CITY UTILITIES
DESIGN STANDARDS MANUAL

Book 5
Materials (MA)
MA5 Stormwater Materials and Testing Requirements

September 2017

MA5.01 Purpose

This Chapter covers typical materials used for stormwater projects.

MA5.02 Allowable Pipe Materials and Testing Requirements

Figure MA5.1 summarizes pipe materials used for gravity storm sewer installations and is to be used as a reference for acceptable storm sewer pipe materials. The following sections in this chapter provide detailed requirements for each pipe material.

Figure MA5.1 Allowable Pipe Materials Summary

Pipe Material	ASTM Standard	[1]Min. Cover (ft)	Sizes (Diameter, in.)			Bedding Requirements	Master Spec Number
			Minimum-Private	Minimum-Public	Maximum		
Reinforced Concrete(RCP)	ASTM C76 ASTM C507 ASTM C506 ASTM C1577 ASTM C1504	<3	8	12	144	Rigid Detail - BS-4	33 05 34.13
Ductile Iron (DIP)	AWWA C151	3	8	12	64	Flexible Detail - BS-5	33 05 33
Polyvinyl Chloride(PVC)	ASTM D3034 ASTM F679		8	12	48		33 05 37.13
Profile Wall Polyvinyl Chloride	ASTM F949		8	12	36		
High Density Polyethylene (HDPE)	ASTM F2306 ASTM F2648		8	12	36		33 05 38.13
Corrugated Metal (CMP)	ASTM A760 ASTM A762 ASTM B745 ASTM A761 ASTM B746		8	12	144		33 05 41
Dual Wall Corrugated Polypropylene (PP)	ASTM F2736		12		30		33 05 51
	ASTM F2881		36		48		
Pipe Underdrains	ASTM F2648 (HDPE) ASTM F949 (PVC)	-	4	6	-	-	33 46 16.19
Utility Trench Drains	-	-	-	-	-	Concrete Encased	33 44 16

Note: 1 - Minimum cover from finished grade to top of pipe (O.D), at completion of all project restoration.

1. Pipe Testing Requirements

   The following subsections include quality assurance and quality control requirements for the pipe material listed in this chapter.

2. Quality Assurance

   A. Manufacturers Qualifications

   - Pipe manufacturers shall have a minimum of 5 years of successful experience producing specified pipe and fittings, and must document their success by showing evidence of at least 5 installations in satisfactory operation within the United States.
   - Concrete pipe and fittings shall be from a source listed in the most recent INDOT list of Certified Precast Concrete Producers, in accordance with ITM 813.

   B. Supply and Compatibility

   - Pipe, fittings and appurtenances shall be suitable for the specified service and integrated into the overall piping system by the pipe supplier.

3. Field Quality Control

   This section covers pipe-testing requirements after installation of the pipe. The following testing is required for stormwater projects:

   - Vertical Deflection Test (Mandrel Test) for Flexible Pipe
   - Televised Inspections (for public projects)

   The following testing for stormwater pipe is used based on project specific requirements:

   - Low Pressure Air Test
   - Hydrostatic Test
   - Large Diameter Pipe Joint Test

   A. Vertical Deflection Test (Mandrel Test) for Flexible Pipe

   1. Conduct vertical deflection tests not less than 30 days after the installation of the pipe, bedding and backfill.
   2. Testing is conducted on all pipe runs (defined as length of continuous pipe from structure to structure) containing 3 or more pipe-to-pipe joints.
   3. A rigid ball or mandrel that has a diameter of at least 95% percent of the base inside diameter or average inside diameter of piping is used to test the deflection of the piping. The ball diameter depends on which is specified in applicable ASTM standard, including the appendix, to which the pipe is manufactured.
   4. The test is performed without mechanical pulling devices.
   5. Pipe segments that exceed a deflection of 5% are not acceptable and must be replaced/repaired, in compliance with City Utilities Engineering standards.

