

Article 4 Stormwater

Table of Contents

I.	Stormwater Design.....	4-1
A.	General.....	4-1
1.	Stormwater Management Facilities.....	4-1
2.	Easement Requirements.....	4-1
3.	Plan Information Required.....	4-2
4.	Public Street Stormwater Management Guidelines.....	4-3
B.	Pipe Capacity Design	4-3
C.	Hydraulic Gradient.....	4-4
D.	Pipe Size	4-4
E.	Design Velocity	4-4
F.	Slope and Grade	4-4
G.	Depth and Location	4-5
H.	Separation Clearances	4-6
I.	Sump Pump Discharges and Footing Drains	4-6
J.	Curb Drain	4-6
K.	Manholes.....	4-7
L.	Inlets and Catch Basins	4-8
II.	Stormwater Materials	4-8
A.	Pipes, Joints, and Leads	4-8
1.	Allowable Storm Sewer Pipe Materials.....	4-8
2.	Joints and Lubricants	4-9
3.	Pipe Marking.....	4-9
4.	Manufacturer’s Certification.....	4-10
5.	Materials Inspection	4-10
6.	Storm Sewer Service Leads and Fittings.....	4-11
B.	Manholes and Drainage Structures	4-11
1.	Manhole and Drainage Structure Materials.....	4-11

2.	Joints, Tees, and Radius Pipe Sections	4-12
3.	Frames and Covers	4-12
4.	Manhole Steps	4-12
5.	Connections of Storm Pipe to Precast Manholes	4-12
C.	Cured in Place Pipe (CIPP)	4-13

I. Design

A. General

1. Stormwater Management Facilities
 - a) Stormwater Management facilities shall be designed and permitted in compliance with [City Code, Chapter 55 \(Unified Development Code\), Section 5.22 \(Stormwater Management and Soil Erosion\)](#), which also adopts standards of the WCWRC by reference.
 - b) Stormwater management design plans shall include required data as set forth in [City Code, Chapter 55 \(Unified Development Code\), Section 5.29.6 \(Site Plans\)](#).
 - c) Stormwater management facilities must be located such that they do not impede maintenance of public improvements.
2. Easement Requirements
 - a) Storm sewer easement widths shall be equal to $2D+10$ feet, where D is the maximum depth of the sewer trench on a given run of sewer. The minimum storm sewer easement width shall be 30 feet.
 - b) The storm sewer shall be located 5 feet from the center of the easement, leaving D feet on one side of the sewer and $D+10$ feet on the other.
 - c) Storm sewer easement widths may vary from run to run of sewer provided that the above requirements are met.
 - d) When storm sewers cannot be located in standard width easements, the easement width and pipe location therein must be approved by the PSAA. In such cases, increased slope, casing pipe, alternate pipe material, or other special provisions may be required.

- e) For stormwater management facilities which are designed to be Public Improvements, easements of sufficient width shall be provided for maintenance purposes. A maintenance access easement from a public or private right-of-way to the stormwater management facility shall also be provided. Such access will be on a slope of 5:1 or less and shall be constructed to withstand the passage of heavy equipment and provide access to all components of the facility.
- f) Where stormwater discharge from a Public Improvement is designed to flow through a private stormwater management facility, easements and/or flow-through rights shall be provided.

3. Plan Information Required

- a) Plans shall conform to the requirements of Article I (General), Section III (Content of Plans and Detailed Specifications) of these Standards.
- b) In addition, the following information shall be provided:
 - (1) A copy of the design calculations for all storm sewers.
 - (2) The pipe material, size, percent of grade, and length of run between all manholes or other structures shall be shown in the profile view.
 - (3) All existing and proposed pipe invert elevations at all manholes and other structures shall be shown in the profile view.
 - (4) The percent of grade and invert elevation at the terminal end of all storm sewer service leads shall be shown in the plan view.
 - (5) The hydraulic gradient shall be indicated in the profile view.
 - (6) All service connections are to be stationed in the profile view.
 - (7) A casting schedule shall be provided including:
 - (a) Structure number corresponding to the plan view
 - (b) Station
 - (c) Casting type (manufacturer and catalogue number)
 - (d) Top-of-casting elevation

- (e) All structure invert elevations (including edge drain)
- (f) Structure depth

4. Public Street Stormwater Management Guidelines

- a) Public street construction and reconstruction projects, and utility projects disturbing at least half width of the street's subsoil/full road base, shall conform to the [Policy Statement on Public Street Stormwater Management Guidelines](#).

