22.14 Maintenance and Post Construction Responsibility

All drainage control, flood control and erosion control facilities both public and private shall be regularly maintained. Accumulations of silt, trash, litter or stagnant water which create a health or safety hazard or which endanger the design function of the facility are not permitted. Excessive growth or accumulation of woody vegetation in channels and on dams and levees shall not be permitted. Active erosion due to wind or water associated with drainage control, flood control and erosion control facilities shall not be permitted.

All newly constructed drainage facilities within a public right-of-way must be blocked off at both ends to prevent unauthorized vehicular access with City Standard Tube Gate or removable bollards.

22.15 Common Equations

The most commonly used equations in drainage submittals are: weir, orifice and Manning's. They are presented below.

1. Weirs

A weir is a barrier in an open channel, over which water flows. A weir with a sharp upstream corner or edge such that the water springs clear of the crest is a "sharp crested weir". All other weirs are classified as "weirs not sharp crested". Weirs are to be evaluated using the following equation:

$$Q = CLH^{3/2}$$

where:

Q = Discharge in cfs

C = Discharge coefficient use 2.7. If a discharge coefficient other than 2.7 is to be used, provide justification in the drainage submittal.

L = Effective length of crest in feet

H = Depth of flow above elevation of crest in feet (approach velocity shall be disregarded in most applications)

Weirs are generally used as measuring and hydraulic control devices. Emergency spillways in which critical depth occurs and overflow-type roadway crossings of channels are the most common applications of weirs. Channel drop structures and certain storm drain inlets may also be analyzed as weirs. Special care must be exercised when selecting weir coefficients in the following cases:

a. Submerged weirs

b. Broad crested weirs

c. Weirs with obstructions (i.e., guardrails, piers, etc.)

2. Orifices

An orifice is a submerged opening with a closed perimeter through which water flows. Orifices are analyzed using the following equation:

$$Q = CA\,(2gh)^{1/2}$$

where:

Q = Discharge in cfs

C = Discharge coefficient use 0.6. If a discharge coefficient other than 0.6 is to be used, provide justification in the drainage submittal.

A = Area of opening in square feet

g = 32.2 ft/sec^2

h = Depth of water measured from the center of the opening

Approach velocity shall be disregarded in most applications.

Orifices are generally used as measuring and hydraulic control devices. Orifice hydraulics control the function of many "submerged inlet - free outlet" culverts, primary spillways in detention facilities, manholes in conduit flow, and in storm drain catch basins.

3. Manning's Equation and Coefficient

Manning's equation is used to calculate flow, due to gravity, in open channels and conduits. In a conduit, the HGL must be below the soffit. As the Manning's Roughness Coefficient value increases the velocity decreases and the HGL increases. The equation is presented below:

$$Q = (1.486AR^{2/3}S^{0.5})/n$$

Where:
Q - Flow Rate in Cubic Feet per Second
A - Flow Area
R - Hydraulic Radius; R=A/P where A is the flow area and P is the wetted (flow) perimeter
S - Slope
n - Manning's Roughness Coefficient

Values of Manning's "n" to be used in drainage submittals:

Material	n
Plastic Pipe-smooth bore	0.010
Reinforced Concrete Pipe	0.013
Poured Concrete	0.013
No-joint cast in place concrete pipe	0.014
Reinforced Concrete Box	0.015
Reinforced Concrete Arch	0.015
Streets	0.017
Flush Grouted Rip-Rap	0.020
Corrugated Metal Pipe	0.025
Grass Lined Channels (sodded & irrigated)	0.025
Earth Lined Channels (smooth)	0.030

Arroyo Channels	0.030
Wire Tied Rip-Rap	0.040
Medium Weight Dumped Riprap	0.045
Grouted Rip-Rap (exposed rock)	0.045
Arroyo Overbank	0.045
Jetty Type Rip-Rap ($D_{50 > 24"}$)	0.050

22.16 History

In August of 2015, two technical subcommittees were convened to update this chapter. One subcommittee was convened to evaluate a new hydrologic model, evaluate hydraulic models and revise the closed conduit and open channel sections of this chapter. The current hydrologic model, AHYMO, was not replaced as the subcommittee decided that further study was required.

