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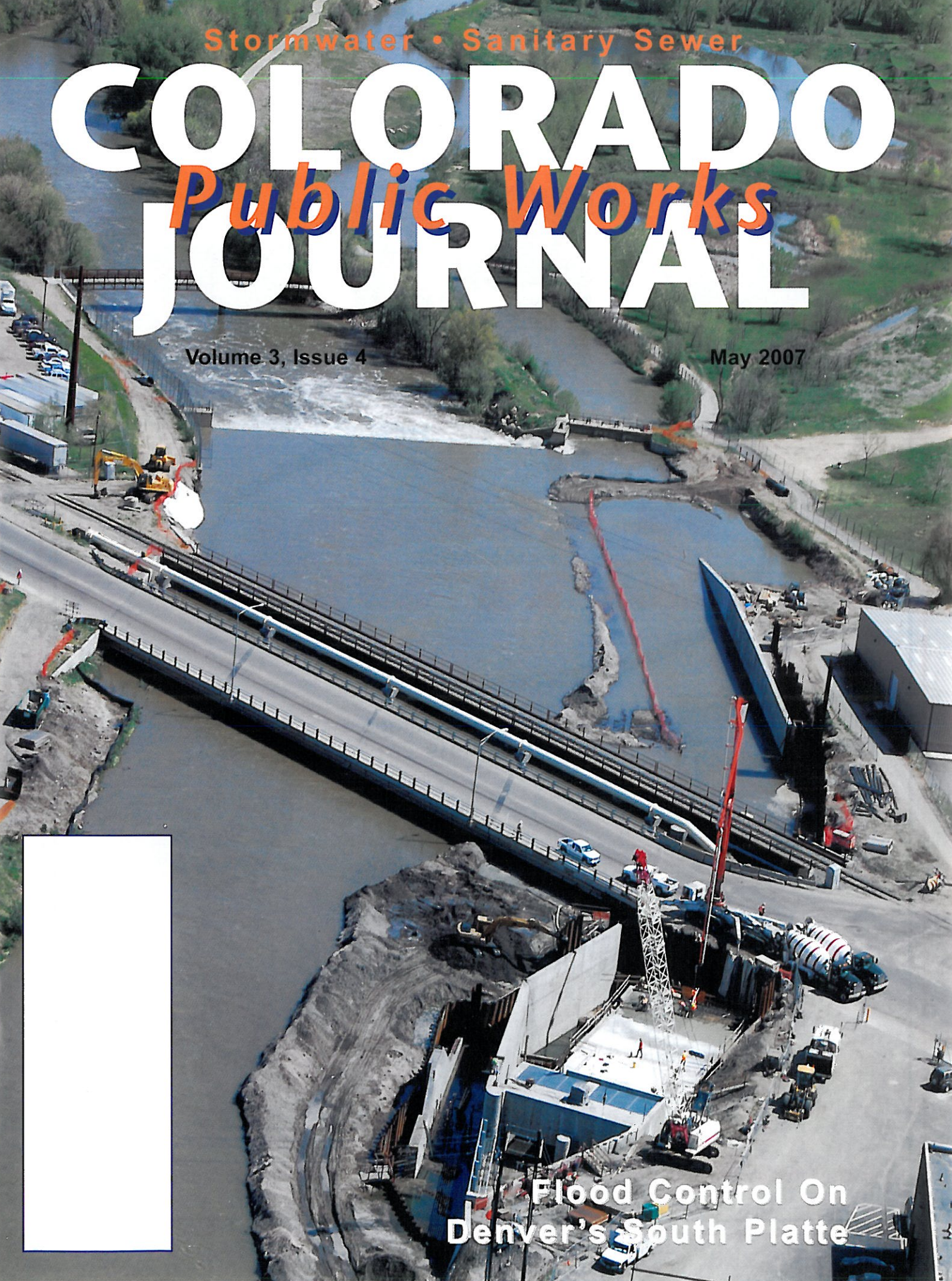


Flood Control On Denver's South Platte

Urban Drainage & Flood Control District: A History Of Accomplishment

Over 80 percent of Colorado's total population resides in a geographic area just east of the Rocky Mountain foothills that constitutes less than 10 percent of the state's total expanse. Between 1970 and 2005, Colorado's population more than doubled, resulting in growth that has melded these "Front Range" communities into a seemingly-continuous strip of development, from Fountain on the south to Wellington on the north. With this growth has come an unprecedented level of importance on inter-governmental cooperation – a level further magnified by agency budget limitations. Managing growth by sharing costs for mutual benefit wherever possible is the strategy of today's prudent local governments.