B. Pipe Capacity Design

1. Sewer capacities shall be based upon storm runoff computed by the Rational Method formula $Q=CIA$, for a 10 percent annual exceedance probability (AEP) storm with a 24-hour duration, where:
 - a) Q = total storm runoff flow, in cubic feet per second (cfs)
 - b) C = runoff coefficient
 - c) I = rainfall intensity rate
 - d) A = total drainage area (acres)
2. Rainfall intensity rate (I) shall be determined by the formula $I = 175/(t+25)$, where, t = the concentration time (in minutes) of the portion of the site being developed (the time, in minutes, for runoff to be contributed to the point of concentration from the entire area of the site being developed).
3. The time of concentration and runoff coefficient shall be subject to the approval of the PSAA.
4. The Engineer shall submit the storm sewer basis of design computation and a map outlining the various areas which drain to the points of inlet used for design, including offsite upstream areas. The design computation sheet shall be sealed by the Professional Engineer who supervised the computations.
5. Sufficient capacity is to be provided in the storm sewer system to handle upstream drainage areas into the system, including allowance for future full development of upstream areas per current or anticipated zoning based on the City's land use comprehensive plan, whichever projects greater flow.

C. Hydraulic Gradient

1. The hydraulic grade line shall be kept within the storm sewer pipe.
2. Unusual conditions will be reviewed on an individual basis, and variances from this requirement must be approved by the PSAA, but in no case shall the hydraulic grade line be less than 2 feet below storm casting rim elevation.

D. Pipe Size

1. Minimum size for public storm sewers, including inlet/catch basin leads, shall be 12-inch diameter if the sewer is receiving surface storm water.
2. 8-inch and 10-inch diameter pipe may be used for public storm sewers if the only contributing flow into the sewer is through a service lead connection (e.g., sump pump, footing drain).
3. Minimum size and grade for private storm sewer leads shall be 6-inch diameter at 1.0% grade.

E. Design Velocity

1. Minimum design velocity for storm sewers shall be 3 feet per second with the pipe flowing full.
2. This velocity is to be considered an absolute minimum, and higher velocities are encouraged for better self-cleansing action.
3. Maximum design velocity for storm sewer shall be 10 feet per second. Special consideration for higher velocities will be given in areas of steep topography.

F. Slope and Grade

1. Minimum and maximum percent slope for public storm sewers shall conform to Table A below where $n = 0.013$ for concrete pipe and 0.012 for PE pipe (see Section II.A. (Pipes, Joints, and Leads) of this Article).

Table A Storm Sewer Minimum Slopes Concrete Pipe				
	Concrete Pipe n=0.013		PE Pipe n=0.012	
Pipe Diameter	Min. Grade (%)	Max. Grade (%)	Min. Grade (%)	Max. Grade (%)
8"	0.75	8.30	0.64	7.10
10"	0.56	6.20	0.33	5.33
12"	0.44	4.85	0.26	4.15
15"	0.33	3.63	0.19	3.08
18"	0.26	2.85	0.15	2.43
21"	0.21	2.30	0.12	1.98
24"	0.17	1.93	0.10	1.65
30"	0.13	1.43	0.08	1.23
36"	0.10	1.13	0.06	0.95
42"	0.08	0.90	0.05	0.78
48"	0.07	0.78	0.04	0.65

Note: Public 8" and 10" pipes allowed only for sump pump or footing drain discharge

2. Caution must be used when designing storm sewers with minimum grades to ensure proper installation.
3. Wherever there is an increase in pipe size at a manhole, the grades shall match at the eight tenths flow lines, which is 0.8 of the diameters of incoming and the outgoing pipes, as measured from the inverts.

