issue was the City of Columbus, Ohio. They conducted an interdepartmental study of federal and state environmental mandates for which it was responsible.

They were motivated because costs to clean up a hazardous waste site mandated by the Resource Conservation and Recovery Act were \$63,000,000 more than the original estimate. Columbus conducted a four month study which concluded that, for existing requirements between 1991 and 2000, environmental projects and programs would cost them \$1.6 billion. This staggering amount was more than city officials could ever have imagined. The study became a national milestone and is becoming important in framing the current debate over regulatory costs and benefits. For the first time, a community collected the data it needed to identify how much of its municipal budget was being spent for state and federal environmental compliance. From nearly 11% of its budget in 1991 the figure jumped to 18% by 1995 and 23% in the years beyond.

Following Columbus' model, the municipality of Anchorage conducted a similar analysis. Anchorage found that the estimated cost of environmental regulations to the municipality would total \$430 million for the 1991-2000 period. Costs for both Columbus and Anchorage were inflation adjusted at the prevailing 7% rate for environmental projects. Clean Water Act compliance is the most expensive program accounting for 36% of the costs. The Clean Air Act accounted for 34% and Resource Conservation and Recovery Act costs were 21%.

Other cities and counties should follow the lead of Columbus and Anchorage and conduct similar studies. For information on the Anchorage study, contact the Office of the Mayor, Municipality of Anchorage, 632 West 6th, #812, Anchorage, Alaska 99501. The Columbus report was compiled by the Columbus Environmental Review Committee in May 1991. Michael J. Pomtali was the Columbus official who coordinated the study. I suggest that anyone interested in developing similar studies for their communities

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Floodplain Management Notes

by

Bill DeGroot, P. E.

Chief, Floodplain Management Program

Implementation Planning

Last year I said in this column that we were beginning two implementation studies which would help us determine if we should continue to develop preventive master plans which rely heavily on regional detention facilities, or if we should be headed in another direction. I indicated that we would have these studies done by mid-1992, I lied. Actually, I didn't lie, but I was overly optimistic.

The Irondale Gulch study has proven to be difficult due to the large number of parties which have an interest in drainage in this basin. However, I remain optimistic that a workable resolution will be found in 1993. The Lone Tree Creek, Windmill Creek and Dove Creek basins study is nearing completion and awaits decisions from the sponsors on whether to pursue the recommended plan.

Rather than wait another year to give you the results of this study, I thought I would summarize the recommended plan for the master plan, "Outfall Systems Planning, Lone Tree, Windmill and Dove Creeks Area" (OSP) dated 1987. The intent of this summary is to briefly describe the implementation plan and why it is needed.

The Urban Drainage and Flood Control District has been assisting local governments in the formulation of master plans for more than 20 years. In the early years these master plans were aimed almost exclusively at defining remedial solutions to existing problems.

At the same time the District was defining 100-year floodplains in undeveloped areas and assisting local governments in enforcing floodplain regulations and other land use controls on those floodplains. Under this approach, developers of new projects were required to "deal with" 100-year floods and floodplains which were based on flows from assumed fully developed drainage basins. "Deal with" means such activities as staying out of the floodplain, filling fringe areas in accordance with floodplain regulations, or channelization. The key factor was that the developer of the floodplain had to address the

future developed basin discharges on his own.

In the mid-eighties the District began assisting local governments in the formulation of master plans for undeveloped drainage basins. The intent was to get out ahead of development so that reasonable decisions regarding drainage could be made when development plans were proposed. We soon found that regional detention facilities invariably were a preferred flood control option on paper, but they proved to be very difficult to implement.

While it has been reasonable to require a developer to "deal with" the developed basin 100-year discharge, it has not been reasonable to require that same developer to build a regional detention facility which takes more land, costs more money and stores other developers' water as well as his own. It has also not been acceptable to allow downstream development to rely on planned upstream regional detention which has not been constructed and for which there was no mechanism to guarantee construction. Finally, it has not been considered acceptable to use tax monies to build flood control facilities to accommodate new development. Recently stormwater quality has also been injected into the mix. In the case of the three basins under discussion here, stormwater quality considerations also involve specific concerns for Cherry Creek Lake.

The District, in cooperation with Arapahoe County, Arapahoe Water and Wastewater Authority and the Cherry Creek Basin Water Quality Authority (CCBWQA); began this implementation study in an effort to find a way to foster timely construction of the master planned facilities, with new development paying for the facilities for which they create the need, but only when the new development occurs and not before. The consulting firm of CH2M-Hill was retained, with legal assistance from Sherman and Howard, to complete this implementation plan.

The proposed implementation plan has several key aspects: a revised OSP, revised cost estimates, an allocation of who is responsible for each facility in the OSP, right-of-way (ROW) acquisition strategies, a construction phasing plan, a financing plan and a proposed institutional arrangement. A discussion of these aspects follows.

The OSP was reviewed for continued appropriateness and

several adjustments were made. The decision was made to switch from wet ponds with filtration to wet ponds only, with no filtration. It was also determined that, whereas the original master plan called for stormwater quality treatment at almost every regional detention facility, it was more practical, and more economical, to consolidate stormwater quality facilities at fewer sites. In a number of instances it was also found to be beneficial to combine some of the planned quantity detention into fewer facilities.

Every element of the master plan was classified according to its function and who should construct it, as defined below:

+ Remedial facilities - address existing problems by increasing capacity or decreasing discharges.

+ Maintenance - the repair of existing facilities with no increase in capacity.

+ Land owner facilities - on-site facilities which cross public or private land.

+ Regional facilities - those for which the need is generated by new development, and it is felt that the development which creates the need should be responsible for paying for these facilities. Regional facilities have been further divided into water quantity and water quality functions.

The responsibility for implementation of remedial or maintenance facilities will continue to rest with the local governments, with possible assistance from the District. Land owners (public and private) will continue to be responsible for "dealing with" the drainageways which cross their land, with two differences. Instead of always using the fully developed basin discharge, the land owner will be able to use the master plan discharges. In most cases that will mean smaller discharges because of the master planned regional detention facilities, whether the detention has actually been constructed or not. The other difference will be where a regional detention facility has been planned for that land, in which case more land may be required, but the land owner will be compensated for that land in some manner. The regional facilities are the financial responsibility of the developers who create the need.

It is imperative that the ROW for planned regional detention facilities be acquired, or otherwise tied up as soon as possible in order to assure the continued viability of the revised OSP. The potential loss of ROW is a

constant concern and inhibits local governments' ability to allow developers to use master planned discharges which rely on future detention facilities. The implementation plan recognizes the need to adequately compensate the owners of the land.

Because no entity has the funds available to acquire ROW now, and because it is believed that developers who create the need should pay for the solution, methods of compensation other than cash which are available to local governments are included in the plan and are encouraged. The key is to treat each site individually, and to negotiate compensation with each owner individually according to his situation.

Cost estimates were updated for each facility in the revised OSP according to the the categories of remedial, maintenance, regional quantity, and regional quality. A phasing plan was developed which specifies when each specific facility should be in place, not by specific dates but according to the amount of development in the basin upstream from each facility. A number of detention ponds are proposed to be constructed in several phases, in order to accommodate only that development which has occurred.

Construction costs for the regional facilities have been allocated to the currently undeveloped land, on a per acre basis, according to both the total undeveloped area and the projected impervious area. These costs are not final, and would have to be refined upon execution of the implementation plan, but they give a good indication of the range of potential costs to developers to implement the regional aspects of the OSP. The unit costs range from \$1753 to \$3975 per undeveloped acre; and from \$2275 to \$7161 per impervious acre for regional quantity and quality facilities. By comparison, for regional quantity facilities only, the costs range from \$602 to \$1146 per undeveloped acre; and from \$815 to \$2065 per impervious acre. ROW is not included in these cost estimates.

Some type of institutional arrangement is necessary to implement the above regional aspects. In addition to the sponsors of this study, small portions of the study area are located in Douglas County and Aurora, and they will have to be brought into the operation if it is to be a truly regional implementation effort.

The consultant has recommended the establishment of a storm drainage utility modeled after a water or sewer utility. The Arapahoe Water and Wastewater Authority is best suited to assume that role because it already provides water and sewer service in the basins and has a billing system in place. An intergovernmental agreement (IGA) would have to be developed between the sponsors, Douglas County and Aurora to establish parameters for the storm drainage utility.

The following issues must be resolved in order to complete this implementation planning effort:

+ Are the per acre costs allocated to the currently undeveloped land reasonable?

+ Should regional facilities for both quantity and quality be included in the implementation plan, or should quality be handled separately, either by the CCBWQA or by the local governments through the requirements of the National Pollutant Discharge Elimination System?

+ Is there agreement on establishment of a storm drainage utility, or expansion of Arapahoe Water and Wastewater Authority's responsibilities, in conjunction with the appropriate IGA, as the preferred institutional approach to implementation of the OSP?

+ Should funds be acquired from developers through a one time exaction at the time of development, ongoing service fees, or a combination of both?

+ Long term ownership and maintenance responsibility for the facilities which would be constructed under this plan must be determined.

Failure to adopt a coherent and systematic implementation plan, whether the one recommended here or another option, would require that we go back to requiring every developer to "deal with" the fully developed basin discharge.

Flood Warning Program

The District continued to operate and expand its flood warning program in 1992 under the direction of Kevin Stewart. Kevin's detailed report on this year's effort appears elsewhere in this issue.

CASFM Awards Given

The firm of Love and Associates was honored last summer by the Colorado Association of Stormwater and Floodplain Managers (CASFM) at its third annual conference held in Breckenridge. The firm was presented the Grand Award for Engineering Excellence in the field of Floodplain/Stormwater Management for the multi-objective planning, design and construction supervision of the University of Colorado at Boulder Research Park.

Concern for the quality of runoff entering Boulder Creek, the need to maximize developable land, and the required mitigation of nine acres of wetlands prompted Love to design several lakes and a wetland park within the floodplain. There, wetland vegetation cleanses stormwater runoff, preserves flood capacity, and slows flood flows from Boulder Creek. In total, twenty-three acres of wetlands, ponds, multi-functional paths, and educational and recreational features have been constructed. Upon completion, the park will include an interpretive area, boardwalks, a research area, and an amphitheater. Additionally, an irrigation waterway serves as the central focus of the campus environment, and Skunk Creek was relocated to its historic channel.

Also receiving CASFM awards for outstanding achievement were the City of Boulder for its Stormwater Quality Education Program, the City of Fort Collins for its Creekside Park project, and McLaughlin Water Engineers for the City of Brighton South Outfall System and the Superior Metropolitan District No. 1 Rock Creek Drainage Improvements project.

District Award

For the third year in a row the District has received a "Certificate of Achievement for Excellence in Financial Reporting from the Government Finance Officers Association of the United States and Canada. The certificate is presented to government units whose comprehensive annual financial reports achieve the highest standards in government accounting and financial reporting.

Congratulations to Frank Dobbins and Darla Schulz, the District's finance and accounting team.

A JOINT EFFORT TO PREPARE PART 2 OF THE NPDES APPLICATION

by

Ben Urbonas, P.E., John T. Doerfer, L. Scott Tucker, P.E.

