ARTICLE V

STORM SEWER AND DRAINAGE DESIGN

Section 501 Minimum Requirements for Storm Sewer and Drainage Design

501.1 **Drainage Area Plan**. A plan of the drainage area at a scale of 1" = 100' with one (1) foot contour intervals using U.S.G.S. datum for areas less than 100 acres or a plan of the drainage area at a scale 1" = 300' with 5' contour intervals for larger areas. This plan shall include all proposed streets, drainage and grading improvements with flow quantities and direction of flow at all critical points. All areas and subareas for drainage calculations shall be clearly distinguished.

501.2 **Hydraulic Data**. Complete hydraulic data showing all calculations shall be submitted. A copy of all nomographs and charts used in the calculations shall be submitted if other than those included in this Article.

501.3 **Plan and Profile**. A plan and profile of all proposed improvements at a scale of 1" = 50' horizontal and 1" = 5' vertical shall be submitted. This plan shall include the following:

1. Location, sizes, flow line elevations and grades, type of pipe, channels, boxes, manholes and other structures drawn on standard plan-profile sheets.

2. Existing and proposed ground line profiles along centerline of the drainage improvement.

3. A list of the kind and quantities of materials.

4. Typical sections and reinforcement of all boxes and channels.

5. Location of property lines, street paving, sanitary sewers and other utilities.

501.4 **Field Study**. A field study of the downstream capacity of all drainage facilities and the effect of additional flow from the area to be improved shall be submitted. If the effect is the endangerment of property or life, the problem must be solved before the plan will be given approval.

501.5 **Storm Water Flow Quantities**. Storm water flow quantities in the street shall be shown at all street intersections, all inlet openings, and at locations where flow is removed from the streets. This shall include the hydraulic calculations for all

inlet openings and street capacities. Street flow shall be limited to a maximum of five (5) cfs in each gutter. Flow over this must be removed.

Section 502 Requirements Relating to Improvements

502.1 **General Design Requirements**.

A. All bridges shall be designed to accommodate a 100-year frequency rain. Box culverts, pipe culverts, channels and ditches shall be designed to accommodate a 100-year frequency rain at all locations having a drainage area in excess of 1.0 square miles. Locations having a drainage area of less than or equal to 1.0 square miles shall be designed to accommodate a 25-year frequency rain.

B. Channel improvement shall be such to prevent erosion while maintaining natural channels where possible. Velocities shall be low enough (less than 5 fps) to prevent scouring. A series of detention structures, restrictions, etc. are recommended. Concrete lined channels and pipes shall be used when scouring velocities cannot be controlled.

502.2 **Specific Requirements for Various Improvements**.

A. **Bridges and Culverts**. Bridges, box culverts or concrete pipe culverts shall be provided where continuous streets or alleys cross water courses. The structure shall be designed in accordance with City specifications for materials and to carry HS-20 loadings in all cases.

B. **Closed Storm Sewers**. Closed storm sewers shall either be reinforced concrete box or pipe of approved type designed for HS-20 loadings. Reinforced concrete pipe or reinforced concrete boxes must be used within two (2) feet of the back of the street curb and under paved areas. All storm sewers having trench walls within two (2) feet of the back of the street curb shall be backfilled with granular material. The use of corrugated steel, zinc-coated pipe and extra strength clay pipe will not be permitted with two (2) feet of the curb or under pavement areas.

Grades for closed storm sewers shall be designed so that the velocity shall not be less than three (3) feet per second and shall not exceed twelve (12) feet per second. The use of corrugated polyethylene pipe is permitted outside the paved areas.

C. **Open Paved Concrete Channels**. Grades for open paved channels shall be designed so that the velocity shall not be less than three (3) feet per second and shall not exceed twelve (12) feet per second. Such concrete channels may be of different shapes according to existing conditions; however, a channel with a flat bottom and 4:1 to 5:1 side slopes is the

most desirable type and shall be used whenever possible. The thickness of channel paving shall depend on conditions at site and size of channel; however, a minimum thickness of six (6) inches is required. A six (6) inch free board must be provided. An eighteen (18)-inch toe wall is required at both the outlet and inlet ends of the channel.