G. Depth and Location

1. Storm sewer depth design shall be based on the contours of the land being served. Storm sewers in public rights-of-way shall be deep enough to serve neighboring properties as the storm sewer is extended at a future date.
2. Minimum depth of storm sewer shall be 3 ½ feet from finish grade to the top of the pipe, including inlet/catch basin leads.
3. The maximum depth to invert of any storm sewer shall not exceed that recommended by the manufacturer for each size and class of pipe.

4. See Article 5 (Streets), Section I (Street and Pavement Design), B.13., of these standards, for utility location requirements.

H. Separation Clearances

1. There shall be a minimum of 10 feet of horizontal clearance and 18 inches of vertical clearance at perpendicular crossings between water mains and storm sewers, when measured from outside edge to outside edge of the pipes.
2. There shall be adequate horizontal separation between storm sewers and all other utilities to allow a 1:1 trench slope from the bottom of the deeper utility that will not undermine any shallower utility, or a minimum of 5 feet of separation whichever is greater.
3. There shall be a minimum of 1 foot of vertical clearance at perpendicular crossings of storm sewers with utilities other than water mains.

I. Sump Pump Discharges and Footing Drains

1. Sump pump discharges shall comply with [City Code, Title VIII \(Building Regulations\), Chapter 100 \(Construction Code\), Section 8.122 \(Sump pump discharges - footing drain\)](#).
2. Sump pump discharge lines shall be designed such that the discharge enters the public storm system via gravity.

J. Curb Drain

1. The curb drain is generally installed between 2-6 feet in depth.
2. Curb drain pipe shall be 6-inch HDPE, DR17 with green stripe or approved equivalent. HDPE curb drain pipe shall meet AWWA C906 and ASTM D3350 standards. All HDPE pipe used for curb drain purposes will be ductile iron pipe size (DIPS).

3. HDPE pipe must be produced from resins meeting the requirements of ASTM D1248 designation PE4710, ASTM D3350 cell classification 445474C, and will meet the requirements of AWWA C906. Material taken from HDPE pipe will meet the minimum stability requirements of ASTM D3350. Pipe will be legibly marked at intervals of no more than five feet with the manufacturer's name, trademark, pipe size, HDPE cell classification, appropriate legend such as DR 11, ASTM D3035, AWWA C906, date of manufacture and point of origin. Pipe not marked as indicated above will be rejected.
4. HDPE fittings shall be made from material meeting the same requirements as the pipe. Fittings shall be molded or fabricated by the manufacturer of the pipe. Where applicable, fittings shall meet the requirements of AWWA C906. Molded fittings shall be manufactured in accordance with either ASTM D2683 (socket fused) or ASTM D3261 (butt fused) and shall be marked accordingly.

K. Manholes

1. Manholes shall be placed at the end of each line, at every change of grade, direction, and pipe size, and at each junction of storm sewer mains.
2. The maximum distance between manholes shall be 400 feet for pipes 36-inch or less in diameter and 500 feet for pipes 42-inch or larger in diameter.
3. Minimum inside diameter of manholes shall be 4 feet. Diameters greater than 4 feet shall be required based on the size, number, and alignment of pipes entering the manhole in accordance with Article 12 (Standard Details), SD-ST-1A (Standard Storm Manhole - Separate Base) and SD-ST-1B (Standard Storm Manhole - Precast and Leaching Bases) of these Standards.
4. Minimum manhole access diameter shall be 2 feet.
5. All manholes shall be located such that they will be directly accessible by vehicular maintenance equipment. Manholes shall be located within 10 feet of edge of pavement.
6. All surfaces to be utilized for manhole access shall be designed to support a fully loaded storm sewer cleaning vehicle (66,000 pounds).
7. No openings shall be made in precast units which would leave less than 18 inches of undisturbed circumferential wall length, or which would remove more than 40% of the circumference along any horizontal plane.

L. Inlets and Catch Basins

1. Maximum design flow to be accepted by a single inlet or catch basin shall be less than or equal to 2.5 cfs.
2. Inlets or catch basins shall be placed in the curb line at the following locations:
 - a) All vertical road profile low points.
 - b) At the point of curvature (spring point) of intersection radii unless the intersection contains a crosswalk with ramps in which case the structure shall be upstream of such crosswalk.
 - c) At locations deemed necessary by the PSAA to provide proper site or public street drainage.
3. High capacity shall be used at all low points on streets.
4. Inlets and catch basins shall be designed with a 2-foot deep sump.