Introduction

In the last issue of *Flood Hazard News* we reported on how Denver, Aurora and Lakewood joined forces with the District to prepare Part 1 of the Colorado Discharge Permit (CDP) Applications for each of their separate stormwater systems. That article also described how the three cities, along with the District and a number of other jurisdictions had set up a Joint Task Force (JTF) to address the requirements imposed on the municipalities of the United States by EPA's promulgated regulations for the National Pollution Discharge Elimination System (NPDES). This JTF worked very well in assisting the three cities to complete Part 1 of their applications to the Colorado Water Quality Control Division (State) in 1991. How the JTF's effort continued in the preparation of Part 2 of the application is described below.

Part 2 of the Application

After the Part 1 application was submitted, the District continued to work closely with the JTF and continued to provide technical support to each of the three cities on an as-needed basis. In addition, the District continued to contract for all support consulting and other services using its own resources.

The preparation of Part 1 of the municipal separate stormwater NPDES permit application, while intensive and resource demanding, was basically an inventory of the existing storm sewer system and municipal land use conditions. On the other hand, Part 2 was more difficult to complete. The Federal Regulations (40 CFR Part 122) required the following to be submitted with the application:

- * Information demonstrating adequate legal authority of the applicant to control industrial discharges, illicit discharges, illegal spills and dumping; to enter into interagency agreements; to insure compliance; and to conduct inspections for compliance.
- * A list of industrial dischargers to municipal storm sewers.
- * Stormwater runoff characterization data.

- * Estimates of annual stormwater loads for 12 constituents.
- * A schedule to furnish loads and Event Mean Concentrations (EMCs) for all major outfalls.
- * A proposed follow-up monitoring program.
- * A proposed Stormwater Management Plan (SMP).
- * Estimates of pollutant reductions resulting from the SMP.
- * A fiscal analysis and how the SMP will be funded.

Because Part 2 of the application requires the commitment of municipal fiscal resources over the life of the permit, usually a five-year period, its preparation is much more complicated. In order to avoid making commitments that may exceed each city's ability to pay, each city's staff had to develop a draft SMP and estimate the cost of its implementation. As a result, each city's plan was revised at least once to seek a balance between the proposed SMP, its cost and available funds. The goal was to develop a plan that was responsive to the Maximum Extent Practicable (MEP) intent of the 1987 Clean Water Act. The SMPs that resulted from the iterative process were presented to city management and elected officials of each city for approval. It is a wonder that each city is committing funds to comply with this federally-mandated program at a time when their budgets are strained and funds are in short supply.

Unfortunately, even as the SMPs were being prepared much was not known about the actual effectiveness and long-term performance of many of the Best Management Practices (BMPs) that needed to be considered for inclusion. The technical literature suggested many BMPs, but much of the reported effectiveness of these practices is based on assumptions and computer modelling, instead of actual field data. The data that is available indicates a wide range in potential effectiveness between installations and between different tests. In addition, information on how to size and design some of the BMPs is sketchy, limited to narrative discussion, lacks sound technical basis, is inconsistent, or suffers from all of the above. At the same time, information on the load reduction

capabilities of non-structural BMPs is based solely on intuition and guesses, and not on field studies or measurements. Yet the applicants were required to provide estimates of the effectiveness of their proposed SMPs.

Realizing the limitations of available information, the JTF decided to first critically evaluate all known BMPs reported in the literature. As a result a new BMP manual was developed and published as *Volume 3 - Best Management Practices of the District's Urban Storm Drainage Criteria Manual*. Its content is limited at this time to seven structural BMPs that had a reasonably solid technical basis plus a record of acceptable performance in other parts of the United States. Several other structural BMPs showed promise, but lacked solid field-tested design guidance. Those will be evaluated in the future and may be added to the new manual. The selection of non-structural BMPs was more intuitive and was based on their potential cost-effectiveness in reducing stormwater pollutant loads.

The District staff will perform load reduction estimates for the three cities. These will be based on the wet-weather data collected under a joint monitoring effort and on estimates of the effectiveness of the BMPs described in each city's SMP. How accurate these estimates will be is anyone's guess, but they are required by the federal regulations. If we are lucky, these estimates will be within the correct order of magnitude.

Stormwater Characterization and Loads

The District and each of the three cities executed an agreement to fund the stormwater monitoring effort required for the Part 2. The District then contracted with the U.S. Geological Survey (USGS) to collect needed wet weather data for three storm runoff events at each of eight monitoring sites. The total cost of this monitoring effort was \$320,000. USGS contributed \$120,000 of this total. The data is being evaluated at this time for consistency and reasonableness before final system-wide loads are submitted to the state. A dry summer delayed the receipt of

the data and the state was asked to grant an extension for its submittal until basic data integrity assessments are completed, something that needs to be done if the data is to be used in subsequent problem assessment and load estimates.

This monitoring program was designed to help characterize the urban stormwater runoff quality in the Denver region. The three cities are part of one continuous large metropolitan area and one set of data should achieve this goal. As a result, the total number of monitoring sites was less than would have been required under three individual efforts, namely, eight instead of fifteen to thirty sites. Each site cost \$40,000 to instrument, collect samples and to test for the 138 constituents listed in the Federal Regulations. The total savings in monitoring costs alone that resulted from a joint program is between \$280,000 and \$880,000. Credit for this must be given to the State of Colorado for recognizing the cost implications of wet-weather monitoring and agreeing to a reasonable joint stormwater characterization effort.

Estimating Pollutant Loads From Each City

The District will calculate the annual stormwater loads of approximately 12 constituents from each of the three cities. We hope to achieve uniformity in the load estimating procedures used and in the results reported by each applicant. Early in 1992, the JTF concluded that a simple model based on average Event Mean Concentrations (EMCs) and annual runoff volumes should be used. Due to highly variable temporal and areal distribution of individual rainstorms, especially in a semi-arid climate, using continuous modelling or more complicated models will not improve the accuracy of load calculations.

Load estimates are being made separately for each city using linked spreadsheets. Thus, one set of EMC data obtained from the wet-weather monitoring is linked with the land use and runoff coefficient data for each of the major watersheds and with the average annual excess precipitation to calculate the total load of each of the 12 constituents listed in the Federal Register. The results will be reported to the state by each city. The accuracy of these estimates is expected to be reasonable and is limited only by the accuracy and consistency of wet-weather data and the land use

information reported by each city in Part 1 of the application.

Consultant Services

As reported elsewhere in this newsletter, a Best Management Practices manual was prepared by the District. This was done with the general guidance and input from the JTF and many other interested parties. The JTF provided day-to-day technical guidance and a consultant was asked to distill this input into a usable document. Drafts of this manual were distributed to an array of interested parties and, in the process, many of the ambiguities found in new criteria manuals were found and eliminated.

The manual has several different parts. It addresses stormwater quality management, non-structural BMPs, structural BMPs and erosion control. It is structured to permit revisions and additions as new information is developed or is discovered. The goal is to re-examine and update the entire document within the first five-year NPDES discharge permit period.

Estimating the Cost of SMPs

The importance of estimating the cost of the municipal SMPs for inclusion in Part 2 of the application cannot be overstated. A consultant was asked to help us with this task in order to avoid the possibility of overlooking costs of implementation and administration of each SMP. All related costs were identified and a cost estimating procedure was developed to estimate the cost of each SMP task. Spreadsheets were developed for each city that link the city's manpower and equipment-use unit costs with estimates of needed work to develop, implement and operate each of the many SMP tasks.

As each city's SMP was developed, estimates were made of the man-hours and equipment hours needed for each year over a five-year period. These were entered into the spreadsheets, resulting in cost estimates for each of the five years of the permit. This proved to be an extremely valuable calculation. It revealed how quickly small commitments added up into very large and significant costs that will have to be paid by each city.

Concluding Remarks

The District and the three largest cities within the District continue to work together to prepare Part 2 of each city's stormwater discharge permit application. Part 2 is much

more difficult to prepare. The difficulties stem from several sources, most important of which is that staff time and fiscal resources of each city and the District are being committed with the submittal of Part 2 of the application. In addition, one needs to choose very carefully among the BMPs reported in the literature to select ones that have the best chance of being implemented and are known to provide reliable performance. It is hoped that the JTF process has resulted in wiser and more cost-effective decisions.

The preparation of the permit applications for the three cities will cost approximately \$2 million. A recent survey by the National Association of Stormwater and Flood Management Agencies revealed the average cost to prepare an application for medium and large cities in the United States will be \$761,000. The average for the JTF effort per city is somewhat less. Never-the-less, these applications will cost ten times more than originally estimated by EPA and shows that despite serious fiscal problems, these municipalities are treating this Federally-mandated program very seriously. Each city has already spent their funds to comply with the permit application requirements and will need to spend even more to implement their proposed SMPs.

As a result of the activities of the JTF, the Denver metropolitan area is well positioned to deal with stormwater quality management in the future. A new BMP manual, cost estimating systems to help control fiscal commitments, system inventories, stormwater management plans and other products that resulted from the cooperative effort between the District, Denver, Lakewood, Aurora and many other interested organizations will enable not only the three cities, but all smaller Denver area municipalities to move forward, when they are mandated to do so, in the management of stormwater quality. It remains to be seen how the permit writers of Colorado will react to the permit applications and what requirements and fiscal demands will emerge through permit conditions for these three cities. Please stay tuned for further reports.

BEAR CANYON CREEK IN BOULDER

A History of Change

by

Michael A. Stevens and Ben Urbonas

INTRODUCTION

Bear Canyon Creek flows through the south end of Boulder, Colorado. During the last decade we have been studying a 2,000-foot reach in Martin Park that drops 49 feet in elevation. Our goal was to determine if this reach has been stabilized, and if the previously installed stone drop structures are working properly.

As the park was initially constructed, this reach was configured as a trapezoidal ditch, nearly void of herbaceous vegetation. Because of its steep slope and new urban developments upstream, the streambed degraded through the park. An attempt to stop this bed lowering by building 11 gabion drop structures failed. By 1981, the center portions of all these structures were destroyed.

In 1982, the 11 drops were rebuilt as sloping drops constructed of 18-inch loose riprap with upstream cutoff crests made of 3-ft grouted boulders. These structures were constructed as designed, except that the loose riprap was somewhat smaller than that called for. This quickly became apparent when the flow in a small runoff event eroded away some of the riprap on the downstream side of the crests of 10 of the structures.

The damage was repaired in 1983 by placing stone no less than 18 inches in the places where the riprap had been removed. Since then, no discernible flood related damage has occurred. Two floods, each about 25 percent of the 100-year flood of 2,100 cfs, occurred in 1990 and 1991. The high-water marks of both were surveyed and the entire reach restudied to gain insight in streambed stability of a steep gradient urban stream. The resulting underlying conclusion is that within the 10 years this stream has been studied, a new equilibrium slope has not been attained and the current bed profile is not as originally anticipated.

STREAMBED STABILITY

Field Data. Because of urbanization, diversion structures and stream stabilization upstream of the Park runoff frequency increased and very little bed-load sediment reaches the study reach. As a result, the streambed has degraded. Although the new drop structures fixed the bed level at 11 points along the stream,

they did not stop the streambed's degradation - yet! The flow continues to dig below the designed equilibrium slope line. The reason is that the accelerating flow approaching the crest transports bed particles up and over the crest. The equilibrium slope is controlled not by the crest level but by the tractive forces at which the flow can no longer lift bed particles over the crest.