While this is nothing new for communities in the Denver metro area, officials in formerly outlying areas have not only had to develop infrastructure, they've had to make it jibe with that of their now-abutting neighbors. Those officials have naturally looked to the larger agencies for example, both good and bad.

When it comes to flood control, coordinated cooperation is the key. Development creates storm runoff that can result in catastrophe downstream, so all agencies in the watershed must develop systems that capture and control runoff as close as possible to where it falls as rain. Colorado legislators were impelled to action in June 1965 when severe thunderstorms sent a volume of water some 40 times greater than normal raging down the South Platte River toward Denver. Though certainly not Colorado's first major flood, it was far and away the most costly, destroying over 25 bridges, inundating over 250,000 acres of eastern plains farmland and leaving a swath of damage from Littleton to Julesburg estimated at over a half billion dollars.

One of the legislature's resulting actions was to establish the Urban Drainage and Flood Control District for the purpose of assisting local governments in the Denver metropolitan area with multi-jurisdictional drainage and flood control efforts. The District, now commonly referred to simply as "Urban Drainage," began operating in 1969 as an independent agency, with a modest-sized staff, governed by a board of directors consisting primarily of various elected officials of member communities supported by two registered professional engineers.

Now in its 38th year, Urban Drainage has certainly established itself, serving an area of over 1600 square-miles and operating four distinct programs under a $22 million 2007 budget. Though the agency has accomplished much since those earliest years, it has remained true to its original concept: to *keep the staff small* and to *utilize private consultants and contractors* as much as practical.

The following paragraphs describe the District's first few years, paraphrased from a three-part article authored by Kenneth R. Wright, P.E., in 1970 for *Concrete Pipe News,* a quarterly publication of the American Concrete Pipe Association.

A cooperative effort to deal effectively with the problems of urban storm drainage. . .

To implement the objectives of developing a comprehensive approach to storm drainage in the Denver area, a three-stage program – covering criteria, master planning and construction – was initiated by the Denver Regional Council of Governments in 1967. Much of the nation's urban growth through the 1950s and '60s was generally unplanned and rather haphazard. Citizens living in new housing tracts were usually enticed into annexation through water and sewer services, the primary and sometimes only real benefit municipalities could offer to encourage incorporation.

As roadways are paved and structures are built, runoff is increased due to the correlating increase in imperviousness; yet controlling runoff was not a priority when compared to the importance of providing drinking water and processing human waste. "Give the rainwater time and it will find its balance with the environment" was the prevailing attitude.

Surveys strongly reflected an absence of coordinated leadership in controlling storm runoff in communities all across the country. The Denver area was no exception, having approximately 40 separate government entities independently attempting to manage storm events within their boundaries. But Denver was unique in one respect – a movement had been created among several dozen engineers in the area who recognized the necessity of regional harmony in stormwater control objectives.

These engineers, together known as the "Five-County Engineers Group," reasoned that potentially great urban costs resulting from flooding would be minimized if only planners would treat natural drainage routes as design constraints on development. A local survey helped prove the point, and the group was soon recognized as the Urban Drainage Advisory Committee of DRCOG and became the driving force in guiding the Urban Drainage and Flood Control District Act through the state legislature and into law on July 1, 1969.

Member governments of DRCOG each contributed funds for the preparation of a standardized criteria manual that would provide order to the chaos existing in drainage planning and design, improve the urban environment and provide a sound basis for future drainage improvement expenditures. Large volumes of runoff would continue to flow downhill following natural and historic routes, the committee pointed out, no matter what regulations were decreed or ordinances were passed. That fact would be the underlying principle in everything Urban Drainage would set out to accomplish.

Resolving stormwater problems in the Denver Metro area would now take a unified and integrated approach. With the District's 15-person Board of Directors seated, little time was lost in organizational undertakings. James Quinn, P.E., was hired

Harvard Gulch in southeast Denver in 1965, opposite page, and after flood control improvements, above.

as Urban Drainage's first Director, and he established a multi-pronged approach for the area that would summarize current drainage problems and establish priorities for corrective measures, stop new problems from further developing and institute the provisions of the Flood Insurance Act of 1968.