II. Materials

A. Pipes, Joints, and Leads

1. Allowable Storm Sewer Pipe Materials
 - a) Concrete pipe conforming to ASTM C76 (Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe), Class IV or Class V, as required based on depth and loading.
 - b) Corrugated, smooth interior, polyethylene pipe (PE) conforming to AASHTO M294 (Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter), or ASTM F2306 (Standard Specification for 12 to 60 in. [300 to 1500 mm] Annular Corrugated Profile-Wall Polyethylene (PE) Pipe and Fittings for Gravity-Flow Storm Sewer and Subsurface Drainage Applications), is permitted for areas more than 5 feet from the edge of a street.
 - c) Corrugated metal pipe may be used for single family residential driveway culverts with approval of the PSAA. Where approved, pipe shall conform to AASHTO M36 (Standard Specification for Corrugated Steel Pipe, Metallic Coated for Sewers and Drains), Type I (Circular) or Type II (Arch).

- d) For any class of pipe, a higher strength or greater thickness of pipe may be substituted for the minimum strength or minimum thickness of pipe specified for that class of pipe.

2. Joints and Lubricants

- a) Lubricants used in making up joints shall be supplied by the pipe manufacturer, and the joints shall be coupled in accordance with the manufacturer's requirements.
- b) Joints for PE pipe shall be gasketed water-tight joints meeting ASTM D3212 (Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals). Gaskets shall conform to ASTM F477 (Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe).
- c) Joints for reinforced concrete pipe shall meet ASTM C443 (Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets).
- d) Joints for corrugated metal pipe shall be made with coupling bands which conform to AASHTO M36 (Standard Specification for Corrugated Steel Pipe, Metallic Coated for Sewers and Drains).

3. Pipe Marking

- a) The following information shall be clearly marked on each length of pipe:
 - (1) The pipe designation and class (e.g., C 76, Class IV). For PE pipe, this shall include the PVC cell classification.
 - (2) The name or trademark of the manufacturer.
 - (3) Identification of the manufacturing plant.
 - (4) The date of manufacture.
 - (5) Testing lot number or testing lab stamp.
 - (6) Beveled pipe shall be marked with the amount of bevel, and the point of maximum length shall be marked on the beveled end.

4. Manufacturer's Certification

- a) All pipe furnished shall be accompanied by the manufacturer's certificate of test showing conformity with the stated Specifications. Each certificate shall identify a specific lot number, quantity of pipe, and show actual test results for the lot furnished. These certificates shall be submitted to the PSAA and must be pre-approved prior to the start of construction.

5. Materials Inspection

- a) All pipe furnished shall be subject to inspection on arrival at the job site by the PSAA. The purpose of the inspection shall be to cull and reject pipe or fittings that, independent of physical tests specified under the standard specifications designated herein, fail to conform to the requirements of these Standards.
- b) The Contractor shall notify the PSAA sufficiently in advance so that an Inspector can be on the job site during the unloading of materials. A minimum notice of 24 hours is required for such unloading and inspection.
- c) Rejected pipe shall be plainly marked by the Inspector and immediately removed from the site of the work by the Contractor without cost to the City.
- d) Pipe shall be subject to rejection on account of any of the following:
 - (1) Variation in any dimension exceeding the permissible variations given in the material specifications.
 - (2) Blistered, fractured, creased, or cracked pipe or fittings.
 - (3) Variation of more than one-sixteenths inch ($\frac{1}{16}$ ") per lineal foot in alignment of pipe intended to be straight.
 - (4) Insecure attachment of fittings.
 - (5) Unpigmented or non-uniformly pigmented pipe.
 - (6) Defects that indicate imperfect proportioning, mixing, or molding.
 - (7) Surface defects indicating honeycombed or open texture.
 - (8) Damaged ends where, in the judgment of the PSAA, such damage would prevent making a satisfactory joint.