Before the channel began degrading, about 1965, Bear Canyon Creek had a saucer-shaped cross section with a top width of around 55 feet and a bank-full depth of 6 feet. Degradation began in the center of this cross section where the flow was the fastest and the depth the greatest, creating an inner channel within the old cross section. Because of the nature of the soil, the initial cut did not widen much and the banks were not threatened. The initial cut served as the low flow channel. As degradation continued, more flow became concentrated in this inner channel, enhancing the lowering process.

In 1992, the bed of the creek is, on the average 1.2 ft lower than in 1981. The degradation has been greatest just downstream of the twin-box culverts under Broadway (Figure 1). The degradation and local scour here have lowered the bed three feet prior

to 1981 and another three feet since then (Figure 2), the result being an adverse creek bed slope between Broadway and the next structure downstream.

Downstream, the degradation is less at this time, because the materials eroded upstream deposit and slow degradation. This is a temporary situation, however, as there will be essentially no transport in the final equilibrium channel.

The process of degradation in this steep gradient creek is not uniform with respect to either time or space (see Figure 3). The flows are erratic and so is the transport. Materials on the bed vary from gravel to cobbles and small boulders. As an example, structure 7 was completely buried in gravel and small cobbles derived from degradation upstream. In the last two years, much of this material has been moved away and there now is a drop in the streambed across the structure.

Some Theory. Without sediment inflow, the final equilibrium slope is determined by the design flow, the size of the bed material, and the proximity of the structures that generate high turbulence in the flow.

For normal creek flow (no abnormal turbulence), the three equilibrium profiles for a unit discharge of 50 cfs/ft over a drop structure are shown in Figure 4. The

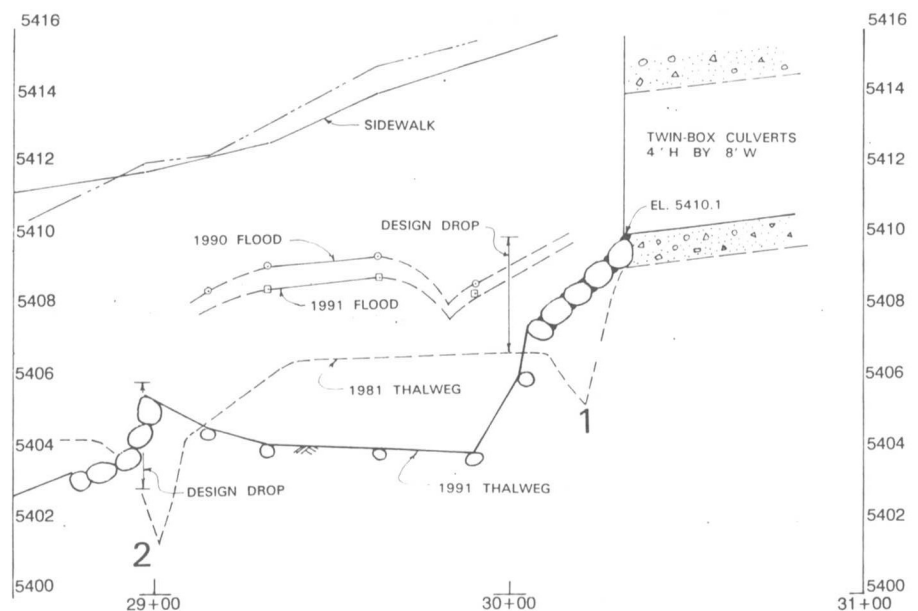


Figure 1. Reach profile with the most degradation. Note the bed below the downstream crest and the bed-slope is adverse.

bed material here is at the point of incipient motion. An analytical expression relating the velocity for incipient motion, V_c , and mean rock size, D_m , is

$$V_c = \sqrt{265 D_m \left(\cos \alpha + \frac{\sin \alpha}{\tan \theta} \right)} \quad (1)$$

Here alpha = slope angle of the bed, positive when the bed slopes in the opposite direction as the energy grade line of the stream (an adverse slope); and theta = angle of repose for the bed material. Equation 1 expresses the moment balance of a stone on a slope. The last term on the right accounts for the fact that a stone is more stable on an adverse slope than on a normal one. The number 265 depends on the density of the rock and the assumptions made on the stress required to move the bed material. This number should be obtained from the analyses of field structures and discharges.

When Equation 1 is combined with the backwater equations, the bed and water surface slope can be computed. The results are clear. Streams with finer bed material need to have the equilibrium slope set on a grade which starts below the level of the downstream crest. In this specific case, this is about 2.2 ft for bed material equal in size to 0.15-ft (1.8 inch) gravel and 0.8 ft for the 0.25-ft (3 inch) cobble. There is no dip in the profile for the 0.5-ft (6 inch) cobble.

When much turbulence is generated at drops or other types of structures, it causes local scour in addition to the general degradation discussed above. Turbulence levels are especially high when structures are very close together and even greater adverse equilibrium slopes can result.

RECOMMENDATIONS

The study of a high gradient, urban influenced, Bear Canyon Creek through Martin Park in Boulder, Colorado has prompted the following set of initial recommendations to designers when dealing with similar conditions:

1. The equilibrium slope method of designing the grade of an alluvial drainageway is valid. The design is most conservative and most easily accomplished when it is assumed there is no resupply transport of

bedload into the design reach. Otherwise, one must determine this sediment inflow, a most difficult task.

2. In channels with fine bedload sediment, large design unit discharges, or both, the equilibrium slope must begin below the crest of the downstream structure or control point.

3. Base estimates of the lowering of the equilibrium slope line on field measurements of comparable channels. Equation 1, used to estimate equilibrium slopes given here, has not yet been validated to be universally applicable.

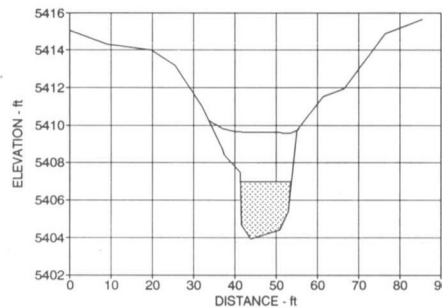


Figure 2. Cross section at Station 29+91. Note the 6-feet of degradation and local scour.

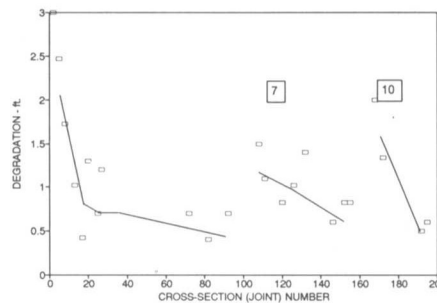


Figure 3. Degradation in Bear Canyon Creek, 1982 to 1992. Section Number 0 is upstream-most of a 2,000 foot-long reach. Structures 7 and 10 are in the areas of temporary deposition of eroded upstream bed materials.

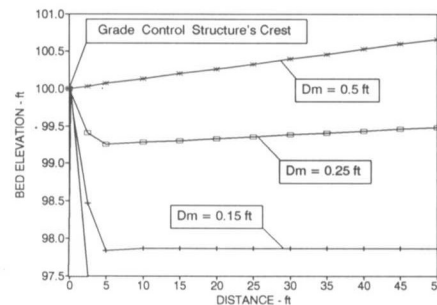


Figure 4. Equilibrium slope upstream from a fixed crest. D_m is the bed material size. Large materials have steep slopes and less degradation.

Revegetation Workbook

In February, 1993, the District will publish, *Design Workbook for Establishment of Natural Vegetation*. This workbook will be a condensed version of the *Guidelines for Development and Maintenance of Natural Vegetation* which was developed for the District in 1984. It summarizes the data necessary for the design, construction, and maintenance of natural vegetation areas in the metropolitan Denver area.

This condensed version summarizes four major activity phases required to develop natural vegetation areas; planning/design, construction, establishment, and maintenance. Intended as a ready reference during the design process, this summary will enable the user to make logical design and management decisions based upon site conditions and a sequence of options.

Included in the workbook will be a "Revegetation Matrix" and a corresponding "Project Worksheet." The matrix can be used as a guide to make step by step decisions during the design and construction process. The worksheet is a convenient recording form for those decisions. Recording the individual actions of each project on the worksheet ensures a ready reference of critical decisions which can be reviewed at a later date to help determine the success or failure of each individual project.

A major element of the process to obtain the most favorable turf establishment depends upon an understanding of soil types and the selection of the best grass seed mix adapted to that soil type. The revegetation matrix provides the guidance required to complete a project in a satisfactory manner without a highly technical background. Use the soil checklist, included in the workbook, and the matrix in a hands-on approach to define the problems and produce an ideal revegetation solution.

Copies of this workbook will be available in February, 1993, and will be provided to all interested parties at a nominal cost. Contact the District if you are interested in obtaining a copy.

PLANNING PROGRAM ACTIVITIES

by

Ben Urbonas
Chief, Master Planning Program

Planning Projects

A total of seven master planning efforts were completed and five new ones started in 1992. The table titled "Status Of Planning Projects" lists the projects that were under way in 1992 and the ones we hope to begin in 1993. We will begin consultant selection for those scheduled for 1993 as soon as the funding agreements are finalized between the District and the local sponsors. As explained in our last *Flood Hazard News* article, we now address the need for Best Management Practices (BMPs) to manage stormwater quality in all master planning projects, which adds a new dimension and a new challenge for us and our consultants. We foresee 1993 as an exciting year as we launch the listed planning projects, some of which will be very large.

Technology Transfer

In November the District began distributing the new Volume 3 of its *Urban Storm Drainage Criteria Manual* (see a related article announcing its release). The initial efforts that led to the development of the final revisions of this manual began about three years ago. Its preparation involved a large number of individuals and organizations, too numerous to list here. We hope that we listed all of them in the "Acknowledgments" section of the new manual. We are very grateful to everyone who has contributed and if we failed to specifically list your name or organization, please accept our apologies. At this time we are beginning to assemble information for future additions to this manual and to identify areas that need further development or treatment. If you have any suggestions as to what needs to be added or changed, please let us know and we will see if they can be included in future updates.

The video tape developed by the Ohio Homebuilders Association on "Keeping Soil On Construction Sites: Best Management Practices" is available for loan from us for up to one week to anyone wanting to view it. Until a similar video is developed for the semi-arid high plains, viewing of this video is strongly recommended. It provides an excellent treatment on how to address erosion control during construction.