Quinn understood the fact that effective floodplain zoning was the most important single tool available to reducing costs of damage caused by flooding. Working closely with municipal entities would be paramount to success and would allow for problems to be dealt with at the proper level. The District would not be a cure-all; people would have to be the driving force. The organization merely provides the political body necessary for oversight of coordinated strategies that make mankind more compatible with the natural environment.

A significant step forward in coordinating flood control activities was the publishing of the *Urban Storm Drainage Criteria Manual*, an over-two-year project completed in the District's first official year of operation. Five hundred copies of the two-volume, 800-page reference guide were distributed throughout Colorado and other parts of the nation as well as to selected foreign countries. The manual brought together the gamut of drainage practice from policy to hydraulic structure design and construction. Implementing the recommendations of the manual was Urban Drainage's mission.

The law allowed the District to undertake flood control and drainage projects, giving it responsibility for improvement and maintenance of drainageways as well as power of condemnation. Additional broad powers with respect to drainage and flood control were also given, including instigating floodplain zoning laws and flood-proofing measures.

Work done in terms of construction projects would not be the yardstick used to appraise Urban Drainage's efforts, even though the projects to be undertaken would certainly be significant. True measure of success is the depth to which drainage philosophy and concepts are adopted. Such a policy stresses non-structural approaches to storm control, those that require more brain and less brawn. Relying on sensible zoning, creative flood protection and proven upstream concepts will not only reduce flood damage, it will reduce the cost of reducing flood damage.

New developments would now be required to

National Flood Insurance Program

Created through the National Flood Insurance Act of 1968, NFIP makes it possible to insure property against damage from flooding. Nearly 20,000 communities across the United States and its territories participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes Federally-backed flood insurance available to homeowners, renters, and business owners in these communities. Community participation in the NFIP is voluntary.

Flood insurance is designed to provide an alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods. Flood damage is reduced by nearly $1 billion each year through communities implementing sound floodplain management requirements and property owners purchasing flood insurance. Additionally, buildings constructed in compliance with NFIP building standards suffer approximately 80 percent less damage annually than those not built in compliance.

In addition to providing flood insurance and reducing flood damages through floodplain management regulations, the NFIP identifies and maps the nation's floodplains. Mapping flood hazards creates broad-based awareness of the flood hazards and provides the data needed for floodplain management programs and to actuarially rate new construction for flood insurance.

www.fema.gov/business/nfip/

create a system to collect, retain and slowly release stormwater runoff through localized ponding. Cities and Counties would be required to institute master planning of major drainageways so that land or right-of-ways to property can be acquired in advance of need.

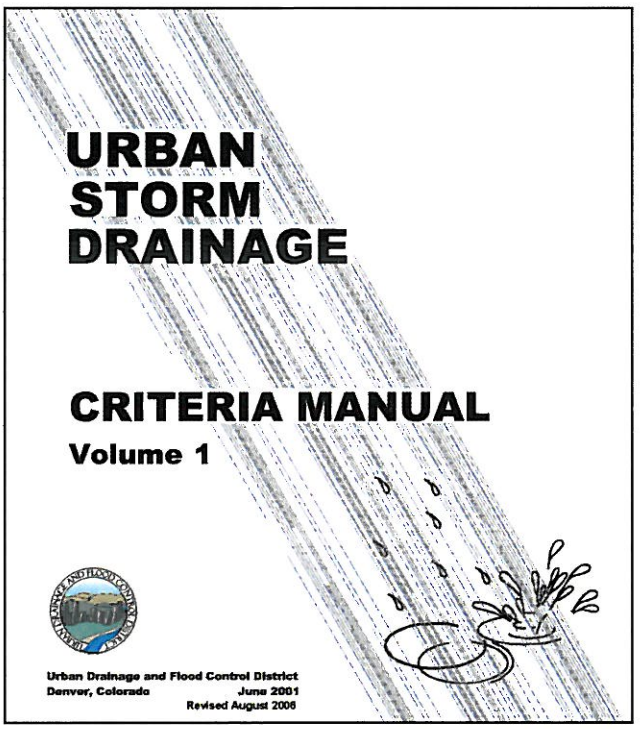
Though only about 10 percent of the land area of Denver was included in the District's preliminary engineering study, it was believed that the floodplain regulation approach would be the most successful and least costly procedure to prevent the creation of new problems. A unique sample floodplain regulation was developed for use in the manual that allowed for land value to be factored in, especially where the floodplain is typically wide and subject to shallow levels of water. Developing rainfall/runoff relationships for specific areas would be critical to overall success, yet would take time to study the effect of urbanization on runoff and develop a corresponding base of data.

