

SECTION 4 – STORM DRAINAGE SYSTEMS
CITY OF CARO
ENGINEERING DESIGN STANDARDS

A. Plans and Specifications - Submittal Procedure

1. The plans and specifications shall be submitted in accordance with Section 1-General Requirements & Submittals.

B. Plans and Specifications - Design Considerations: General

1. Storm sewer systems for roadways and individual parcels less than thirty (30) acres (not including off site drainage areas) shall be designed for a ten (10) year storm by means of the rational method formula: $Q=CIA$; where Q is the peak rate of runoff in cubic feet per second, A is the area in acres, C is the co-efficient of runoff for the drainage area and I is the average rainfall intensity in inches per hour for a certain time of concentration. The rainfall intensity shall be determined by the formula: $I=175/(T+25)$; where T is the time of concentration equal to the time required for a drop of water to run from the remote point of the watershed to the point for which runoff is being estimated. In most instances, an initial T equal to twenty (20) minutes for residential areas can be used. Use T equal to fifteen (15) minutes in other land use areas.

Larger drainage areas shall be designed by a method approved by the City.

The calculations submitted shall indicate the following information for each pipe: Drainage District Number, Structure Number of Receiving and Collecting Structures, Area, "C" Factor, Intensity, "Q", Length, Size and Slope of Pipe Run, Velocity, Pipe Capacity, Rim Elevation and Elevation of the Hydraulic Gradient.

2. The Developer's Engineer shall use judgment in arriving at proper imperviousness factors, but in general, the following "C" factors are acceptable minimums. The applicant shall submit calculations to justify the "C" factors used.
 - A. Lawn areas – 0.2
 - B. Pavement and roof areas – 0.9
 - C. Overall area of single-family subdivision – 0.35
 - D. Overall area of multiple housing development – 0.55
 - E. Overall area of commercial development – 0.80
 - F. Overall area of industrial development – 0.80

3. The plans shall include a hydraulic design calculation for each run of pipe and open channel. Flow velocities shall be calculated using Manning's equation:

$$Q=VA=\frac{1.49(A)(rH)^{2/3}\sqrt{s}}{N}$$

The following "N" factors shall be used as follows:

Concrete Pipe	=	0.013
PVC Pipe	=	0.010
Corrugated Pipe	=	0.021

4. The 10-year storm hydraulic gradient for non-submerged drain systems shall be maintained below the top of the sewer pipe.
5. A drainage area map showing all sub-watershed areas, runoff coefficients, acreage of each area and proposed drainage system in plan view, shall be included with the plans.
6. All off-site drainage flowing onto the site shall be included in the drainage area map and such flows provided for in the design calculations.
7. Storm water detention or retention is required for all developments in the City.
(See Section 5 – Storm Water Basins for applicable information)

C. Plan and Profile - General

1. All storm sewers shall be shown in Plan and Profile, with the profile generally shown below the plan view. All structures and end sections shall be sequentially labeled in both plan and profile views.
2. Scale of plan portion of sheet shall be no smaller than 1 inch = 50 feet, with scale of profile portion of sheet, 1 inch = 50 feet horizontal and 1 inch = 5 feet vertical.
3. All elevations shall be on U.S.G.S. datum.

D. Plan View

1. Plan portion of sheet shall include, at a minimum:
 - a. Existing topography and all existing and planned surface and underground improvements in streets and easements in which sewer construction is proposed, and in contiguous areas if pertinent to design and construction.
 - b. Location and direction of flow of each section of proposed sewer between manholes.
 - c. Locations of all manholes and other sewer appurtenances and special structures, with proposed rim elevations for all inlets and catch basins.
 - d. Elevations shall be on U.S.G.S. Datum. There shall be a minimum of two (2) benchmarks and one (1) benchmark at least every 1,200 feet.

E. Profile View

1. Profile portion of sheet shall appear below companion plan portion, generally projected vertically and, as a minimum, show the following:
 - a. Size, slope, length, type and class of pipe, and controlling invert elevations for each section of proposed sewer between manholes.
 - b. Limits of special backfill requirements.
 - c. Profile (over centerline of proposed sewer) of existing and proposed finished ground and pavement surfaces.
 - d. If the hydraulic grade is provided in the previously mentioned calculations, then it does not have to be shown on the profile.
 - e. Location of existing and proposed utilities crossing the line of the sewer or otherwise affecting sewer construction.
 - f. Location, by station, of every proposed manhole with manhole number, invert elevation of all inlet and outlet pipes, and top of casting elevation.
2. Manholes shall be identified by numbers assigned consecutively and increasing in magnitude in the direction opposite to the direction of flow.
3. All catch basin and inlet leads shall have a minimum slope of one percent (1%).