STATUS OF PLANNING PROJECTS

Project	Sponsor(s)	Consultant	Status
Denver Criteria	Denver	Kiowa Engineering	Completed in 1992
Beebe Draw	Brighton, FRICO & Adams Co.	Wright Water Engineers, Inc.	Completed in 1992
Moon Gulch	Jefferson Co. & Arvada	HDR Engineering	50% Complete
Western Hills Outfalls	Adams County	WRC Engineering	Completed in 1992
Bullhead Gulch	Lafayette & Louisville	ASI	Completed in 1992
Happy Canyon Creek	Douglas Co. & Arapahoe Co.	Kiowa Engineering	95% Complete
Columbine Basin	Arvada & Wheat Ridge	Muller Engineering	75% Complete
Upper Lena Gulch Update	Jefferson Co., Lakewood & Golden	Boyle Engineering	75% Complete
Westerly Cr. u/s of Havana	Aurora	Merrick	35% Complete
Lower Slaughterhouse Update	Littleton	Boyle Engineering	50% Complete
Upper Weir Gulch Update	Lakewood & Jefferson Co.	Kiowa Engineering	75% Complete
NPDES Data Management Software - Ph.2	None	Jansekok	Completed in 1992
NPDES Part 2 Support	None	CH2M-Hill	Completed in 1992
Erosion Control Criteria	None	Kiowa Engineering	Completed in 1992
Newlin/Baldwin Gulch	Parker & Douglas Co.	Kiowa Engineering	5% Complete
Box Elder Creek, Ph. I	Aurora Arapahoe Co. Adams Co.	n/a	Begin in 1993
Box Elder Creek, Ph. II	Aurora Arapahoe Co. Adams Co.	n/a	Scheduled for 1993
Drainway A Update, Ph. I	Louisville	n/a	Began in 1992
Drainway A Update, Ph. II	Louisville	n/a	Scheduled for 1993
Arapahoe Gulch	Golden	n/a	Scheduled for 1993
Arapahoe Gulch	Golden	n/a	Scheduled for 1993
Dry Gulch Update	Lakewood	n/a	Scheduled for 1993
Todd Creek	Thornton Brighton Adams Co.	n/a	Scheduled for 1993
Stapleton Drainage	Denver	n/a	Scheduled for 1993

We have also been working with the Environmental Compliance Technology Department of the Red Rock Community College to develop ongoing control training. The first "trial" one-day session took place on December 10, 1992. The 25 "students" in this session were from a number of local governments, contractors, CDOT, District and other organizations. This first session was used to "fine tune" the training materials and course content. Red Rocks will offer this one-day course over the coming months and if you have an interest in attending, call

Scott Olson at 988-6160, X-282, for schedules and costs. We hope to have this first training course serve the needs of field personnel, namely, construction workers, superintendents, inspectors, etc. Subsequent training courses to serve the needs of designers are also being planned by Red Rocks.

Software

The University of Colorado at Denver has essentially completed for the District the development of a set of software design packages addressing storm sewers, inlets,

detention basins, prismatic open channels, etc. Contact Dr. James Guo at 556-2849 to order any of these individual programs or the entire series, or to update the software you may have obtained from them before. The current packages have addressed many of the problems and issues the various testers and users have brought to Dr. Guo's attention in the past.

Stormwater NPDES Activities

In a related article we report on the Part 2 activities that have occurred since November of 1991. The final NPDES separate stormwater permit application regulations for Denver, Lakewood and Aurora were delivered to the Colorado Water Quality Control Division (CWQCD) on November 16, 1992. Now we wait for the CWQCD's response and draft permits for these three cities.

In 1992 we began holding regular meetings with the Phase II municipalities (i.e., with populations less than 100,000). Attendance has been great and we even have cities outside of the District participating. These meetings provide all municipalities the opportunity to discuss the current status of Federal laws and regulation, what each municipality is doing to prepare for NPDES permit applications, what problems they are experiencing, and various other related technical and non-technical issues. If your municipality has not yet attended these informal meetings and would like to do so, call John Doerfer to find out when the next meeting is to take place. Everyone is welcome to attend.

The applications of the three larger municipalities contain a proposal to the CWQCD to perform certain tasks as a joint effort between the three cities and the District. These include an ongoing stormwater monitoring program; development of public educational materials for proper use and disposal of paints, automotive products, pesticides, etc.; and continued updating and development of the BMP Manual. The District will want to involve everyone who is interested in contributing ideas and materials in this task. We hope to do so through Joint Task Force meetings, which are open to everyone interested in attending, and through the Phase II municipality meetings. We see this as another opportunity to develop products that can benefit everyone in the Denver region.

New Manual of Stormwater Best Management Practices

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

After an almost three-year effort, the Urban Drainage and Flood Control District (District) has published *Volume 3 - Best Management Practices of the Urban Storm Drainage Criteria Manual (USDCM)*.

The purpose of this publication is to provide design guidance for local jurisdictions in selecting and designing best management practices (BMPs) for stormwater quality improvement. At this time it contains an introduction to stormwater quality management; a discussion on stormwater quality, its hydrology and pollutant loading; technical criteria for seven structural BMPs; a description of several nonstructural BMPs; and a chapter on erosion control practices during construction.

The format of Volume 3 is similar to the original USDCM and was selected to permit revisions and additions to be incorporated into it as they occur in the future. The BMP manual may be obtained from the District at a cost of \$40.00 plus \$3.50 for postage. This price includes any additions and revisions that are issued by the District through 1997, several of which are already being planned.

In addition to this BMP manual, there are also three recently released publications that address urban stormwater and management of its quality. These are:

1. *Stormwater Management* by Martin P. Wanielista and Yousef A. Yousef, published by John Wiley and Sons, 1992. Available through bookstores.

2. *A Current Assessment of Urban Best Management Practices - Techniques for Reducing Non-Point Source Pollution in Coastal Areas* by Thomas Schueler, Peter Kumble and Maureen Heraty, 1992, available from Metropolitan Washington Council of Governments, Washington D.C.

3. *Stormwater - Best Management Practices Including Detention* by Ben Urbonas and Peter Stahre (2nd Edition), Prentice Hall, 1993. Available through bookstores.

DO YOU KNOW WHERE YOUR SPIRANTHES ARE?

By Barbara Benik, P.E.
Project Engineer, South Platte River Program

Hopefully, you know where they aren't!

Spiranthes diluvialis, the Ute ladies'-tresses orchid, is an endangered species known to occur in Boulder and Jefferson Counties. In July, the U. S. Fish and Wildlife Service (USFWS) extended the possible range of the orchid to the entire State of Colorado, and subsequently required that a survey for the orchid be performed for those projects subject to the Corps of Engineers 404 permit process. Now, every time we apply for a Nationwide, General, or Individual 404 Permit, we are required to address the Ute ladies'-tresses orchid.

The peak time for observing the orchid is from mid-July to the end of August. It is during this period that the orchid is in bloom, thus making it easier to see. It is possible, however, to perform surveys outside of this six week window provided the surveyor knows the life cycle of the orchid.

We were informed of this new survey requirement with less than a month remaining in the blooming period. Nevertheless, the District staff scrambled to complete orchid surveys for over fifty sites where projects have been planned for the next year.

So, the next time you apply for a 404 permit, make sure there are no *Spiranthes* in your project area.

Note: In November the USFWS published new ranges for the orchid: Boulder and Jefferson Counties and the South Platte River 100-year floodplain and perennial tributaries.



A Ute ladies'-tresses orchid past its prime (but it's the only picture we had).

DESIGN AND CONSTRUCTION NOTES

by

David W. Lloyd, P.E.

Chief, Design and Construction Program

Nineteen Ninety-two was another year of much activity in the Design and Construction Program. Approximately \$6.5 million of District funds were encumbered, resulting in the start of 14 new design projects and our participation in approximately 20 construction projects over 1992.

The District, in cooperation with Adams County, recently contracted for the redesign of Little Dry Creek from Clear Creek to 64th Avenue. The original design of this facility called for a grass lined channel throughout the reach which is currently occupied by an existing borrow pit. Adams County, in it's negotiations with the property owner for the channel right-of-way, discovered that the owner was interested in selling the entire pit area to the project sponsors. The redesign of the facility will allow the flows from Little Dry Creek to discharge into the pit which will have approximately a 7-acre lake surface. From the lake, flows will discharge over a broad crested weir to Clear Creek. Besides being a less expensive alternative than the open channel, we should realize some much needed water quality benefits.

Another design project recently underway is Marston Lake North from Sheridan Boulevard to Quincy Avenue. Most of this reach is encompassed by the Pinehurst Country Club. In addition to designing a new cross drainage structure at Sheridan, the design will take into consideration the impacts of storm flows to three existing instream lakes at Pinehurst. Storm flows of recent years have caused overtopping of the embankments on these lakes creating concern that they might ultimately fail.

We've recently completed the design of improvements on Sand Creek in Aurora from Buckley Road to Colfax Avenue. Most of the work on this project is centered around the replacement of an existing 11 foot drop structure just downstream of Colfax. Because of it's importance to the structural integrity of the Colfax bridge, the Colorado Department of Transportation will participate with the City and District in funding construction of the new drop structure.

STATUS OF DISTRICT DESIGN PROJECTS

Project	Participating Jurisdiction(s)	Status
Drainageway No. 4	Lafayette	Complete
First Ave Trib - Ph 2	Lakewood	Complete
Four Lakes Drainage	Arapahoe County	Complete
Four Sq Mile - Westerly	Arapahoe County	Complete
Lower Goldsmith Gulch	Denver	Prelim Design on Hold
Gunbarrel - 71st Street	Boulder County	Complete
Kalcevik Gulch	Adams County	Complete
Little Dry - Cl Ck to 64th	Adams County	50% Complete
Lower Hoffman	Adams County, Thornton	Complete
Marston Lake North	Denver	50% Complete
Meadowlark Drainage	Westminster	Complete
Prentice and Big Dry	Greenwood Village	Complete
Ralston/Leyden Feasibility	Arvada, Corps of Engrs	65% Complete
SJCD at Kendall	Jefferson County	Complete
Sand Ck - Buckley to Colfax	Aurora	Complete
Spring Creek	Arapahoe County	Complete
Upper Slaughterhouse	Arapahoe County	Complete
Upper Slaughterhouse	Littleton	Complete
Van Bibber Feasibility	Arvada, Corps of Engrs	85% Complete

STATUS OF DISTRICT CONSTRUCTION PROJECTS

Project	Jurisdiction(s)	Cost	Status
Brighton North Outfall	Brighton	\$650,000	50% Complete
Creekfront at Cherry Creek	Denver	\$1,795,500	Complete
Dayton Street Outfall	Aurora	\$800,000	Complete
First Ave Trib - Phase 2	Lakewood	\$600,000	Complete
Four Lakes Drainageway	Arapahoe County	\$270,500	Complete
Granby/Sable	Aurora	\$752,000	40% Complete
Gunbarrel - 71st Street	Boulder County	\$75,000	Complete
Huron Street Outfall	Adams County	\$2,078,000	95% Complete
I-25/40th & Inca	Denver	\$1,900,000	80% Complete
Lakewood/Dry Gulch	Denver	\$2,100,000	Complete
Lena Gulch @ 20th Ave.	Lakewood	\$500,000	Complete
Lower Hoffman Drain	Adams County, Thornton	\$400,000	Complete
North Branch - Sloans Lake	Edgewater, Wheat Ridge	\$1,500,000	75% Complete
Prentice Gulch at Holly	Greenwood Village	\$250,000	25% Complete
SJCD Flow Separation	Littleton, ArapCo	\$120,000	Complete
Tanglewood Creek at 121st.	Westminster	\$55,000	Complete
Univ/Mex - Ph III & IV	Denver	\$1,400,000	Complete
Upper Slaughterhouse	Littleton	\$1,000,000	Complete
Westerly Creek Dam Repair	Denver, Aurora	\$450,000	Complete

The District and City of Denver, through it's Wastewater Management Division and Parks Department, recently completed construction of a \$2 million project on Lakewood Gulch and Dry Gulch. Approximately \$1 million worth of channel improvements were constructed; which consisted of several drop structures, regrading of channel banks and armoring of the low flow channel where needed. In addition to the channel improvements, approximately

\$1 million worth of park improvements were installed under the same contract. Overall, this project was a good example of local and governmental cooperation and has helped transform what was once a neighborhood eyesore into a resource of which the neighborhood can be proud.

