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**PART III - MINIMUM DESIGN STANDARDS  
SECTION 105**

**DRAINAGE SYSTEM DESIGN**

**105.1 SPECIFICATIONS AND SCOPE**

All design and analysis of storm drainage systems in the City of Arvada shall be done in accordance with the Urban Drainage and Flood Control District Vol. 1, 2, & 3, Latest Edition (The Manual) or as specified within this section.

All subdivisions, planned unit developments, development of a vacant lot or any construction of exterior impervious surface submitted to the City for approval shall include a hydrologic analysis and hydraulic design for storm drainage.

**105.2 METHODS OF ANALYSIS**

All analyses must be in conformance with The Manual. Two acceptable methods of flow analysis are the Rational Method and the Colorado Urban Hydrograph Procedure (CUHP).

105.2.1 Rational Method

Flows may be determined by the extended form of the rational formula:

- A. Rainfall intensities shall be taken from the Rainfall chapter of The Manual.
- B. The minimum time of concentration for flow analysis is five (5) minutes.

105.2.2 Colorado Urban Hydrograph Procedure Method

Flows may be calculated by the Colorado Urban Hydrograph Procedure and meet the requirements of The Manual.

105.2.3 Facility Capacity Criteria

Drainage facilities must meet the following design criteria:

- A. Curb flow capacity is reached when the flow crosses the back of the curb or the crown of the street is reached, whichever is less.
- B. Transfer of water from one flow line to another by flow over the crown, will not be allowed.
- C. Storm sewer shall be designed to carry the 5 year runoff.
- D. Minimum size for storm drainage pipe shall be fifteen (15) inches.

- E. Pipe under streets shall be designed for soil and live loads in accordance with acceptable highway design criteria. The D-Load method is an acceptable method of design.
- F. Collector streets shall be drained so that the center twelve (12) feet are clear of water during the 5-year storm.
- G. Arterials shall be drained so that the center 24 feet are clear of water during the 100-year storm.
- H. Local streets shall have catch basins at the point where either side of the street reaches its capacity for the 5-year frequency storm.
- I. Catch basin capacity shall be calculated in accordance with the methods outlined in The Manual, Volume 1.
- J. Culverts under streets (excepting major arterials) shall be designed with an emergency overflow for passing the 100-year storm. In determining the required capacity of the overflow, the culvert shall be assumed blocked unless its cross-sectional area exceeds twenty (20) square feet, in which case 60% of its flow capacity may be used.
- K. Major channels shall be designed to safely pass the 100-year storm. Design and improvements shall be made in accordance with the recommendations of The Manual.
- L. Velocities in any conduit or channel shall be controlled so that the conduit or channel will not be damaged by flows from the 1% annual chance flood, unless otherwise instructed by the City Engineer or designee.
- M. Suggested values of Manning's "n" appear in Table 105.1 below.

**TABLE 105.1**

Roughness Coefficient

<u>Character of Section</u>	<u>Mannings 'n'</u>
Polyvinyl Chloride Pipe .....	0.011
Concrete Pipe .....	0.013
Corrugated Metal: 2 2/3" x 1/2" Corrugation .....	0.024
3" x 1" Corrugations .....	0.027
Structural Plate: 6" x 2" Corrugations .....	0.033
Open Channels: Undisturbed .....	0.035
Earth Reshaped .....	0.020
Grassed and Shaped .....	0.030
Concrete Lined .....	0.013
Rip Rap Lined .....	0.035

105.2.4 Stormwater Detention

The City of Arvada Land Development Code requires that additional runoff caused by development be detained on the development site.

105.2.5 Detention Volume

Detention volume shall be determined in accordance with The Manual.

105.2.6 Detention Time

No specific detention time is required under normal conditions. However, if the City Engineer or designee determines that a longer detention time is in the City's best interest, he may require a flow rate less than half the historic peak flow rate ( $Q_H/2$ ) before two (2) times the historic concentration time ( $2T_c$ ) is reached.

105.2.7 Allowable Release Rate

The allowable release rate shall be calculated as determined by The Manual; however, the maximum release rate from the detention facility shall not exceed the historical peak runoff rate for the same frequency storm.

When it is in the City's best interest to alter this release rate, the City Engineer or designee may request a specific release rate.

105.2.8 Detention Facilities

The type and design of detention facilities shall be in accordance with The Manual, Volume 2.

Overflow structures shall be provided where the design capacity of the detention structure can be exceeded. This overflow structure shall return the overflow water to the historic channel without causing damage to either the detention pond or overflow structures.

105.2.9 Detention Pond Slopes

Side slopes on detention ponds shall be a maximum of 4:1. The bottom of the ponds shall be a minimum of 2% across landscaped areas.

105.2.10 Flood Hazard Exposure

Developers shall design and accomplish final grading in such a manner that buildings and basement openings will be at or above an elevation that will prevent adverse effects from flood waters due to a 1% annual chance storm.

105.2.11 Policy of Adequate Drainage

- A. Adequate drainage of runoff means the effective conveyance of storm and other surface waters through and from the development site and the discharge of such waters into a natural watercourse, i.e., a stream with incised channel (bed and banks), or pipe capacity analysis required through two downstream manholes without adverse impact upon the land over which the waters are conveyed or upon the watercourse or facility into which such waters are discharged.
- B. Include sufficient easement and infrastructure extensions to property lines to permit future development reasonable access to drainage facilities for connections.
- C. The drainage system shall be designed:

1. To convey such waters to a natural watercourse, i.e., a natural watercourse at the natural elevation, or an existing storm drainage facility.
  2. To discharge the surface waters into a natural watercourse at the natural elevation, or into an existing facility of adequate capacity.
- D. The drainage system shall be designed such that properties including public right-of-ways, over which the surface waters are conveyed, from the development site to discharge point(s), are not adversely affected.
  - E. Concentrated runoff shall not be discharged on an adjoining property unless an easement expressly authorizing such discharge has been granted by the owner of the affected land or unless the discharge is into a natural watercourse, or other appropriate discharge point as set forth above.
  - F. The owner or developer may continue to discharge stormwater which has not been concentrated into a lower lying property.
  - G. If the discharge conditions are not met and the discharge may aggravate an existing drainage problem or cause a drainage problem, the developer must provide a drainage system satisfactory to the City Engineer or designee, to preclude an adverse impact upon the adjacent or downstream property.
  - H. Where open streams are involved, the designer must assess the stream adequacy to receive the two-year run-off without causing erosion or over-bank flooding.
  - I. The downstream extent of this review shall be to the point at which an adequate channel is found.

### **105.3 WATER QUALITY TREATMENT**

Water quality treatment of stormwater runoff must be provided in accordance with The Manual Vol. 3, latest edition.

### **105.4 IRRIGATION DITCHES**

Required irrigation ditch flow shall be determined by existing water rights flowing across and below the subject property shall be submitted to the City Engineer or designee. Alternatively, the ditch pipe and/or structures shall be designed to carry a consistent flow of water as the existing ditch is capable. Unless otherwise approved by the City Engineer or designee, all irrigation ditches must be piped.

All irrigation ditch piping must be approved, signed and dated by the President or other authorized officer of the ditch company, prior to approval by the City Engineer or designee.