Members of this subcommittee are listed below:

Curtis Cherne, PE, CFM
Technical Subcommittee Chair
City of Albuquerque

Daniel Aguirre	Wilson and Company
Rick Beltramo	Galway Construction
Alandren Etlantus	Bohannan Huston Incorporated
Andreas Sanchez	SSAFCA
Gerhard Schoener	SSAFCA
Stephen Scissons	Army Corp of Engineers
Brad Bingham	AMAFCA
Shahab Biazar	City Engineer
Brian Patterson	Titan Development
Rita Harmon	City of Albuquerque
Charles Easterling	Easterling and Associates
Kevin Daggett	City of Albuquerque
Dave Thompson	Thompson Engineering Associates
Don Briggs	Bernalillo County
Hugh Floyd	RESPEC
Pat Stovall	Smith Engineering
Vince Carrica	Tierra West

The second subcommittee convened to evaluate all other sections of the chapter. The chapter was reorganized for easier use and was structured with the approach to help the development community with site development. Some of the larger changes are:

Addition of Floodplain Development

Addition of Valley Drainage Criteria

Emphasis on Downstream Capacity and Offsite Flows

Incorporation of erosion control specifications for pipes outletting into ponds and arroyos from "Urban Storm Drainage Criteria Manual Volume 2" from the Urban Drainage and Flood Control District, Denver, Colorado, June 2001, revised April 2008.

Addition of Low Impact Development

Removal of Probable Maximum Flood/Precipitation and Dam Design

Members of this subcommittee are listed below:

Curtis Cherne, PE, CFM
Technical Subcommittee Chair
City of Albuquerque

Don Briggs	Bernalillo County
Abiel Carrillo	City of Albuquerque
Kevin Daggett	City of Albuquerque
Scott Steffen	Bohannan Huston Incorporated
Ron Bohannan	Tierra West
Ron Hensley	The Group
Diane Hoelzer	Mark Goodwin and Associates
Jeff Mortensen	High Mesa Consulting Group
Graeme Means	High Mesa Consulting Group
Brian Patterson	Titan Development
Kevin Patton	Pulte Homes
David Soule	Rio Grande Engineering
Jeff Wooten	Wooten Engineering
Rita Harmon	City of Albuquerque

The DPM Technical Subcommittee would like to dedicate this revision to Jeff Mortensen P.E., who sadly passed away during the revising of this manual. Jeff was very knowledgeable in all aspects of drainage and he was involved with the creation of Chapter 22 and every revision since its inception.

February 2015, the DPM revision was approved to incorporate requirements from the EPA MS4 Permit for post-construction development and infiltration was acknowledged in the design of ponds.

Section 22.2, Hydrology was first published in March, 1982, as one of the sections in the three-volume Development Process Manual (DPM). The DPM is the result of the effort of a special team of City of Albuquerque staff and Albuquerque Urban Advisory Council members. The Manual was created in response to mutual needs of the private and public sectors in Albuquerque to clarify the development process. The Three volumes of the DPM are: 1 - "Procedures", 2 - "Design Criteria". The Third Volume "Policies and Plans" is obsolete.

A major revision to Section 22.2 was adopted with the approval of a "Notice of Emergency Rule" by the City in January, 1986. This revision deleted a procedure which based rational method "C" coefficients on SCS Hydrologic Soil Group, and adopted Rational Method Coefficients based on textbook and handbook references.

The "D.P.M. Subcommittee on Drainage" was established by the City of Albuquerque in January, 1987. The Subcommittee held its first meeting in February, 1987. The Subcommittee consisted of members from City staff, Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) staff and local engineering consultants, and was organized to update and revise the DPM design criteria for Section 22.2, Hydrology. The Bernalillo County Public Works Department later joined the Subcommittee. In January, 1990 the subcommittee changed its name

to the DPM "Drainage Design Criteria Committee" to avoid potential confusion with another committee established by the DPM Steering Group.

The Drainage Design Criteria Committee has met on a regular basis to develop a major update of the hydrology section of the DPM. In 1987, a research study to determine local infiltration factors was conducted by Dr. Richard Heggen at the University of New Mexico to supplement the work of the Committee.

A "draft" of the "Revision of Section 22.2, DPM" was distributed for community review in January, 1990. This document recommended use of initial abstraction and uniform infiltration to complete rainfall loss. It also included a procedure for smaller basins based on the Rational Method, and a procedure for large and small watersheds based on the HYMO computer program.

With the adoption of the Bernalillo County Storm Drainage Ordinance (No. 90-6) the County Engineer was responsible for establishing criteria, procedures and standards for the design of flood control, drainage controls, and erosion control improvements. To fulfill this requirement, Bernalillo County adopted "Interim Drainage Design Criteria for Bernalillo County" (April, 1990). This document incorporated Parts A, B, E and F from the January, 1990 draft of Section 22.2, Hydrology.