B. Televised Inspection for All Pipe Materials

1. Televise completed sewer and appurtenant structures, including manholes and chambers, and provide to City Utilities Engineering a copy of the video on digital video disc (DVD) or portable storage device. Software shall be compatible with Pipelogics version 6.0 software.
2. Inspection shall be performed by a subcontractor certified in Pipeline Assessment Certification Program (PACP) by National Association of Sewer Service Companies (NASSCO). Provide copy of PACP certification prior to starting inspection.
3. Televising shall conform to coding and reporting standards and guidelines specified in PACP. Identify report annotations, pipe conditions, and pipe defects in accordance with PACP. Severity ratings shall be calculated in accordance with PACP.
4. Camera for main line shall be pan-and-tilt, radial viewing, pipe inspection camera that pans plus-or-minus 275˚and rotates 360˚. Use camera with an accurate footage counter that displays on television monitor exact distance of camera from centerline of starting manhole. Use camera with height adjustment so that lens is always centered at one-half inside diameter or higher, in pipe being televised. Provide lighting system that allows features and condition of pipe to be clearly seen. Camera shall operate in 100% humidity. Camera, television monitor, and other components of video system must produce a minimum 450-line resolution colored video picture. Picture quality and definition shall be satisfactory to City Utilities Engineering.
5. Repair apparent leaks in a manner satisfactory to City Utilities Engineering without additional cost to City Utilities and re-televise the pipe.

C. Low Pressure Air Test for Gravity Storm Sewers:

- DIP (for diameters ≤ 36-inches)
- PVC
- HDPE

1. Plug and bulkhead ends of pipe segment to be tested.
2. One plug shall have an orifice to pass air and a second orifice shall be continuously connected to a pressure gauge having a range from 0 to 10 psi, minimum divisions of 0.10 psi, and accuracy of 0.04+/- psi.
3. The air supply line shall have a positive on-off valve and suitable means for readily disconnecting from the control panel.
4. The section of pipe shall be pressurized to approximately 4 psi.
5. The air shall be shut off and allowed to stabilize for a minimum of 2 minutes. If during this time the pressure drops below 3.5 psi, more air shall be added to raise pressure to a minimum of 3.5 psi.

6. After the air has stabilized, the air line shall be disconnected and timing will begin.
7. The time of test in minutes will be equivalent to one-half of the nominal diameter of the pipe being tested.
8. The maximum allowable pressure drop during the specified time period will be 1.0 psi.

D. Hydrostatic Testing for:

- DI Pressure (AWWA Manual M41)
- PVC Pressure Pipe (AWWA Standard C605)
- HDPE Pressure Pipe (ASTM F2164)
- Concrete Pressure Pipe (AWWA M9)

1. Preparation for Testing:

   - Follow appropriate preparation for testing as specified in the manuals above for specified pipe material.
   - Prior to testing the contractor shall ensure that the line is clean and free of dirt and debris.
   - Prior to testing, ensure that adequate thrust protection is in place and joints are properly installed.
   - Prior to testing, install test riser and ensure equipment is properly calibrated.

2. Test Procedure for DIP and PVC Pressure Pipe:

   - Fill pipeline slowly to minimize air entrapment and surge pressures. Fill rate shall not exceed one foot of pipe length per second in pipe being tested.
   - Expel air from pipe as required. Obtain approval of City Utilities Engineering prior to tapping pipe for expelling air.
   - Examine exposed joints and valves, and make repairs to eliminate visible leakage.
   - Add fluid as required to pressurize line to 150psi or otherwise specified test pressure. Maintain test pressure for a stabilization period of ten minutes before beginning test.
   - Timed test period shall not begin until after pipe has been filled, air has been expelled, and pressure stabilized.
   - Timed Test Period: After stabilization period, maintain test pressure for at least two hours. During timed testing period, add fluid as required to maintain pressure within five psig of required test pressure.
   - Pump from test container to maintain test pressure. Measure volume of water pumped from test container and

record on test report. Record pressure at test pump at 15 minute intervals for duration of test.

- Results of the test shall be logged using the inspection form provided in Exhibit MA6-1.

3. Test Procedure for HDPE Pressure Pipe:

   - Fill pipeline slowly to minimize air entrapment and surge pressures. Fill rate shall not exceed one foot of pipe length per second in pipe being tested.
   - Expel air from pipe as required. Obtain approval of City Utilities Engineering prior to tapping pipe for expelling air.
   - Examine exposed joints and valves, and make repairs to eliminate visible leakage.
   - The test section and the test liquid shall be allowed to equalize to a common temperature.
   - After filling pipeline and purging air, gradually pressurize pipe to 150 psi or otherwise specified test pressure and maintain required test pressure for 4 hours for pipe to expand. During expansion, add fluid to maintain required test pressure. Begin timed test period after expansion period and other requirements are met.
   - Timed test period shall not begin until after pipe has been filled, exposed to required wetting period, air has been expelled, and pressure stabilized.
   - Timed Test Period: After 4-hour expansion phase, reduce test pressure by 10 psig and do not add liquid. Test pressure shall then remain steady for 1 hour, indicating no leakage.
   - If no visible leakage is observed and pressure remains within 5% of the original test pressure for 1 hour, a passing test is indicated.
   - Results of the test shall be logged using the inspection form provided in Exhibit MA6-2.