D. **Open Ditches (Earth Channels).** Ditches shall have a gradient that limits the velocity within 1.5 to 5.0 feet per second depending on existing soil conditions. Such ditches shall have a minimum side slope ratio of 3:1. Encroachment of buildings and improvements on natural or designated drainage channels for the channel's flood plains is prohibited. Such flood plains are areas of land adjacent to an open paved channel or earthen ditch that may receive a flood condition from a 100-year frequency rain. The limits of such flood plains shall be indicated on drainage improvements plans. Short sections, such as those following the outlets of small culverts, may exceed the velocity of 5.0 feet per second provided that:

1. UV protected geotextile netting (such as North American Green C-350) is used.

2. Rip-rap is not acceptable and cannot be used for this purpose.

Section 503 Runoff Calculations

503.1 The rate of runoff concentrated at any point shall be determined by the Rational Formula:

Q	=	CIA, in which
Q	=	Runoff in cubic feet per second
C	=	The runoff coefficient for the area
I	=	Design rainfall intensity in inches per hour over the area based on time of concentration and rainfall intensity curves included as a part of these regulations. A five (5) minute time of concentration is the minimum permitted.
A	=	Drainage area, in acres.

A. **Runoff Coefficient**. The runoff coefficient "C" is the variable in the Rational Formula least susceptible to precise determination and the one, which requires the greatest exercise of engineering judgment because of the many area characteristics, which affect the runoff coefficient. Among the factors to be considered in influencing the runoff coefficients are the following: present and future zoning; terrain; local ponding or depressions; the amount of pavement; roofs, turf, and other areas having different degrees of imperviousness.

The selection of a coefficient should take into consideration the probable ultimate development of presently undeveloped areas. Suggested values of runoff coefficients are included in the following table:

Suggested Runoff Coefficients	
"C" Value	**Surface Conditions**
.10 - .15	Tall grass, brush
.15 - .20	Parks, golf courses, farms and one (1) acres single family residences
.35	Single family residences on lots of not less than 15,000 sq. ft.
.45	Single family residences on lots of not less than 10,000 sq. ft.
.47	Single family residences on lots of not less than 7,500 sq. ft.
.51	Single family residences on lots of not less than 6,000 sq. ft.
.90	Gravel surfaces
.95	Asphalt and concrete surfaces
1.00	Buildings and other structures

B. **Rainfall Intensity**. The average frequency of rainfall occurrence used for design determines the degree of protection afforded by a drainage system. Maximum intensity of rainfall of a given expectancy is greater for a short period of time than for longer periods. Therefore, it is assumed that the maximum runoff will occur as soon as all parts of the drainage area under consideration are contributing. The length of time from the beginning of rainfall until runoff from the most remote point in the drainage area reaches the point under consideration is called the time of concentration. This may include overland flow time and channel or gutter flow time. Nomographs that may be used for determining time of concentration are included in these regulations. Once the time of concentration is known, the design intensity rainfall may be determined from the rainfall intensity curves included in these regulations.

Section 504 Sizing of Storm Sewers and Drainage Structures

504.1 The size of closed storm sewers, open channels, culverts and bridges shall be designed so that capacity will not be less than the computed runoff using the Manning Formula:

$Q = (1.486/n) (r^{2/3}) (s^{1/2})$

Q = Capacity = Discharge in cubic feet/sec.
a = Cross-sectional area of water in conduit or channel in square feet
r = Hydraulic radius of water in conduit or channel = area/wetted perimeter
s = Mean slope of hydraulic gradient in feet per foot
n = Roughness coefficient, based on condition and type of material of conduit or channel lining

Values of "n" for various kinds of pipe for use in Manning Formula:

Concrete Pipe - 0.013
Corrugated Metal Pipe - 0.024
Concrete Lined Channel - 0.015
Earth Channels - 0.030 to 0.050

504.2 **Design Tabulations**. For systems of storm sewers with inlets in various locations, the time of concentration at any point will be time of concentration at the most remote inlet up stream, plus the flow time in the storm sewer to the point under consideration. Computations for systems lend themselves readily to tabulation showing the drainage area, time of concentration runoff and capacity of each inlet and section of sewer under consideration. This data is to accompany the improvement plans.

504.3 **Street Flow**. Street flow shall be limited by pavement encroachment and depth of flow as indicated in the following table, with five (5) cfs the maximum flow in each gutter.

Street Flow	
Street Classification	***Maximum Encroachment of a 2-Year Storm**
Local	No curb overtopping. Flow may spread to crown of street.
Collector	No curb overtopping. Flow spread must leave the equivalent of one (1) 10-foot driving lane clear of water.
Arterial	No curb overtopping. Flow spread must leave the equivalent of two (2) 10-foot driving lanes clear of water. One lane in each direction.
*Where no curbing exists, encroachment shall not extend past property lines.	

The storm sewer system shall commence at the point where the volume equals five (5) cfs.