In January, 1991, a revision of "Section, 22.2," was distributed to eight (8) Federal and State agencies, and to 26 local engineering firms. A public "Notice of Review" was published in the Albuquerque Journal and Tribune on February 4, 1991. Following incorporation of review comments, the August, 1991 version of Section 22.2, Hydrology was released for use by the Drainage Design Criteria Committee. This version included the placement of the rainfall peak in this second hour of the design storm. Modifications to the Probable Maximum Flood procedures incorporated a "local storm" and a "general storm." A "Notice of Second Review" was published in the Albuquerque Journal and Tribune on August 31, 1991. The August, 1991 version has been accepted by the City, County and AMAFCA as an allowable procedure for hydrologic analysis and design of flood control structures.

The January, 1993 version of Section 22.2, Hydrology incorporates comments received since August, 1991. The version includes a procedure to evaluate basin hydrology for steep natural slopes, and some text revisions suggested by the USDA Soil Conservation Service. For most applications, there will be no computational differences between the January, 1993 version and the August, 1991 version. The text has been reformatted into seven (7) separately numbered parts to simplify future revision of the document.

The pages which follow replaced all previous pages in the Hydrology Section of the DPM (Section 22.2, pages 2 through 21). Following a public review and comment period, the revised Section 22.2, Hydrology was approved by the City Engineer and the Mayor. In the City of Albuquerque, the revision became effective on April 7, 1993. Bernalillo County also adopted the revision as the standard for design of flood and drainage control, effective April 7, 1993. The revised Section 22.2, Hydrology is to be regarded as the principal reference for hydrologic design in the City of Albuquerque and Bernalillo County.

The Drainage Design Criteria Committee wish to acknowledge the assistance of the many individuals who reviewed the document. In particular we wish to thank Richard Leonard, Brian Burnett and Dwayne Sheppard for their work on the Committee.

The D.P.M. Drainage Design Criteria Committee:

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Surface Water Hydrologist
Bernalillo County Public Works

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City of Albuquerque

22.17 Reference

The reference section remains unchanged, as the latest revision used committee members' experience. Their years of experience were a valuable resource. Their names are listed in the History section.

Hydraulics

A. Weirs and Orifices

1. King and Brater: Handbook of Hydraulics, McGraw Hill Book Company, Inc., New York, Fifth Edition 1963

2. Merritt: Standard Handbook for Civil Engineers, McGraw Hill Book Company, Inc., New York, 1968

3. Streeter: Fluid Mechanics, McGraw Hill Book Company, Inc., New York, Fifth Edition

B. Closed Conduits

1. Los Angeles County Flood Control District Design Manual - Hydraulic, P.O. Box 2418 Los Angeles, California 90054 Rev. 1973.

C. Channels

1. Chow: Open Channel Hydraulics, McGraw Hill Book Company, Inc., New York, 1959

2. U.S. Army Corps of Engineers:- Hydraulic Design of Flood Control Channels EM 1110-2-1601,. Office of the Chief of Engineers, Washington, D.C. 20314, 1970

3. Merritt: Standard Handbook for Civil Engineers, McGraw Hill Book Company, Inc., New York, 1968.

4. Morris and Wiggert: Applied Hydraulics in Engineering, the Ronald Press Company Second Edition, 1972

5. U.S. Department of the Interior, Bureau of Reclamation: Hydraulic Design of Stilling Basins and Energy Dissipaters, U.S. Government Printing Office, Washington, Fourth Printing, Revised 1973

6. U.S.D.A Soil Conservation Service: Planning and Design of Open Channels, Technical Release No. 25, Washington, D.C., October, 1971

7. U.S.D.A Soil Conservation Service:. Sedimentation, National Engineering Handbook, Section 3, Chapter 4, Washington, D.C., 1971

8. Simons, Li and Associates: Design Guidelines and Criteria - Channels and Hydraulic Structures on Sandy Soil, P.O. Box 1816 Ft. Collins, Colorado, 80522, 1981

9. Los Angeles County Flood Control Authority, Design Manual Hydraulic P.O. Box 2418 Los Angeles, California 90054 Rev. 1973.

10. Albuquerque Metropolitan Arroyo Flood Control Authority Draft Design guide for Trapezoidal Concrete Flood Control Channels, Rev. April, 1982.

D. Catch Basins

1. Los Angeles County Flood Control Authority, Design Manual - Hydraulic P.O. Box 2418 Los Angeles, California 90054 Rev. 1972.

E. Street Hydraulics

1. See Reference C-1

2. See Reference C-4

F. Berms and Levees

1. See Reference C-6

2. See Reference C-7

3. See Reference C-8