This past year also saw the completion of a project that had its origins in the late '70s. The SJCD Flow Separation project was

completed recently and brought to a conclusion a project that has been in the planning stage for many years. The project consisted of three flow separation structures, two on the Last Chance Ditch at SJCD South and Normandy Gulch and one on the Nevada Ditch at SJCD South. The project sponsors on this project were the Nevada and Last Chance Ditch Companies, the City of Littleton, Arapahoe County and the District. Two of the structures consisted of inverted siphons and the third an elevated flume to carry ditch waters safely across existing drainageways which had been experiencing significant increases in flow due to upstream urbanization.



Four Lakes Tributary channel in Arapahoe County.



Circular drop structure on Dry Gulch (center left) and confluence of Lakewood Gulch and Dry Gulch (top center), a joint flood control and recreation project.



Kalcevik Gulch flow separation structure.



Maintenance access/recreation trail on Coal Creek in Lafayette.

South Platte River Program Notes

by

Barbara Benik, P.E., Project Engineer, and
Ben Urbonas, P.E., Chief
South Platte River Program

Maintenance of South Platte River

In 1992, the South Platte River routine maintenance work included an equivalent of 57 miles of mowing, 8 miles of tree trimming and pruning, and 86 miles of debris removal. Our largest routine maintenance problem remains the removal of dumped trash along the river. The worst example is the dumping of old tires. The photograph shown here only reveals a small part of a single dumping which occurred in October. It consisted of over 350 tires. At another location we found over 300 tires. Clearly, these are illicit and illegal activities that cost the taxpayer. To remove and properly dispose of these two dumpings cost the taxpayer over \$2,100. Because of the large volume, we were able to dispose of tires for only \$0.50 per tire plus the cost of removing them from the river and haul charges. Nearby landfills, however, charge \$3.00 to \$3.50 to dispose of each tire. We have requested the City of Denver and other local governments to look into these types of problems and to prosecute anyone who is caught dumping into the river.

Restoration projects along the river during 1992 included: repair of erosion damages along the maintenance trail and repairs to the trail itself; restoration and revegetation of 1500-feet of bank in Adams County at two locations; installation of a sloping rock check structure in Adams County; revegetation of restored banks at several locations; and modifications to the sloping boulder grade control check structure installed immediately upstream from Mineral Avenue in 1991.

The 404 General Permit that was issued in 1987 expired in November. It was reissued to the District for another five-year period by the Chatfield office of the Corps of Engineers. This permit continues to be a valuable instrument. The average processing time for restorative maintenance activities remains less than nine days and saves both the District and the Corps (including all referral agencies) much staff time and direct cost. These resources are much less than otherwise are spent to obtain an individual permit. Savings in

obtaining these permits are plowed back into bank and river restoration activities, including the restoration of previously destroyed or damaged riparian, avian, wildlife and aquatic habitat.

Cooperative Activities

This year we initiated another cooperative project, which we hope to complete early in 1993. The Bloom project includes approximately 700-feet of bank restoration and stabilization. The owners, Jack and Kathy Bloom, are dedicating to the District an 8-acre easement for river channel maintenance access and flowage right-of-way. Three more cooperative projects are identified to begin in 1993 and we will report on them in the next issue of *Flood Hazard News*.

Capital Improvement Activities

The total replacement of the maintenance/hiker/biker trail between 8th and 13th Avenues was completed as a joint effort between Denver and the District. This trail section was very narrow and included two wood-decked sections. The trail and the decking were badly deteriorated and required much maintenance to keep in operation. Instead of a six-foot wide asphalt trail with very little right-of-way we now have a 10-foot wide concrete trail within ample right-of-way previously owned by a railroad company. Additionally, maintenance trail access ramps were constructed at 8th Avenue.

The District entered into an agreement with Denver to fund the construction observation services for lower Central South Platte River channel improvements. This \$7,000,000 project will rebuild the diversion and boat bypass structure at Confluence park, widen 3,500 feet of river channel and expand the riparian zones along its banks by as much as 100 feet in width. When completed, these improvements will permit eventual removal of over 300 acres within central Denver from the 100-year floodplain.

The third and final phase of bank restoration work between 78th and 88th Avenues was completed. This is a jointly funded project with the City of Thornton that has now stabilized, restored and cleaned up 4,700 feet of bank. As a final step in 1993, we hope to revegetate these river banks with riparian and dry land species for the entire length, which will bring to a conclusion this bank stabilization and restoration project. We are very

proud of how it turned out and invite you to look at it next time you are biking the one-mile stretch upstream of 88th Avenue.

Other News

The concrete dam located in the South Platte River just downstream from Union Avenue was completely modified by the Colorado Water Conservation Board in 1992 to improve boater safety. The previously existing concrete structure dropped twelve feet at a 3:1 (horizontal to vertical) slope. The new installation has created a series of seven drops, each approximately 2.5 feet high, over a distance of about 1,300 linear feet. We are very happy to see this project completed, as there have been two deaths directly attributed to the unsafe nature of the old concrete structure. Now, when there is sufficient flow in the river, this area is wonderful for rafting, tubing and kayaking.



Tires dumped along the South Platte River in north Denver.



Before and after views of the 8th to 13th trail replacement project.

MAINTENANCE PROGRAM ACTIVITIES

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

Program Direction

Submittal of applications for Nationwide Permits under Section 404 of the Clean Water Act has, by now, become second nature for the Maintenance Program. This year brought the addition of two new dimensions to the envelope of permits surrounding work in drainageways.

The U.S. Fish and Wildlife Service, in coordination with the Corps of Engineers, requires that a field survey be done on all projects subject to a 404 Nationwide Permit to determine the presence or absence of the endangered Ute Ladies'-Tresses Orchid. Virtually every construction project we do is subject to the Nationwide Permit. As a result we will be conducting Orchid surveys on every one of our restoration and rehabilitation projects. The best time to do the orchid surveys is during the six-week blooming period from mid-July to late-August. Surveys during other times can be less reliable but will be done if drainageway problems demand immediate attention.

The Water Quality Control Division of the Colorado Department of Health is administering the erosion and sediment control program within Colorado for the EPA. The program requires that a stormwater management plan be designed and a general permit application be submitted to the Colorado Department of Health before construction can begin on any drainageway project disturbing a land area of five acres or more. The Maintenance Program will certainly meet this permit requirement for the rare maintenance project that is five acres or larger. In addition, we will include erosion and sediment control design and construction in every rehabilitation project we do even if it is less than five acres in size.

The Maintenance Program now has an operational database program to accumulate drainageway maintenance costs. We currently have four years of data on file and will have two more years of data entered by early 1993. As with most databases this information can be sorted in a variety of formats. The most likely uses will be to determine annual costs or per-foot costs for a specific

STATUS OF MAINTENANCE REHABILITATION PROJECTS

Project	Jurisdiction(s)	Cost	Status
ADAMS COUNTY			
Middle Branch Hylands	Westminster	design- \$22,000	100%
Drops and low flow		const- \$275,000	0%-phase 2
Grange Hall Creek	Northglenn	design- \$160,000	100%
Drops and low flow		const- \$623,000	100%-ph.1 & 2
ARAPAHOE COUNTY			
Little Dry Creek	Arapahoe Co.	design- \$76,590	100%
Erosion repair		const- \$189,353	20%-phase 1
Big Dry Creek	Arapahoe Co.	design- \$63,242	100%
Branch 2		const- \$300,000	0%
W. Toll Gate Creek	Aurora	design- \$15,000	100%
Summer Valley Ranch		const- \$100,000	0%-phase 3
Willow Creek	Arapahoe Co.	design- \$39,545	100%
Erosion repair		const- \$182,731	100%-phase 1
Lee Gulch	Littleton	design- \$24,196	90%
drop and low flow		const- \$198,000	0%
BOULDER COUNTY			
Fourmile Canyon Creek	Boulder Co.	design- \$6,700	100%
30th st.-drop,bank repair		const- \$65,309	100%
Wonderland Creek	Boulder	design- \$22,450	95%
Diagonal Hwy.		const- \$150,000	0%
City Park Drainageway	Broomfield	design- \$29,693	100%
Park channel repair		const- \$138,190	40%-phase 2
Basin D-Lac Amora	Broomfield	design- \$30,339	75%
Low flow pipe		const- \$150,000	0%
DENVER COUNTY			
Cherry Creek	Denver	design- N/A	100%
Fence replacement		const- \$47,545	100%
Cherry Creek	Denver	design- \$66,705	95%
Drop structures (Holly)		const- \$220,000	0%-phase 1
Cherry Creek	Denver	design- \$103,389	100%
Creekfront		const- \$900,342	95%
Harvard Gulch	Denver	design- \$32,384	75%
McWilliams Park		const- \$195,000	0%
Lakewood Gulch	Denver	design- \$25,000	0%
Channel repair		const- \$175,000	0%-phase 2
Weir Gulch	Denver.	design- N/A	100%
Fence and access		const- \$51,744	100%
DOUGLAS COUNTY			
East Dad Clark Gulch	Douglas Co.	design- \$33,432	100%
drop structures		const- \$329,210	0%
JEFFERSON COUNTY			
Clear Creek	Jefferson Co.	design- \$21,247	100%
52nd Ave drop structure		const- \$114,412	100%
Lilley Gulch	Jefferson Co.	design- \$25,000	0%
Wadsworth to Estes		const- \$125,000	0%-phase 3
Little Dry Creek	Arvada	design- \$26,550	95%
Harlan to Club Crest		const- \$200,000	0%
Ralston Creek	Arvada	design- \$79,813	100%
Along Brooks Drive		const- \$281,763	100%-phase 1
Sloan Lake	Edgewater	design- N/A	N/A
Along 20th Ave		const- \$45,000	0%
SJCD (So)	Jefferson Co.	design- \$ 22,000	0%
Columbine Knolls South		const- \$100,000	0%

(Continued on page 22)

FLASH FLOOD PREDICTION PROGRAM & RELATED ACTIVITIES

by

Kevin G. Stewart, Project Engineer
Floodplain Management Program

ALERT System News

The District-operated ALERT gaging network continues to gain notoriety as it increases in size and more users become familiar with its capabilities. For example, Television Station KCNC (Channel 4) has purchased an ALERT base station and is collecting data directly from the air-waves. Many Denver area residents now know ALERT data as "RAINSCAN 4." Currently there are ten known points in the District which receive, decode and display data from 129 remote stations and 197 sensors. The table below summarizes the system status as of December, 1992.

Boulder County recently expanded their ALERT network by upgrading two sites to full weather stations. One of these sites is located in the Boulder Creek basin near Nederland and the other at Button Rock Reservoir on North St. Vrain Creek. This provides the Sheriff's Department with useful data (wind speed and direction, temperature, relative humidity, barometric pressure, precipitation) for controlling forest fires in the mountains.