4. Test Procedure for Concrete Pressure Pipe

   - Fill pipeline slowly to minimize air entrapment and surge pressures. Fill rate shall not exceed one foot of pipe length per second in pipe being tested.
   - Expel air from pipe as required. Obtain approval of City Utilities Engineering prior to tapping pipe for expelling air.
   - After filling the pipe allow for a 48-hour momentum wetting period to saturate the concrete lining.

- Bring the pipeline to 120% of the working pressure, and maintain, within 5 psig, the pressure for the test duration of a minimum of 2 hours.

5. Makeup Water Allowances:

   - The allowable makeup water allowance is the maximum amount of water that is added into a pipeline undergoing hydrostatic pressure testing. The allowable leakage rates for the various pipe materials and joints are listed below.
   - Pipes with flanged, welded, or fused joints
     - No addition of makeup water
   - Allowance rates for DIP and PVC pipes joined with rubber gaskets as sealing members include the following joint types; bell and spigot, push on, mechanical, bolted sleeve type couplings, grooved and shouldered couplings
     - Calculate makeup water rates using the following equation.

$$Q = \frac{LD\sqrt{P}}{148{,}000}$$

Where:

Q = quantity of makeup water (gph)
L = length of pipe section being tested (ft)
D = nominal diameter of the pipe (in)
P = average test pressure during the hydrostatic test (psi_{gauge})

     - Figure MA5.2 represents the calculated values of rates per 1,000 feet of pipe at the 150 psi test pressure.

Figure MA5.2 Allowable Testing Allowance for DIP and PVC Pipe (per 1,000' of pipeline at 150 psi)

Nominal Pipe Diameter (in)	Testing Allowance (gph)
4	0.33
6	0.50
8	0.66
10	0.83
12	0.99
16	1.32
20	1.66
24	1.99
30	2.48
36	2.98
42	3.48
48	3.97
54	4.47
60	4.97

Note: Table is an excerpt from AWWA M41 and AWWA C605.

- Allowance rates for Concrete Pressure Pipe conform to Figure MA5.3.

Figure MA5.3 Allowable Testing Allowance Concrete Pressure Pipe

Type of Pipe	Makeup Allowance (gal/in dia/mi pipe/24hr)
AWWA C300, 301 and C303	10

Note: Table is an excerpt from AWWA M9.

MA5.03 Culverts

Culverts are pipes that are exposed, or open, at the upstream and downstream ends of the pipe and typically provide conveyance of surface water underneath a road, driveway, berm, and railway. Refer to the appropriate pipe material section, within this chapter, for specific pipe requirements. End treatments for use on culverts are listed in Section MA5.14.

1. Roadway Culverts

   The following pipe materials are acceptable for roadway crossings

   - Concrete pipe
   - CMP
   - Dual Wall PP

2. Driveway Culverts

   Concrete pipe and DIP, with appropriate cover, are acceptable for driveway crossings. The minimum allowable diameter is 12-inches.

MA5.04 Concrete Pipe

This section covers concrete pipe, including reinforced concrete pipe, elliptical pipe, arch pipe and concrete box sections, for use in non-pressure stormwater applications. Figure MA5.5 lists acceptable concrete pipe for public storm water facilities.

1. Reinforced Concrete Pipe (RCP)

    - Select pipe class based on the project specific external live and dead loads.
    - Class III pipe is the minimum class accepted for public storm water facilities.

2. Horizontal and Vertical Elliptical Pipe (HEP / VEP)

    - Select pipe class based on the external live and dead loads.
        - Horizontal elliptical pipe - Class HE-II is the minimum accepted for public storm water facilities.
        - Vertical elliptical pipe - VE-III is the minimum accepted for public storm water facilities.
    - Elliptical pipe size is specified by (rise" x span"). See Figure MA5.4 for example dimensions.
    - Elliptical pipe is typically tongue and groove joints. Bell and spigot joints are available from various manufacturers but, are not typical.

3. Concrete Arch Pipe

    Select pipe class based on the external live and dead loads.