6. Storm Sewer Service Leads and Fittings

- a) Storm sewer pipes and fittings for building storm sewers shall meet the requirements of the State of Michigan Plumbing Code as adopted per City Code, [Title VIII \(Building Regulations\), Chapter 100 \(Construction Code\)](#). Materials for any portion of a storm sewer lead in the public right-of-way may be required to conform to standards per this Article for public storm pipes at the discretion of the PSAA.
- b) Whenever adapters are required to properly connect the building storm sewer pipe with storm sewer main pipe of another material or manufacturer, the adapters shall be manufactured for that specific purpose and nominal inside diameter of same shall be the same size as the nominal diameter of pipe connected thereto. Such adaptors shall be provided with a stainless-steel shear ring or equivalent device approved by the Engineer to ensure pipe alignment is positively maintained.
- c) Such adapters shall also be furnished and used as required by the manufacturer and shall conform to the State of Michigan Plumbing Code.

B. Manholes and Drainage Structures

1. Manhole and Drainage Structure Materials

- a) Storm manholes and drainage structures for new construction shall be constructed of precast reinforced concrete sections. Manholes must have an eccentric cone and be constructed per Article 12 (Standard Details), SD-ST-1A (Standard Storm Manhole - Separate Base) and SD-ST-1B (Standard Storm Manhole - Precast and Leaching Bases) of these Standards. In reconstruction or other situations where it is not possible to install a precast structure, concrete block structures conforming to Article 12 (Standard Details), SD-ST-5 through SD-ST-7 of these Standards may be utilized upon approval of the PSAA.
- b) Precast reinforced concrete bases, bottom sections, manhole risers, grade adjustment rings, concentric cones, eccentric cones, and flat slab tops shall conform to the requirements of ASTM C478 (Standard Specification for Circular Precast Reinforced Concrete Manhole Sections).
- c) Concrete block for manholes, where permitted, shall conform to ASTM C139 (Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes), and shall be laid with Type M mortar.

- d) Concrete brick shall conform to the requirements for concrete building brick, ASTM C55 (Standard Specification for Concrete Building Brick), Grade N-1.
2. Joints, Tees, and Radius Pipe Sections
- a) Joints on precast manholes and drainage structures shall meet ASTM C443 (Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets), rubber O-ring gasket.
 - b) Precast manhole tees and radius pipe sections shall conform to requirements for reinforced concrete pipe, ASTM C76 (Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe), Class IV, and shall be approved by the PSAA.
3. Frames and Covers
- a) Cast iron frames and covers for manholes and drainage structures shall conform to the requirements of ASTM A48, Class No. 35, per Article 12 (Standard Details), SD-GU-1 (Standard Casting Schedule) of these Standards.
4. Manhole Steps
- a) Plastic-coated manhole steps shall be injection molded of copolymer, polypropylene, encapsulating a ½" grade 60 steel reinforcing bar.
 - b) Steps shall meet the performance test described in ASTM C478 (Standard Specification for Circular Precast Reinforced Concrete Manhole Sections), and shall have an impact resistance of 300 ft.-lbs., with only minor deflection and no cracking or breaking.
 - c) Steps shall resist pull-out forces of 1500 lbs.
5. Connections of Storm Pipe to Precast Manholes
- a) If a flexible neoprene rubber boot is utilized, it shall conform to ASTM C923 (Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals), and be securely clamped into a core-drilled or cast pipe port.
 - b) Pipe ports shall be core-drilled or cast at the point of manhole manufacture and shall be accurately located within ½" of proposed pipe centerline.
 - c) Pipe clamp bands shall be of corrosion-resistant stainless steel.

6. Chimney Seals

- a) See Article 10 (Construction Specifications), Section II. (Utilities), DD.3. for external chimney seal requirements and specifications.

C. Cured in Place Pipe (CIPP)

1. CIPP shall conform to ASTM F1216 (Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Inversion and Curing of a Resin-Impregnated Tube).
2. Use of CIPP shall require approval of the PSAA.
3. Materials and construction installation shall conform to Article 10 (Construction Specifications) of these Standards.