"The key to the Denver success," Wright wrote, "will be the engineer's imagination, backed up by competent attorneys, administrators and public officials – people willing and able to strike out on new frontiers of urban drainage practices and concepts."

Denver Mayor Tom Currigan, left, and Ken Wright, right, of Wright Water Engineers Inc. at the April 1967 christening of flood control improvements on Harvard Gulch. WWE provided design services on the project.

Criteria Manual Promotes A Philosophy While Defining Problem-Solving Procedures

When one accepts the fact that storm runoff obeys the laws of gravity, does not respect political boundaries and will flow down major storm runoff routes even though development may be situated unwisely in respect to these routes, one then understands the need for regional approaches to storm drainage and flood control efforts. Historically, stormwater had always been treated as a common enemy; yet in the 1960s, as more people were making Colorado their home, a group of dedicated professional engineers were instead seeing runoff as a needed resource.



Following a regional approach to stormwater control establishes standardized policy, techniques and design criteria for those governments working together. The great variance in techniques used throughout the country was well-documented in a study of 32 major cities conducted in the mid-'60s. Review of practices in the Denver area at that time revealed a similar hodgepodge and made clear the need for complete analysis of storm runoff, including determination of peak rates, total volume and time-distribution of flow. These were considered the "hydrologic aspects of urban drainage" – that part of the drainage engineer's work which has potentially the most significant effects on the success of efforts.

Hydrologic data can provide the basis for all planning, design and construction of drainage systems. To be in error on the hydrology means systems are either undersized, oversized or just out of hydraulic balance. Because stormwater controls are based on approximations, the depth of data analyzed is critical to accuracy. In the 1960s, there was little specific-area data available. Simply put, too little was known about factors influencing the correlation between rainfall and runoff in urban areas. In 1967, the City and County of Denver constructed two discharge gauges and installed three rainfall gauges on Harvard Gulch to help develop an understanding of rainfall-runoff relationships. It was eventually concluded that rainfall-runoff data from one basin could be readily utilized for other, similar basins within the region.

Urban Drainage and Flood Control District's *Urban Storm Drainage Criteria Manual* is the key tool used to coordinate multiple efforts to create an urban infrastructure that prevents flooding. By dealing with the broad scope of considerations, the *Manual* presents urban flood problems and solutions in proper civil perspective. Creating the first edition was a monumental undertaking that required a truly widespread effort. Nearly all of the governmental bodies in the Denver Metro area contributed to a special account established by the Denver Regional Council of Governments and matched two-for-one by the U.S. Department of Housing and Urban Development. There was enough money, in fact, to also fund research by the U.S. Geological Survey to collect and record additional rainfall-runoff data to be used in the *Manual.* Government and local engineers worked together to choose the best gaging sites.

The *Manual* was primarily envisioned to provide technical design criteria in a manner which would be suitable for adoption by practitioners from different government entities. It would present the best current practices along with the latest developments in an easy-to-update format. It was important not to incorporate techniques or methodologies that were not proven or had been determined ineffective or impractical. To ensure this, local engineers contacted professional counterparts in selected cities across the nation to gain knowledge by sharing experiences. It quickly