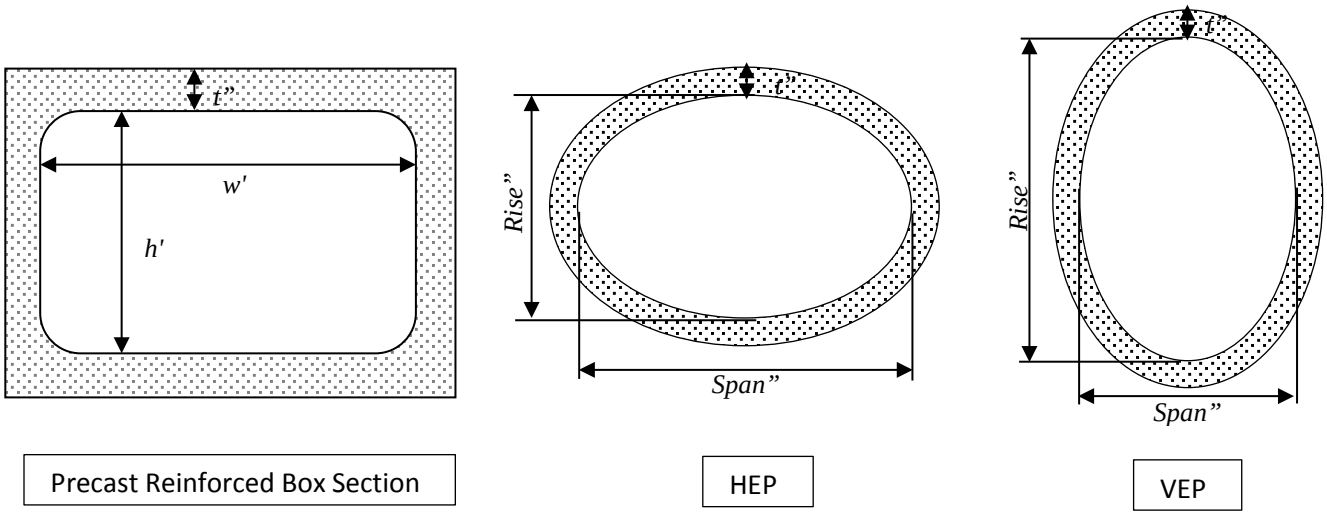
    - Class A-III is the minimum acceptable for public storm water facilities.
    - Arch pipe size is specified by (minimum rise" x minimum span").

4. Precast Reinforced Box Sections

    Precast reinforced concrete box sections are manufactured according to ASTM C1577.

    - Table 1 in ASTM C1577 lists the design requirements for precast concrete box sections under earth dead and HL-93 live load conditions.
    - Box sections sizes specified by (w' x h' x t"). See Figure MA5.4 for example dimensions.

Figure MA5.4 – Concrete Pipe Example Dimensions



Precast Reinforced Box Section | HEP | VEP

5. Precast Reinforced Three Sided Structures

   Precast reinforced concrete three-sided structures are manufactured according to ASTM C1504. These structures do require a footing to support the structure from settlement.

   - Dimension and reinforcements details are designed in accordance with Section 3, 5, and 12.14 of the AASHTO - LFRD Bridge Design Specifications.
   - The minimum concrete compressive strength is 5,000 psi, and the minimum steel yield is 65,000 psi for welded wire reinforcement and 60,000 psi for deformed billet-steel bars.

Figure MA5.5 – Concrete Pipe

Material	Class	Designation	Joints	[1]Gaskets	Sizes (in)		
					Min – Private	Min – Public	Max
Reinforced Concrete Pipe	III IV V	ASTM C76	Bell and Spigot	Rubber Gasket (ASTM C443)	8	12	144
[2]Horizontal Elliptical Pipe	HE-II HE-III HE-IV	ASTM C507	Tongue and Groove	Rubber Gasket (ASTM C443)	18	18	144
[2]Vertical Elliptical Pipe	VE-III VE-IV VE-V VE-VI			Flexible Sealant (ASTM C990)	36	36	144
[2]Arch Pipe	A-III A-IV	ASTM C506		Rubber Gasket (ASTM C443)	15	15	132
Concrete Box Sections	ASTM C1577 Table 1	ASTM C1577	Tongue and Groove	Flexible sealant with External joint sealer system or membrane system	3’ W x 2’ H x 4” Wall Thickness	3’ W x 2’ H x 4” Wall Thickness	12’W x 12’H x 12” Wall Thickness
Concrete Three Sided Structures	-	ASTM C1504			-	-	-

Note- 1- For RCP, Horizontal Elliptical pipe and Arch Pipe with diameters larger than 24”, flexible sealants may be used in lieu of rubber gaskets.
Note-2-The sizes listed are the pipe designated equivalent round size; refer to the related ASTM for exact pipe dimensions.

MA5.05 Ductile Iron Pipe (DIP)

This section covers ductile iron pipe (DIP) for buried applications. Figure MA5.6 lists acceptable DIP for public storm water facilities.