The Bear Creek flood detection project, which was funded in 1989, is nearing completion. Permissions are still being sought for installations at a few remaining gage sites. The biggest improvement this year was finding the Choke Cherry Reservoir repeater site at Genesee which is capable of relaying radio signals from the most difficult mountain canyon stations. Special thanks to Don Van Wie of DIAD, Inc. (the District's ALERT system maintenance contractor) for identifying Choke Cherry as the best repeater site for Bear Creek and to Newt Free, District Manager, and the Board of the Genesee Water and Sanitation District for giving us permission to use this site.

Many software enhancements and creative applications continue to evolve at Denver area base stations. This is clearly a never-ending process and, as more computer-literate users begin experimenting with new ideas, the more we can expect to see in the future.

One of the more apparent improvements developed over the past two years is in the use of computer graphics and translated digital mapping from other GIS and

CADD systems (GIS: Geographic Information System, CADD: Computer Aided Drafting and Design). The following precipitation map (Figure 1) illustrates how digital mapping is used to enhance the presentation of ALERT data. Bruce Rindahl, design engineer with the City of Aurora, can be thanked for much of the initial development work.

Another example of graphics aided data interpretation is shown for an Arvada stream gage on Ralston Creek near Carr Street (Figure 2). This color display updates automatically as data is received and if studied closely, you will find 33 sensor readouts including: three hydrographs with variable time scales; one bar graph showing current water surface elevation; and 29 text readouts which provide basin rainfall data, stream stage and discharge at Carr Street; and upstream discharge measurements. Helpful flood information is also provided on the display and if a single picture is not adequate, the software is capable of "zooming" to another display. Similar templates are being developed for all stream gage points in the network.

A future flood detection project is anticipated for the Dutch Creek basin in southern Jefferson County, benefiting unincorporated areas and the Town of Columbine Valley. A planning study is also underway in Douglas County to complete a preliminary detection network design and evaluate potential benefits of implementing a county-wide system. The City of Aurora is looking at expanding their network to provide additional real-time data for water resources management. Creative alternative uses for ALERT data continue to evolve and requests for historic data are increasing. There is no question about it, the ALERT system is now serving the public in

ways that were never thought of when the first gaging network was installed for Boulder Creek in 1979. The District appreciates the contributions of the many dedicated individuals involved with this program.

National Council Being Considered

The Southwestern Association of ALERT Systems (SAAS) and the ALERT Users Group (AUG), representing the western United States, hope to ratify an agreement in 1993 to form a policy advisory council of real-time data users to deal with issues of common interest on a national scale. Examples of such issues include: National Weather Service (NWS) modernization, NEXRAD implementation and related product dissemination, NWS policies concerning local government cooperators, federal allocations and regulations governing the use of hydrologic radio frequencies, flood warning program credit qualifications under FEMA's community rating system, warning programs related to dam safety, Corps of Engineers funded flood warning activities, and others. Initial members of the council will be comprised of selected leaders from the two ALERT users groups. Special steps are also being taken to include appropriate representation from the eastern United States.

The NWS has endorsed this idea at the highest levels. Lou Bouzi, Deputy Director in charge of NWS's Transition Program Office, has been identified as the council's contact at NWS headquarters in Silver Spring, Maryland. Local officials from around the country and many others involved with using real-time hydrologic and meteorologic data are encouraged by the willingness of NWS and other federal agencies to allow us to have a voice in matters which will eventually impact our programs.

CURRENT ALERT SYSTEM STATUS:

NETWORK	STATIONS	PRECIP	STAGE	WEATHER SENSORS
District Wide	12	10	10	4 (1 station)
S. Platte & MP	4	3	3	
Lena Gulch	9	6	3	
Ralston Creek	13	12	8	4 (1 station)
Westerly Creek	10	10	6	
Toll Gate Creek	11	11	8	6 (1 station)
Goldsmith/Harvard	5	5	4	4 (1 station)
Bear Creek	12	11	6	
Boulder County	53	41	12	10 (2 stations)
TOTALS	129	(109)	+ (60)	+ (28) = 197 SENSORS

New Flood Warning Plans

New flood warning plans were released this year for Bear Creek in Jefferson County and Toll Gate Creek in Aurora. The Boulder Creek plan, first written in 1979, was completely re-written in 1992 by including South Boulder Creek and the tributary streams which impact the City of Boulder most heavily. All seven flood warning plans currently in effect have similar formats and will continue to be updated and exercised annually by the District. Upon request, the District also assists local governments with their routine updating of local emergency operations plans and incident command manuals. All District plans are identified as flood annexes or technical appendices to local emergency plans.

Significant Hydrologic Events

The 1992 flood season produced only a few marginally exciting days with the total number of "Message Days" being slightly less than average. April and May passed without any messages being issued. The summer months of June, July and August brought us 29 message days with monthly totals of 11, 10 and 8 respectively. For the first time in the 14-year history of the program, no messages were issued in September. The following days highlight the more notable hydrologic events of 1992:

June 6: It seems like every year, the first week in June can be counted on for something interesting to occur weather-wise. This typical Saturday afternoon won the honors as the first message day of the year, producing a thunderstorm in Aurora that dumped approximately one-inch of rain in 40 minutes between 5:00 and 6:00 p.m. The heaviest rainfall measured by the ALERT system occurred at the Granby Ditch gage near 6th Avenue and Buckley Road. No major flood problems were reported. The stream gage on Sand Creek below I-225 measured its annual peak at 7:18 p.m.

The Henz Meteorological Services (HMS) 3:45 p.m. forecast indicated rainfall amounts just below flood potential and therefore, messages were not issued at that time. As the situation changed, messages were later issued for Arapahoe and Douglas Counties, including the City of Aurora. This event was of sufficient magnitude to prompt the NWS, at 5:45 p.m., to issue an urban and small stream flood advisory effective until 6:45 p.m.

The Westerly Creek basin experienced enough runoff to cause

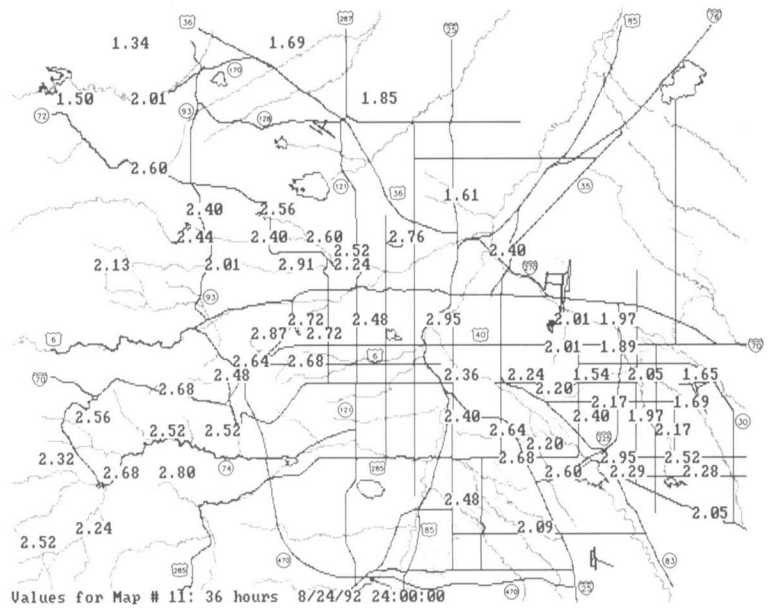


Figure 1. Thirty-six hour rainfall depths for the Denver area on August 24-25.

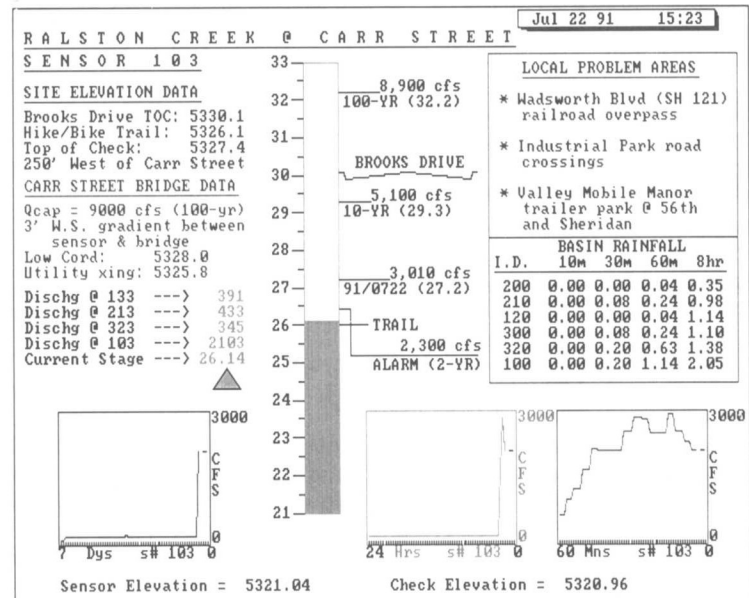


Figure 2. Sensor readouts for the Ralston Creek at Carr St. gage site.



Figure 3. I-25 at Evans Ave. on July 20, 1992.

water in the Expo Park detention basin to rise four feet. An interesting point about this is that it took almost two days for the pond to drain due to a plugged outlet. The ALERT stage gage at Expo Park provided an excellent record of this incident.

July 15: Aurora's turn again! This time it was a Wednesday at the beginning of the hurry-home rush between 4:00 and 6:00 p.m. with the heaviest measured rainfall occurring east of I-225 in the Toll Gate Creek drainage basin. The Sable Ditch ALERT gage near 18th and Chambers received 1.54" of rain over a 75-minute period with nearly an inch occurring in 30-minutes. Aurora street crews were mobilized and preparing for problems by 4:00 p.m. HMS messages were issued for Aurora at 3:32 p.m. The NWS had a severe thunderstorm warning in effect for SW Adams and NW Arapahoe Counties at 3:40 p.m. and flood advisories were issued for Aurora by 4:40 p.m.

On July 17, a highwater survey was performed for the District by Leonard Rice Consulting Water Engineers, Inc. of Denver. This type of activity is routine for the District in documenting flood events, but in recent years, more emphasis has been placed on verifying the performance of stream gages. This gives us added knowledge about rainfall/runoff processes in the Denver area, permits us to further refine hydrologic models, and improves our capability to detect and predict of floods with greater lead-time for warning.

Annual peaks were measured on this day at the following Aurora gage sites:

- Sable Ditch at 18th Ave.
- Westerly Creek basin at 11th & Havana.
- West Toll Gate Cr below Mexico.
- East Toll Gate Cr at Buckley Rd.
- Toll Gate Creek at 6th Ave.
- Granby Ditch at 6th Ave.

July 20: This Monday afternoon produced the most intense measured rainfall of the year in Denver causing a closure of I-25 at Evans from reported 4-foot water depths on the freeway (Figure 3). As usual, the storm waited for the evening rush-hour to begin with the peak rainfall occurring between 4:00 and 5:00 p.m. The storms on this day were small in size and short-lived, lasting generally no more than 30 minutes. However, those 30 minutes were quite impressive at some locations. The Harvard Gulch ALERT station at Jackson Street, located northwest of

the Yale Ave.-Colorado Blvd. intersection, is the nearest automated rain gage to where the I-25 flood problem occurred. This station measured a total amount of 1.50" in 28 minutes beginning at 4:13 p.m. with a peak 5-minute intensity of 5.4 in/hr. This intense 5-minute period has a calculated rainfall frequency of 10-years. The most intense short-duration rainfall measured on this day was at the Virginia Court gage in Aurora where a 5-minute intensity of 7.2 in/hr (~ 25-year frequency) was recorded.