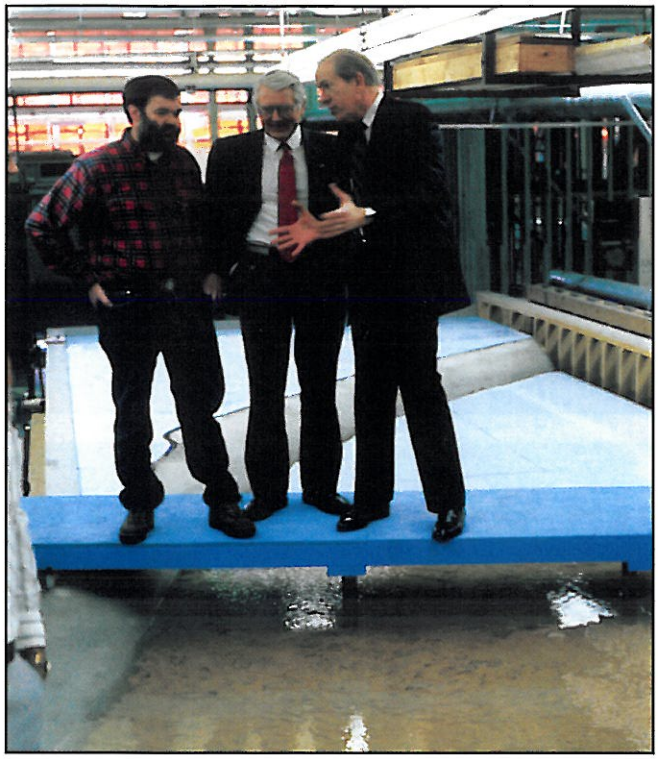
became evident that while cities were spending meaningful amounts of both time and money on urban drainage works, few standardized approaches were being utilized. Planning was typically for the very short term and often only done to meet immediate needs. Significant advances in hydrology needed to be better communicated to practitioners in the field, and the *Manual* could help do that.

It was decided to develop the *Manual* around three basic thrusts – utilizing proven techniques, utilizing hydraulic and hydrologic approaches not specifically engineered for urban situations and developing – from scratch – policies, methods and procedures which would be practical and acceptable to most urban engineers. Basic approaches used for larger projects would be applied to urban drainage wherever possible.

Formulating a fundamental approach to flood control was the overall objective, as drainage engineering was recognized as much more than just building pipelines, culverts and channels. A "dual system" approach was proposed which would consist of both minor and major storm drainage system designs, and it was adopted as the fundamental approach for the *Manual.*

Drainage criteria promoted in the *Manual* needed to be developed and stated as a form of policy in order to generate compliance. Four principles were laid out as the foundation upon which everything else would be structured: 1.) Drainage is a sub-system of the total urban system; 2.) Drainage is a space allocation problem; 3.) Stormwater runoff is a resource out of place; and, 4.) An urban drainage strategy should be a multi-purpose, multi-means effort. Along with the policy statements was a floodplain regulation using the 100-year flood as the measure.

The initial review procedure for the *Manual* was a step-by-step method performed by a technical review subcommittee. Following



Engineers view and discuss a Bureau of Reclamation model of the South Platte River through Englewood that was built to test hydraulics.

technical reviews and approvals, municipalities were given a chance to review the *Manual* and make comment before final approval by the Urban Drainage Advisory Committee and other DRCOG groups was secured. While the initial reviews were important, the real test was in applying the *Manual's* guidelines to actual practice.

Denver's first *Urban Storm Drainage Criteria Manual* was considered successful because the policy, planning and design aspects enabled multi-means, multi-purpose efforts that were generally supported by data. More importantly, it put a basic document in the hands of contemporaries all on the same side of the matter. The game would be played by essentially the same rules throughout the District.

A letter dated February 10, 1970, to DRCOG from D. Earl Jones of HUD provided comment on the *Manual* and read in part:

"To the best of our knowledge, the *Manual* is the first such standard prepared for implementation throughout an American metropolitan area. Its adoption will permit consistent reactions to basic problems that are independent of political subdivision boundaries. Its philosophy provides for flexible approaches to realization of necessary drainage control and total water resources objectives, and at the same time encourages improved sensitivity to the total ecology. We believe these approaches will save your Region many millions of dollars through the years to come by reducing drainage construction costs and flood hazard exposure, at the same time enhancing the quality of urban life.

"The *Manual* provides a major step toward realization of performance criteria, avoiding perpetuation of flexible standards that inhibit more rewarding design responses. This should foster closer interdisciplinary collaboration.

"The *Manual's* presentation of the latest urban hydrology and design techniques is

Mayor Currigan dedicates the Harvard Gulch Flood Control Project in 1967.

important far beyond your metropolitan area. To our knowledge, the *Manual* is being studied by public works and planning officials in at least 36 communities in 22 states and the District of Columbia, as well as in five foreign countries."

While the *Manual* was essential in the formation of Urban Drainage and Flood Control District, it also proved helpful in resolving institutional problems related to water resources management lying outside of direct functions of the District. Benefits to be achieved through metropolitan-wide cooperation – still a basically new notion – became more apparent when reviewed with the principles and policies of the *Manual* in mind.