- Standard DIP is cement mortar lined with a bituminous seal-coat.
- Consider alternative linings for services involving abrasives, pH levels below 4 and above 12 (6 and 12 without seal coat), acids, industrial wastes, chemicals and scum and grease lines.

Figure MA5.6 –Ductile Iron Pipe (DIP)

Material	Designation	Pressure Class		Joints	Gaskets	Lining	Coating	Sizes (in)		
		Class	Designation					Min - Private	Min - Public	Max
Ductile Iron	AWWA C151	350	AWWA C150	Push-on (AWWA C111 and C151)	Vulcanized SBR	Cement Mortar-AWWA C140	Asphaltic - AWWA C151	8	12	12
		250-350						14		64

1. Coating

   Minimum thickness of the asphaltic coating is 1-mil.

2. Exterior Wrap

   Encase DIP and appurtenances in a polyethylene wrap in accordance with AWWA C105. Polyethylene wrap supplied in sheets or tubes is acceptable. Minimum thickness of linear low-density polyethylene film is 8-mils. Place circumferential wraps of adhesive tape at 2-ft intervals along the barrel of the pipe.

MA5.06 Polyvinylchloride (PVC) Pipe – Non-Pressure

This section covers non-pressurized PVC pipe, Figure MA5.7 lists acceptable PVC pipe for public storm water facilities.

1. PVC Pipe

   PVC pipe has an integral bell elastomeric seal joint and smooth inner wall.

   - If project requires PVC pipe with recycled content, then request pipe that is in compliance with ASTM F1760.

2. Profile Wall PVC Pipe

   Profile wall PVC pipe has a corrugated outer wall with a smooth inner wall.

Figure MA5.7 Polyvinylchloride (PVC) Pipe

Material	Designation	Min Wall Thickness	Joints	Gaskets	Fittings	Sizes (in)		
						Min – Private	Min – Public	Max
PVC Pipe	ASTM D3034	SDR35	Bell and Spigot	ASTM F477 and ASTM D3212	ASTM D3034	8	12	15
	ASTM F679	PS46			ASTM F679	-	18	48
Profile Wall PVC Pipe	ASTM F949	PS46	Bell and Spigot (ASTM F949)	ASTM F477	ASTM F949 ASTMF794	8	12	36

MA5.07 High Density Polyethylene (HDPE) Pipe - Non-Pressure

This section covers non-pressurized High Density Polyethylene (HDPE) pipe, Figure MA5.8 lists HDPE pipe acceptable for public storm water facilities. Based on project specific requirements, HDPE pipe may be specified with or without perforations and with soil or water tight joints.

1. Dual Wall Corrugated HDPE Pipe

   Dual wall HDPE pipe has a smooth interior liner in the waterway and includes an exterior corrugation that helps brace the pipe against deformations. The following list ASTM standards for dual wall HDPE pipe:

   - Pipe manufactured per ASTM 2306 is made of virgin Polyethylene (PE) plastic compound.
   - If project calls for HDPE pipe with recycled content, then require compliance with ASTM F2648.

   Corrugated dual walled pipe is also available with water tight joints; performance is based on ASTM D3212.

Figure MA5.8 High Density Polyethylene (HDPE) Pipe

Material	Designation	Joints	Gaskets	Fittings	Sizes (in)		
					Min – Private	Min – Public	Max
Dual-Wall Corrugated HDPE Pipe	ASTM F2306 (AASHTO M294, Type S)	AASHTO M252 AASHTO M294	ASTM F477	ASTM F2306 AASHTO M252 AASHTO M294	8	12	36
	ASTM F2648[1]						

Note- 1- Typically for non-public applications.

MA5.08 Corrugated Metal Pipe (CMP)

This section covers information on corrugated metal utility piping. Figure MA5.9 lists acceptable metal pipe for stormwater facilities.

CMP is manufactured with various coatings, linings and metal types. They vary based on the required service life and durability. The project site corrosivity must be considered. Highly corrosive environments reduce the lifespan of metal pipe. Consider the following site environmental factors including, but not limited to:

- Soil Resistivity – Soils with a low soil resistivity value tends to allow electrical currents to travel more freely, potentially leading to increased corrosion. Typically, clay soils have a low resistivity, while rock has high resistivity.
- Soil and Water pH – A normal pH is around 5.8, pH values above or below 5.8 tends to increase corrosion.
- Abrasion – High solids within the stormwater increase the abrasion to the pipe and damage the pipes protective coating.