By 3:30 p.m, internal alert messages had been issued for NE Jefferson, western Adams, western Arapahoe and Denver Counties valid from 4:00 to 9:00 p.m. Forecast rainfall was estimated to reach 0.75" to 1.50" and last 30 to 45 minutes. A tornado watch was also in effect for the entire District. The NWS extended an urban and small stream flood advisory at 4:53 p.m. reporting flooded road conditions on I-25 and near Iliff and Chambers in Aurora.

Annual peaks were measured on this day at the following Denver gage sites:

- Harvard Gulch at Jackson St.
- Harvard Gulch at Logan St.

August 24: Beginning shortly after noon on Sunday, August 23, 2 to 3 inches of rain proceeded to fall over the next 36-hours making this period the most significant area-wide hydrologic event of 1992 (see Figure 1). While the runoff volume was high due to the large area affected, rainfall intensities never reached 1.0 in/hr alarm levels and the flash flood potential remained relatively low all day. The most intense hourly rainfall measured by the ALERT system occurred in Boulder at the Boulder County Justice Center, at 6th Street and Canyon Blvd., where 0.6 inches fell between 5:00 and 6:00 a.m. For most areas, hourly rainfall amounts averaged one-quarter inch or less.

Weather forecasts and reports were continually updated throughout the day. The main heavy precipitation concern involved the remnants of a Pacific hurricane which approached the District from the southwest. The eye of the hurricane was apparent on satellite photos and pased just south of the District over Douglas County continuing its northeasterly movement over Bennett, Colorado, missing the metropolitan area of Denver. Local officials were kept continually advised of this situation. The NWS issued a flash flood watch on August 24 at 5:45 a.m. which

expired at 9:00 p.m. NWS and HMS meteorologists remained in constant contact, demonstrating excellent coordination. A flood advisory was issued for the Denver area at 2:30 p.m. due to rainfall cumulations exceeding two inches at many locations.

Annual peaks were measured on this day at many stream gages throughout the Denver metropolitan area. The most note-worthy discharges occurred on the South Platte River. The Henderson gage peaked at 8:15 p.m. with a discharge of 11,770 cfs, which is slightly less than a 10-year flood event. Many other tributary streams such as; Bear Creek, Cherry Creek, Sand Creek and Clear Creek, were also running much higher than normal but their peak flows generally did not exceed a 2-year flood frequency. Some minor records were also set, like at the Englewood Dam ALERT gage in Arapahoe County which measured its highest water level since installation in 1987.

The flood problems that did occur were anticipated and the public was well informed by television and radio stations. The biggest reported problems involved drainage related traffic hassles at known trouble spots but the river rafters had a great time.

This concludes our discussion of what we have identified as the most significant hydrologic events of the year for the District based on measured rainfall and streamflow data and some eye-witness reports. We would appreciate hearing from readers who may be aware of other flood days and receiving any documentation that may be available. Anyone interested in more specific ALERT rainfall or streamflow data should contact the District.

NEXRAD Is Coming To Denver

Larry Mooney, Area Manager at the Denver National Weather Service Forecast Office, has indicated that Denver's NEXRAD radar is scheduled for an April, 1993, delivery. The new Doppler radar will be located near Watkins, Colorado, and is expected to be turned on by mid-summer. Use of the existing radar at Limon will eventually be discontinued. This project is one component of NWS's nationwide modernization plan involving replacement of all existing weather surveillance radars, many of which utilize 1950's technology. In addition to providing much higher-resolution imagery, the new Doppler radars have many other capabilities as illustrated by Figure 4.

The District has taken steps to prepare for the arrival of NEXRAD. A radar options study was completed in 1992 which recommends utilizing the District's existing satellite downlink receiver and purchasing a Kavouras RADAC 2100 computer to display the new radar products. In addition, the RADAC 2100 is capable of displaying satellite pictures and data from other surrounding radars, including Limon. Other users currently sharing the District's dedicated phone line from Limon must now consider alternatives for obtaining live radar. The options study suggests some possibilities but each organization must consider their own requirements. The District does not intend to leave anyone hanging and will keep each group informed regarding decisions that may affect them. Change always offers many new challenges, but the first question for many government agencies will likely be: Are the acceptable alternatives affordable?

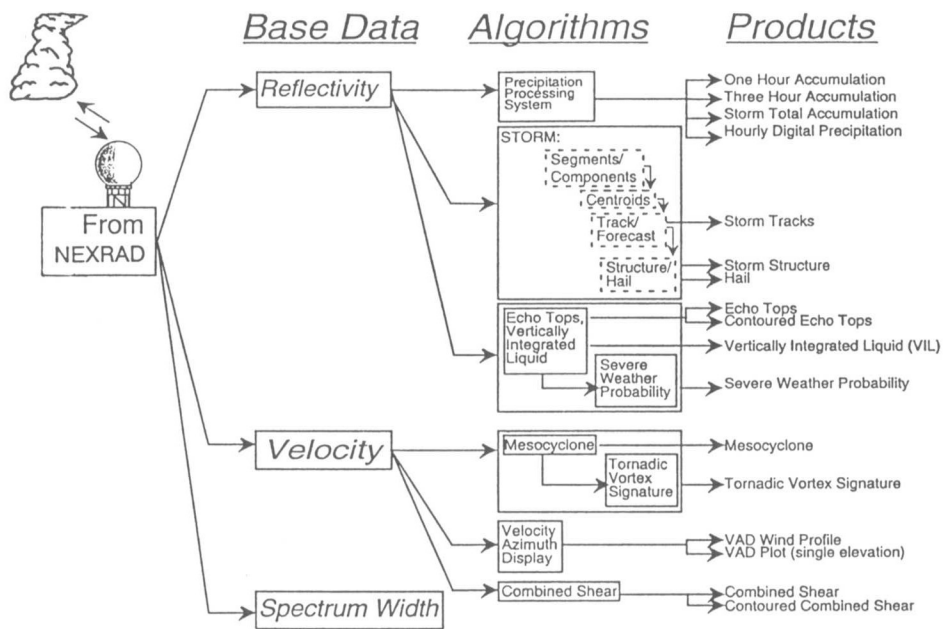


Figure 4. NEXRAD Capabilities.

Tucker (from page 3) contact these cities for additional information.

The Water Pollution Control Act - It Is Time For A Change

On a somewhat different but related issue, I have begun to question the soundness of the basic premise of the Water Pollution Control Act (WPCA). The WPCA was originally passed in 1972 and constituted a dramatic commitment of the nation to clean up our rivers, lakes, streams and wetlands. Strong language was needed as well as lofty goals because water pollution was a problem and there was a long way to go. Because of the WPCA, the U.S. has made significant improvements to water quality, but as obvious problems are addressed emphasis is shifting to other pollutant sources where benefits will not be so apparent and easily identified.

My concern is with the first sentence of the WPCA which states that "The objective of this Act is to restore and maintain the chemical, physical and biological integrity of the nation's waters." Taken literally, the word, "restore" is troubling. Water quality is critical to developing usable, attractive and safe urban stream corridors but it is unrealistic to think in terms of "restoring" the chemical, physical and biological integrity of developed urban stream corridors now existing in our urban

metropolitan areas. Again, taken literally, it is a stated objective of the nation to return these stream corridors to a condition that predates settlement. This is not a realistic objective and not the right objective. The clock cannot be turned back to pre-settlement times.

Realistically, it is even difficult to apply specific criteria to such goals as biological integrity. For example, the State of Colorado is considering the adoption of biological criteria as water quality standards. The Water Quality Division staff concluded that biological criteria should not be adopted as Water Quality Standards at this time. Among other reasons, they cite the lack of data for streams in Colorado that can be used for specifying appropriate "reference reaches" or assessing the comparative biological integrity of impacted streams. They also note that it is extremely difficult to find unimpacted reference waters for the water bodies and habitat types which are commonly affected by point source discharges in Colorado.

It is time to reassess the goals of the WPCA and bring them closer to reality. Good water quality must remain a high priority and good water quality is an important and necessary component of a viable urban stream corridor. However, urban stream corridors have a unique value in an urban context and provide important character to the urban environment

and they need to be preserved and enhanced for what they are. It is not practical to think in terms of restoring the physical, chemical and biological integrity to some predevelopment condition. They are forever changed.

Coal Creek Trail

Another segment of the Coal Creek trail, a joint recreation and maintenance access project, was completed in 1992. This section is located in Lafayette, and connects to a segment of trail constructed through Louisville Open Space and dedicated the same day. This segment was funded by Lafayette, Boulder County and the District.



Boulder County Commissioner Ron Stewart (right) and Lafayette Mayor Larry Gupton cut the ribbon officially opening the trail.

DETENTION (from page 1)
facilities such as soccer and ball fields in the future.

Advantages and Disadvantages

Multiple use has many potential advantages for the local government and/or the land developer. The most obvious advantage is cost savings. Right-of-way, construction, and maintenance costs can all be shared, resulting in overall lower costs than for separate side-by-side facilities providing the same functions. Many times existing parks are the only open land available for the detention option in a remedial flood control project. Reconfiguring an existing park to provide detention can result in more cost effective flood protection while rebuilding or upgrading existing park facilities. Conversely, park and open space facilities are often added to detention ponds.

The only disadvantage of this concept, for new facilities, is that of infrequent flooding. Retrofitting detention into an existing park has the additional disadvantage of temporary disruption of the park during construction.

Maintenance

A standard maintenance approach to take with multiple use facilities is to enter into an agreement with the entity responsible for park maintenance which outlines the responsibilities of both park and flood control interests. Typically, park interests are responsible for routine park maintenance activities such as irrigation and mowing. Flood control interests take responsibility for all flood deposited debris clean up and all flood related damage, such as erosion.

Proper design is also important in minimizing maintenance requirements. District guidelines include the following: 1) Pond side slopes must be 4:1 or flatter, 2) Trickle (low or constant) flows must be controlled in a trickle channel or pipe (except in water quality ponds), 3) Pond bottom cross slopes must be a minimum of 2% and the need for an underdrain system must be considered, 4) Maintenance access ramps to the bottom must be provided and should meet handicapped access requirements if they double as recreational trails, 5) Safety racks and railings should be provided on outlet structures, and 6) All tributary inflow points should be adequately protected to prevent erosion and control trickle flows.

Examples

The following are representative examples of multiple use facilities constructed by the District and local sponsors:

Herbert Hosana Park (Figure 1) - A school site was used for an off-line detention pond. An adjacent landscaped channel will carry flows up to the 25-year flood peak. The abutments of a pedestrian bridge crossing that channel create the restriction which forces larger flows into the detention area. The project required the excavation of 225,000 cubic yards of fill, installation of an extensive underdrain system and outlet works for releasing the stored floodwaters back to the adjacent open channel. The school grounds were transformed into irrigated play fields including soccer fields and a baseball field complete with press box and bleachers.