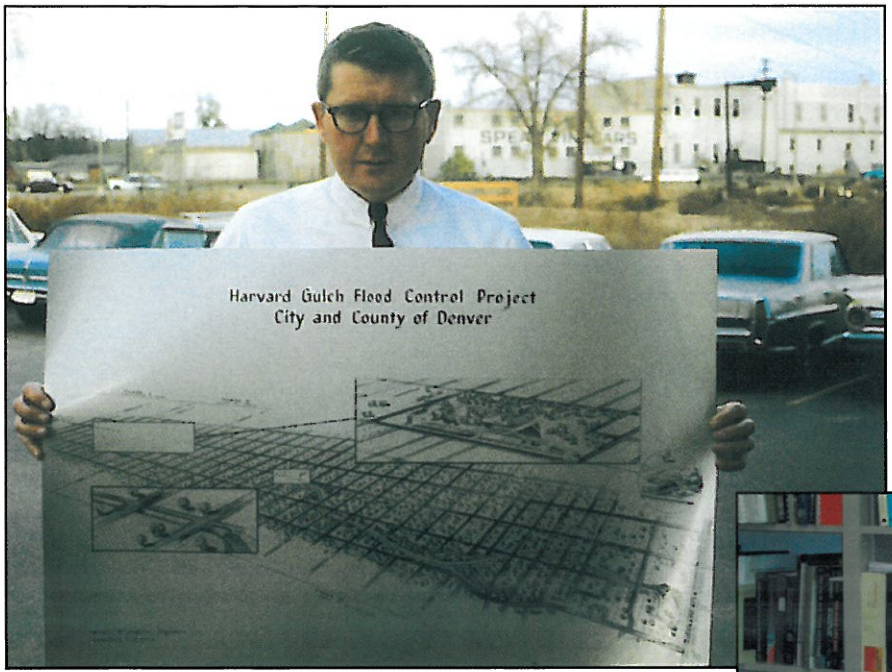
Just as designed, the *Manual* has expanded and been improved each year, keeping the most current regulations and the products, techniques and philosophies they are based on in the hands of the entire Colorado stormwater and flood control industry.

Ken Wright A Pioneer In Stormwater Control

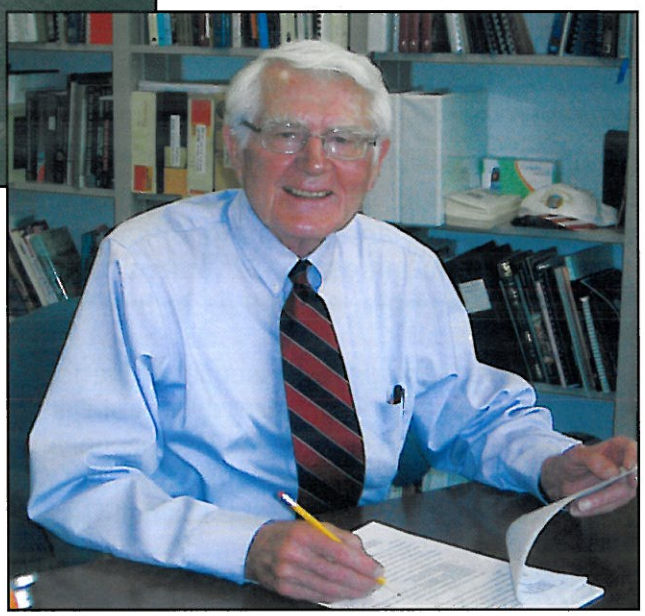
Consulting engineer Ken Wright's interest in drainage and water handling started early. As a construction engineer in Saudi Arabia, fresh out of the University of Wisconsin, he marveled at how the Arab community shepherded their scarce water to sustain their date palms, yet also saw occasional flooding in an area with only about four inches of annual rainfall. As his career advanced, Wright hand-calculated mile after mile of water surface profiles, computed sediment transport and helped determine dam spillway design floods while working for the U.S. Bureau of Reclamation. He was able to transfer his hydrological background to urban drainage design, beginning a Denver-based water resources consulting engineering firm in 1961.