1. Corrugation Patterns

    - CMP may be specified with various corrugation patterns, based on project requirements.
    - The varying patterns provide different flow characteristics.
    - Each pipe material ASTM standard lists acceptable corrugation types.

2. Joint Systems

    - CMP has various jointing systems classified as soil tight, silt tight, leak resistant or special design; see the American Iron and Steel Institute *Modern Sewer Design Manual*.
    - Leak resistant (gasketed) joints are the minimum acceptable for stormwater facilities.

3. CMP Types

    Listed below are typical CMP types these provide varying levels of corrosion and abrasion resistance.

    A. Aluminized Steel

        - The steel sheet used in fabrication of pipe manufactured per ASTM A760 has a protective metallic coating of aluminum (aluminized).

    B. Polymer Coated

        - The steel sheet used in fabrication of pipe manufactured per ASTM A762 has a polymer protective coating over a metallic coating of zinc (galvanizing) or an aluminum alloy.

- Some severe environments may cause problems to accessory items such as rivets or coupling band hardware that does not have a polymer coating.
- Additional protection for polymer pre-coated steel pipe can be provided by use of coatings applied after fabrication as described in ASTM A849.

C. Aluminum Alloy

- Pipe manufactured per ASTM B745 specifies aluminum-alloy sheet metal.

D. Corrugated Structural Plate Pipe

Structural plate pipe is typically used in the construction of pipe, pipe-arches, arches, underpasses, box culverts, and special shapes for field assembly. The following list the acceptable standards for corrugated structural plate pipe:

- ASTM A761 – Galvanized corrugated steel flat plate for field bolted pipe
- ASTM B746 – Aluminum alloy steel flat plate for field bolted pipe.

Figure MA5.9 Corrugated Metal (CMP) Pipe

Type	Pipe Designation	Material	Material Designation	Min Gauge	Joints	Gaskets	Fittings	Sizes (in)		
								Min – Private	Min – Public	Max
Corrugated Metal Pipe	ASTM A760	Aluminized Steel	ASTM A929	14	External Semi-Corrugated (Hugger) Coupling Band	Rubber O-Ring	Match Pipe Mat.	8	12	144
	ASTM A762	Polymer-Coated Steel	ASTM A742					8	12	144
	ASTM B745	Aluminum Alloy	ASTM B744	14	External Semi-Corrugated (Hugger) Coupling Band	Rubber O-Ring		8	12	120
Corrugated Steel Structural Plate	ASTM A761	Galvanized	ASTM A761	-	Field Bolted		-	-	-	-
Corrugated Aluminum Alloy Structural Plate	ASTM B746	Aluminum Alloy	ASTM B209	-	Field Bolted		-	-	-	-

MA5.09 Dual Wall Corrugated Polypropylene (PP) Pipe

This section covers information on polypropylene utility piping. Figure MA5.10 lists acceptable PP pipe for public stormwater facilities. Based on project specific requirements, PP pipe may be specified with or without perforations and with soil or watertight joints.

1. Dual Wall Corrugated Polypropylene Pipe (PP)

   PP pipe has a smooth interior liner in the waterway and includes exterior corrugation that helps brace the pipe against deformations.

Figure MA5.10 Dual-Wall Polypropylene (PP) Pipe

Type	Pipe Designation	Joints	Gaskets	Fittings	Sizes (in)		
					Min – Private	Min – Public	Max
Dual-Wall Corrugated PP Pipe	ASTM F2736	Bell and Spigot (ASTMF2736)	ASTM F477	ASTM F2736	8	12	30
	ASTM F2881	Bell and Spigot (ASTMF2881)	ASTM F477	ASTM F2881	8	36	48

MA5.10 Underdrains

This section covers information related to stormwater underdrains. Underdrains are small diameter pipes that provide subsurface drainage. These pipes are available in multiple materials, with or without perforations and must be protected from fine sediment with geotextiles.

1. Underdrain Pipe Materials

   Figure MA5.11 lists acceptable underdrain pipes for stormwater facilities.

Figure MA5.11 Underdrain Pipe Materials

Material	Designation	Perforations	Joints	Gaskets	Fittings	Sizes (in)	
						Min – Private	Min – Public
Dual Wall Corrugated PVC Pipe	ASTM F949	ASTM F949	Bell and Spigot (ASTM F949)	ASTM F477	ASTM F949 ASTM F794	4	6
Dual Wall Corrugated HDPE Pipe	AASHTO M252 or ASTM F2648	AASHTO M252 AASHTO M294 ASTM F2648	AASHTO M252 AASHTO M294 ASTM D3212	ASTM F477	AASHTO M252 AASHTO M294	4	6

2. Perforations

   Dimensions and configurations of perforations are based on the application and manufacturer's recommendations.