Jefferson High School - The Jefferson High School athletic fields in the City of Edgewater were built across a tributary to Sloans Lake with only an 18" RCP for drainage. As the upstream basin urbanized, flooding of the fields and the neighborhoods downstream became a frequent occurrence. The solution was an off-line detention pond in the athletic fields. The design consists of a 5-year storm sewer under the athletic fields and a small embankment on the downstream side of the fields. Storm flows up to the 5-year peak are now carried under the fields and into the downstream storm sewer system, with flows in excess of the 5-year discharge being detained on the athletic fields. The benefits of this solution are 100-year flood protection downstream and much less frequent flooding of the athletic fields.

Citizens Park (Figure 2)- The same off-line concept was used on another Sloans Lake Tributary in Edgewater, only this time in an existing city park. Five-year peaks bypass the detention facility in a storm sewer in the adjacent street. Larger flows, up to the 100-year event, are diverted off the street into the park. This project provides 5-year protection upstream from the park and 100-year protection downstream. It also included a complete reconstruction of the park with a new restroom and pavilion facility, league-sanctioned horseshoe pits and a lighted ball field.

Wallace Park (Figure 3) - The District, Denver and the Goldsmith Metro District (representing a major

office park development) jointly funded the construction of two detention ponds in a planned park on Goldsmith Gulch. The park provides flood protection, park facilities for the office park and adjacent residential neighborhood and also acts as a buffer between the office park and the neighborhood. Although the ponds were designed as on-line detention, the outlet works were sized to allow the more frequent events to pass through the ponds with little or no detention storage. Only in events of 10-year or greater is there any significant amount of detention storage. This serves to reduce the amount of maintenance and cleanup needed as a result of floodwater storage while at the same time optimizes the 100-year peak reduction.

Rotary Park (Figure 4) - The District and City of Westminster reconstructed and significantly enlarged a small on-line detention pond in the existing Rotary Park. Construction consisted of removing 16,000 cubic yards of material, a new outlet works and emergency spillway and realignment of trickle flows through the park. A concrete low flow channel was constructed along the toe of one side of the pond thus allowing most of the pond bottom to be used as uninterrupted play fields. The whole area was reconstructed with a new irrigation system and sod. A playground was also reconstructed and enhanced. All of the recreational facilities were situated above the frequent inundation areas to limit the frequency of flooding.

Open space and detention - The District owns the embankment for Holly Dam, an on-line flood control facility. South Suburban Recreation and Park District owns the flood pool (24 acres). Tennis courts have been constructed in a terraced fashion beginning at the 10-year flood elevation. A pool and dressing rooms were built above the 100-year level. The District also owns the Englewood Dam embankment with South Suburban owning the flood pool (175 acres) which is being set aside as open space, wetland, and wildlife habitat areas. The District and Boulder County recently constructed a small on-line detention pond on a parcel of City of Boulder owned open space. Special precautions had to be taken to protect the open space values of the land. The process of obtaining permission to use the land was a difficult one but the result was a cost effective flood control project which

enhanced the open space values of the land while at the same time providing much needed downstream flood protection.

Pond "D" (Figure 5) - In 1985, the District and City of Louisville constructed a large on-line detention pond on a rapidly urbanizing drainageway within the City. In addition to providing downstream flood protection, the detention pond was designed to allow for future play fields in the bottom of the facility.

The City recently completed construction of its recreation center adjacent to the detention pond and will now install the play fields.

Conclusions

The above examples include building new detention in existing parks and athletic fields, building new parks in existing detention facilities, building joint park and detention projects, building detention in publicly owned open space, and

obtaining and managing open space in a flood pool area. Many other similar projects have been implemented in the Denver Metro Area. These examples have one thing in common: the joint use of public land and money to provide multiple benefits to society in a cost effective manner.

Editor's Note: This paper was originally presented at the 1992 annual conference of the Association of State Floodplain Managers.



Figure 2. Citizens Park in Edgewater. Home plate is near the high point in the pond bottom. Note the embankment beyond the outfield.



Figure 3. Water features were incorporated into the design of Wallace Park in Denver.

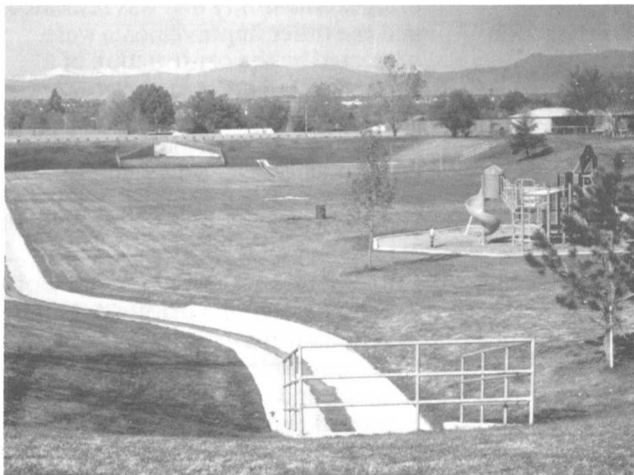


Figure 4. Rotary Park in Westminster. The playground equipment was placed near the high point of the channel bottom.



Figure 5. Pond "D" in Louisville taken from the embankment. The outlet works is in the foreground and the new recreation center is in the background.

Maintenance (from page 15)
drainageway or for a selected type of drainageway.

Restoration Maintenance

In 1992 the restoration program completed nearly \$1.0 million worth of work. About 55 individual projects were completed.

Three separate projects in Jefferson County continued trickle/low flow channel construction that was started last year. The North Tributary to SJCD South was improved by Jefferson County and the UDFCD Capital Program in about 1980. In recent years the unlined trickle channel has eroded the channel banks resulting in dangerous steep banks and threatened public or private improvements. This year's work will complete the installation of an eight-inch deep concrete trickle channel which will help to reduce erosion and make the drainageway more maintainable.

On Lakewood Gulch east of Wadsworth and on Lena Gulch north of 32nd Avenue the problem is the same as described above. Both channels have been sandwiched between residential development with little room left for the creeks to act like natural creeks. Boulders are being used to line the edges of both channels to arrest the lateral erosion. The longitudinal grade of both creeks is stable so the creek bottoms will be left in the natural condition.

The drainage channels in the Montbello area of northeast Denver are concrete lined. The older channel sections are 20 to 30 years old. The sandy soils have provided a stable base for the concrete structures, however some of the channels are cracking and heaving. The old design drawings

show a section that lacked reinforcement and underdrains. Also, the section is not capable of shedding sheet flow at the top of the concrete panels. We are replacing reaches of the channel as funds and priorities permit. The new cross-section includes reinforcement, underdrains, and a shoulder at the top of the section.

Plaza Drive Creek is a small drainageway with a 2% longitudinal grade. In early 1992 we installed "Landglas" across the bottom of the channel. "Landglas" is an inert glass-strand material that is "shot" onto the subgrade and then set in place with an asphalt emulsion. This summer, before the vegetation had become established, Plaza Drive Creek suffered a runoff event that eroded a portion of the channel. We repaired the erosion and since then the vegetation and "Landglas" appear to have stabilized the channel. So far, the product has met our goals of being a cost effective erosion reducing installation that conforms to the ground surface, is inert to sunlight and weather degradation, and provides an open matrix to allow vegetation growth.

Rehabilitation Maintenance

Twenty-four projects were at various levels of design or construction during 1992. Those projects are listed in the accompanying table titled "STATUS OF MAINTENANCE REHABILITATION PROJECTS". Each county had one or more large projects that were constructed in 1992. By the end of 1992 we will have spent about \$3.8 million on rehabilitative design and construction. A few of the unique projects are



Dry Gulch boulder lined low flow channel.

discussed below.

Grouted Sloping Boulder Drops - Drop structures built of sloping grouted boulders have become the standard against which other drops are compared. The main advantages of this type of drop are ease of construction, wide range of design heights and shapes, reasonable costs, and safety.

A 12 foot tall drop at the upper end of **Hidden Lake** in Westminster has stopped a headcut that was a serious safety problem and was about to undermine some private fences. A very similar headcut on **East Dad Clark Gulch** in Highlands Ranch in Douglas County was about to erode a wetland and a planned open space area. A fifteen foot tall grouted sloping boulder drop will be built this winter to solve this erosion problem. At the 52nd Avenue bridge over **Clear Creek** in Jefferson County a utility line had been exposed and the bridge pilings were about to be uncovered. Continued degradation of the creek would have undermined existing bank protection just upstream of the bridge. The utility line was relocated and the other improvements were protected by the construction of a seven foot tall drop.

Cherry Creek - Between Market Street and Colfax Avenue in downtown Denver a \$2.9 million project is nearly finished. Maintenance Program funding was combined with UDFCD Capital Program money, City of Denver Bond Program funds, and private donations to rebuild three deteriorated drop structures, build a reinforced low flow channel, and construct a creekside plaza and linear parkway. The three drops were relocated and combined into two stylized grouted boulder drop structures. This urban amenity is an example of multi-agency funding of a multi-use facility.

Willow Creek - As upstream development has occurred, this creek, in Arapahoe County north of County



One of the Creekfront drop structures.

Line Road, has experienced increased base flows and a rapid lowering of the channel invert. What was a shallow stream flowing through small meadows and stands of trees just a few years ago had become a creek in a five foot deep incised channel. Two drop structures were built to stop the degradation, but very little channel work was done in order to preserve the natural open-space character. This was also our first project to include design and construction of specific project components to reduce site erosion and to capture sediment generated by the construction. We were pleased with the effectiveness of these efforts.

Ralston Creek - Located north of 58th Avenue in Arvada, this creek had been pinched into a 45 foot wide easement between residential developments. Since the low flow channel had a top width of 15 to 20 feet this did not leave much room for an active creek. The right-of-way was so confined that all equipment movement and construction had to be done in the creek-bottom. Our original intent was to leave the channel bottom natural. Unfortunately, the bottom was so soft we had to put riprap in many places to stabilize the subgrade. The main purpose of the project was to install stacked boulder bank protection on both sides of the creek. The boulders were placed in a natural almost-random pattern to make a pleasing channel alignment.



Before and after views of the Hidden Lake inlet channel maintenance.



A wetland bottom channel on Walnut Creek in Westminster designed according to the Urban Storm Drainage Criteria Manual within one year of completion.

BIDTABS UPDATE

The District has recently completed an update of the BIDTABS program. The database now has a complete list of all UDFCD bid tab information for years 1990 through 1992. The data is now manipulated from its own computer software program and does not require any additional software programs to execute it. It can be run on an 8086 CPU or better (for those of you not into computers, that is an IBM XT). We feel the new BIDTABS program is user friendly due to its menu driven format.

The program utilizes two reports to give the user information regarding unit prices of recent bids. The first report offers the user a query screen allowing the user access to specific bid categories along with the high, low and average unit bid prices for various construction items. This can be very useful when estimating the cost of new construction. The second report offers access to all the unit bid prices for a specific project.

If you would like a copy of this data, free of charge, please submit to the District, to Paul Hindman's attention, two 5-1/4" 360K floppy disks, or one 5-1/4" 1.2 meg floppy, or one 720K 3-1/2" disk along with a self-addressed stamped 8-1/2" x 11" envelope. Instructions for the BIDTABS program will be included with its return. Please include \$1.44 on the envelope to cover postage.

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