F. Location of Sewers

1. Storm sewers shall generally be located on the same sides of streets as water mains, and generally within the street right of way.
2. For subdivisions, storm sewers shall be located in the public road right of way or in easements adjacent to the public road right of way. Storm sewers shall not be located in rear yards, except to pick up rear yard drainage or in unusual circumstances, or for sump pump discharge lines.
3. The horizontal alignment of sewers, which are not proposed to generally follow street, drive or parking area pavements, shall parallel property lines or building lines with clearance distances sufficient to accommodate the full width of any proposed easement.
4. Where possible, provide a minimum of three and one-half (3 ½) feet of cover from the top of finish road or earth grade to the horizontal centerline of any storm sewer.
5. In parking areas, catch basins should be located in the gutter or parking stall areas. Catch basins in the driving areas should be avoided when possible.

G. Catch Basin and Inlet Locations

Catch basins and inlets shall be located, in general:

1. So that the flows to be accommodated do not exceed the intake capacity of the structure casting.
2. At all low points in gutters and in swales and ditches, where applicable.
3. At the upstream curb return, if more than two hundred (200) feet downstream of a high point in the gutter, or as required to prevent water from crossing an intersection.

4. Catch basins shall be spaced no more than three hundred and fifty (350) feet from the crest of the road. Subsequent catch basins shall be spaced a maximum of four hundred (400) feet apart.
5. Yard type catch basins shall be provided at all low points in drainage swales. Provide intercepting yard type catch basins such that not more than four hundred (400) feet of swale drainage runs into any one (1) catch basin, other than a low point catch basin where six hundred (600) feet of drainage is allowed.

H. Manholes

1. Manholes shall be located at:
 - a. All changes in alignment.
 - b. Points where the size of the sewer changes.
 - c. Points where the grade of the sewer changes.
 - d. The junction of sewer lines.
 - e. Street intersections or other points where catch basins or inlets are to be connected.
2. Manhole spacing for storm sewers shall be as follows:

Diameter of Sewer	Maximum Manhole Spacing
12" to 42"	400 feet
48" to 60"	500 feet
66" and larger	600 feet

3. Where future connections to a manhole are anticipated, stubs with watertight bulkheads shall be provided.

I. Covers for Manholes, Catch Basins and Inlets:

Cover		Minimum	E.J.I.W.* No.
<u>Designation</u>	<u>Description</u>	<u>Weight (lb)</u>	<u>or Equal</u>
B	Solid Cover	375	1120
B-M1	Flat Grate (Round)	375	1120M1
C	Low Curb Inlet	500	7066
D	Flat Grate (Square)	455	5105
G	Low Beehive Inlet	300	6517
E	High Beehive Inlet	200	6508
K	High Curb Inlet	500	7045

*East Jordan Iron Works

J. Hydraulics

1. Minimum pipe size for sewers, catch basin leads and inlet leads shall be twelve (12) inch nominal internal diameter.
2. Minimum design velocity shall be two (2) feet per second and maximum design velocity shall be ten (10) feet per second, with pipe flowing full.
3. Design life of enclosed storm sewers and bridges shall be fifty (50) years or more, except for driveway culverts in open ditch areas, which shall have a design life of twenty (20) years or more.

K. Open Drains

1. Where proposed, open drains shall be designed to convey the upstream design flow. A one (1) foot freeboard shall be provided.
2. Side slopes of open drains shall have a maximum slope of one (1) foot vertical to six (6) feet horizontal, except that a low flow channel (roadside ditches, rear yard swales, etc.) may have side slopes of one (1) foot vertical to three (3) feet horizontal. Open drain side slopes shall have an established sod surfacing or be seeded, fertilized and mulched as soon as possible after construction.
3. Open drains must have slope protection (i.e. riprap, gabion baskets, etc.) at bends, under bridges and at other critical points required by the City.
4. The City will not accept the work until all turf is established.
5. Hydraulic calculations for open channel flow shall be provided to assure the channel has adequate conveyance. Velocities shall be kept to a minimum, less than four (4) cfs, to prevent scour.

L. End Section and Bar Screens

1. An end section with prefabricated bar screen shall be installed on the end of all storm sewers fifteen (15) inches in diameter and larger. Openings of the bar screen shall be no more than six (6) inches on centers and shall be designed to be sturdy, permanent, easily maintained, and non-clogging.