One of his first jobs as a consulting engineer was the design of a drainageway at the Denver Federal Center in 1962 to protect a federal warehouse from flooding. He then worked to devise the Colorado Urban Hydrograph Procedure and explained the procedure to peers at the 1970 ASCE conference, along with an approach for performance-oriented drainage design. These techniques were employed in the 1965 design of the Harvard Gulch Flood Control Project in southeast Denver. This successful, innovative methodology led to Wright's selection in 1969 by the Five Counties Engineers Group to develop an Urban Drainage Criteria Manual for Denver Regional Council of Governments. In this position, he was instrumental in helping form Urban Drainage and Flood Control District with Senator Joe Shoemaker. Wright then served as the District's sole technical staff member until early 1971. As he helped develop correlations between rain and runoff, Wright quickly became a national spokesman and advocate for floodplain management, detention storage and improved storm drainage works.

For over four decades, Wright and his firm have been recognized as leaders in water resources



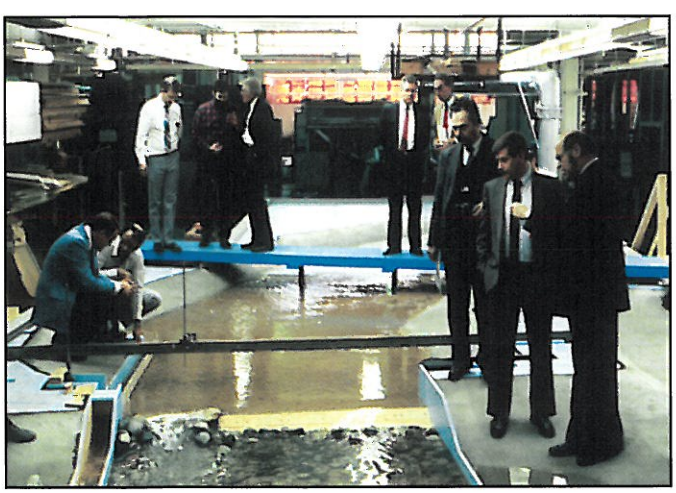
Ken Wright holds a detailed drawing of the proposed Harvard Gulch Flood Control Project in 1965. At that time, the drainage basin was already densely developed and was regularly a problem area for flooding. The successful project provided both the impetus to create a standardized urban criteria manual and the basic data needed to create such a reference guide. Below, Wright sits at his desk in his Denver office.

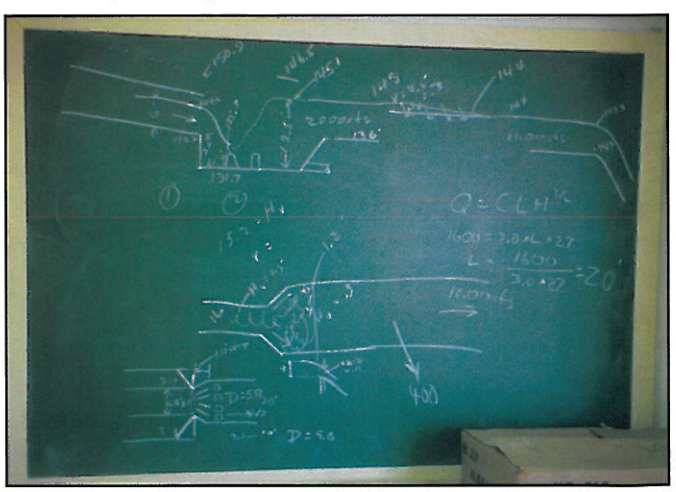


engineering, overseeing such projects in 20 states and several foreign countries. Wright has authored several books and multiple studies that continue to benefit society as a whole. In addition to everyday consulting, he is frequently called upon to provide expert testimony in matters of litigation.

Since 1994, Wright and his wife, Ruth, an attorney, have been involved with paleohydrologic research at Mesa Verde and in Peru. This continuing study of ancient water uses has earned Ken Wright ASCE's Lifetime Achievement Award in 2005 and ASCE Honorary Membership in 2006. Earlier this year, the Wrights were notified that they will receive the Order of Merit for Distinguished Services via Supreme Resolution of Peruvian President Alan Garcia for their hydrological research work in Peru.

"It's humbling to have your accomplishments recognized by peers," Wright says. "We've always considered ethical business practices and professional conduct more important than personal or corporate gain."





South Platte River at Union Ave. model provided solid data that allowed for redesign of a high hazard dam that had contributed to the deaths of several kayakers. Technical analyses were complex for the design of the Harvard Gulch project, as evidenced by the chalkboard from one of the many meetings.