   - Pipe connected by bell and spigot joints shall not be perforated in the area of the bells and spigots.

3. Fine Sediment Protection

   Perforations on underdrains must be protected from fine sediment to prevent the underdrain from clogging. The following are two acceptable methods for providing protection:

- A geosynthetic filter sock wrap that fits around the circumference of the pipe per manufacturer's recommendations. Coordinate the material requirements with the pipe manufacturer.
- Wrap the underdrain pipe trench with a nonwoven geotextile fabric. Refer to Chapter MA4 – Common Materials and Testing Requirements for nonwoven geotextile fabric requirements.

4. Cleanouts

Cleanouts must be spaced as follows to allow maintenance access to all sections of the pipe.

- Cleanouts are spaced at a minimum of 300 feet apart along the total length of the underdrain.
- The material, joints, and fittings of cleanouts must be compatible with the underdrain pipe material per pipe manufacturer's recommendations.

MA5.11 Manholes

This section covers information on precast concrete storm drainage manholes and pipe to manhole connection requirements. Precast storm drainage manholes are manufactured by wet cast methods using forms. Table MA5.12 lists typical storm drainage manholes.

Figure MA5.12 Storm Drainage Manholes

Material	Designation	Detail Numbers	Joints	Gaskets	Pipe Connections	Sizes (in) Min
Precast Concrete	ASTM C478	STR-30-1 STR-30-2 STR-30-3 STR-30-4	Tongue and Groove	Preformed Flexible Sealant (ASTM C990)	Grout Collar or Rubber Gasket Boot	48

1. Pipe Connections to Manhole

   A. Pipe opening in manholes are either pre-formed by the manufacturer or field drilled

      - When using RCP, the pipe manhole opening diameter shall not exceed the pipe outer diameter plus six inches (O.D.+6")
      - When using non-concrete pipe, the manhole pipe opening diameter shall not exceed the pipe outer diameter plus four inches (O.D.+4")

B. Connections between the manhole and pipe must be soil tight. The following methods are appropriate:

- Grout collar- placed in the annular space between the manhole and pipe. Use Class A or Class B grout in accordance with Chapter MA4 – Common Materials and Testing Requirements.

Note - Projects that are located in the downtown district, or near sensitive building foundations and structures must require that rubber gasket boots are utilized for the pipe to manhole connections.

- Rubber Gasket Boot- Use one of the following manufactured in accordance with ASTMC923.
  a) For pipes ≤36" diameter:
    - Press-Seal PSX: Positive Seal
    - NPC Kor-N-Seal II 306 Series
  b) For pipes ≥36" diameter:
    - A-Lok Premium
    - Press-Seal WS 30 Waterstop Grouting Ring

MA5.12 Inlet Structures

This section covers information on stormwater drainage inlets. Inlets are area drains, catch basins and yard drains and typically used to convey stormwater runoff into the collection system. Figure MA5.13 lists typical inlet structures for use in stormwater applications. For each inlet's application information refer to Exhibit MA5-1.

1. Precast Inlet Structures

   Precast structures are available in a variety of sizes and are typically used within the right-of-way and parking areas.

2. Plastic Inlet Structures

   Nyloplast plastic structures are available in a variety of sizes ranging from an 8" drain basin to a 30" drain basin and typically used for applications outside of the right-of-way. Each drain basin size has a matching grate assembly that is available from the manufacturer and is based on the specific application.

3. Pipe to Structure Connection

   Connections between the inlet and pipe must be soil tight. Projects that are located in the downtown district, or near sensitive building foundations and structures must require that rubber gasket boots are utilized for the pipe to manhole and inlet connections. The following methods are appropriate:

   - Rubber Gasket Boot- Use one of the following manufactured in accordance with ASTMC923.

a) For pipes ≤36" diameter:
- Press-Seal PSX: Positive Seal
- NPC Kor-N-Seal II 306 Series

Figure MA5.13 Inlet Structures

Material	Designation	Detail Numbers	Joints	Sizes	
				Min-Private	Min-Public
Precast Concrete	ASTM C478	STR-32-1 STR-32-2 STR-32-3 STR-34-1 STR-34-2 STR-34-3 STR-34-4	Tongue and Groove	30" Diameter 30" x 30" Square	
Plastic	ADS Nyloplast Drain Basin (or approved equal)			8" Diameter	12" Diameter

MA5.13 Utility Trench Drains

This section covers linear utility trench drains that capture overland sheet flow and convey runoff to the stormwater collection system. Figure MA5.14 lists the common trench drain types.

- Utility trench drain pipes that are PVC, HDPE, or CMP must have the pipe encased in concrete.
- Proprietary trench drains are acceptable and for use outside of the right-or-way. Coordinate with manufacturer's requirements and recommendations.

Figure MA5.14 Utility Trench Drains

Type	Grate I	Pipe/Trench Material	Detail Numbers
Trench Drain Type I	Cast Iron Grate	Reinforced Concrete	SW-5-1
Trench Drain Type II	Slotted Vane Drain	HDPE PVC CMP	SW-5-2
Proprietary Trench Drains	Conform to manufacturer's requirements		

MA5.14 End Treatments

This section covers end treatments for storm sewer pipe including end sections, erosion control, backflow prevention and pipe anchoring. End treatments are required to ensure free flowing inflow and outflow, prevent floatation, and protect against soil erosion. Based on project requirements various end treatment shapes may be utilized including:

- flared
- safety metal grated
- headwalls
- headwall with wingwalls
- slope matching mitered structures
- grated box
- engineered baffles and structures

Typical end section structures are listed in Figure MA5.15.

Figure MA5.15 End Treatments

End Treatment Material	Material Designation	Joint to Pipe	Detail Number
Precast Concrete – Flared End Section	ASTM C76	Tongue and Groove	STR-46-3
Cast in Place Concrete Headwall	Concrete Requirements are listed in Chapter MA4 –Common Materials and Testing Requirements		STR-39
Cast in Place Concrete Headwall with Wingwalls			n/a
Cast in Place Reinforced Concrete Slope Walls			n/a
Metal	AASHTO M 218 or ASTM A929	Flat Strap Connector	STR-46-2
		Threaded Rod	
		Dimple Band Collar (Bolted to End Section)	

1. Anchoring

   Provide pipe anchoring for all non-concrete pipes, to protect against floatation.

   An 18” toe plate extension is required for all steel end sections. See STR-37 for toe plate extension.

   For pipes ≥ 60-inches, the applicable INDOT standard details and specifications shall be used for pipe end anchors.

2. Energy Dissipation

   Energy dissipation is used to reduce the outlet velocity and to help prevent erosion. The following are acceptable energy dissipation materials:

   - Riprap – Refer to Chapter MA4 – Common Materials and Testing Requirements
   - Engineered baffled spillway
   - Geotex
   - Scourstop
   - Proprietary erosion control products

3. High Water Protection-Gates and Check Valves

   For locations where backflow from waterways or water bodies into the piping network is a concern, utilize the appropriate valves or gates.

   A. Rubber Duckbill Check Valves

   Rubber duckbill check valves shall be flow operated check type with a slip-on connection. Inlet port area shall be 100 percent of the connecting pipe port size. The port area shall contour down to a duckbill that shall allow flow in one direction while preventing reverse flow. The flexible duckbill shall be one piece construction with fabric reinforcement. The valve shall also have a Neoprene exterior wrapping, or approved equal, for protection against sunlight attack. The following products are acceptable:

   - Tideflex by Red Valve Company
   - Or approved equal

   B. Metal Top-Hinged Flapgates

   Metal top-hinged flapgates shall be flow operated check type. The port opening shall be equal in size to the connecting pipe. The flap shall allow flow in one direction while preventing reverse flow. The upper hinge shall be designed such that minimal maintenance is required. The following products are acceptable:

   - Waterman Industries F-25 and F-55 cast iron, automatic drainage gates
   - Or approved equal

   C. Sluice Gates

   Use sluice gates in locations where isolation of the system is necessary. Sluice gate design and materials are based on project specific requirements and must be approved by CUE.

4. Trash Racks

   For locations where large objects and debris are a concern utilize trash racks to protect pipes from clogging and downstream facilities. Trash racks should be used at the inlet of an outfall structure. Trash rack bar spacing are designed based upon specific hydraulic and site requirements. Trash rack structures are available in a variety of sizes and manufactured for all pipe material.

5. Stormwater Basin Outfall

   To minimize overloading downstream stormwater facilities, use a t-shape orifice outfall structure. Use a minimum outfall pipe diameter of 12-inch; see Exhibit SW11.7 for the layout and configuration.

MA5.15 Castings Frames and Covers

This section covers the various types of stormwater manhole and inlet structures castings, frames, covers, and grates.

All castings must include environmental lettering to notify the public that the stormwater system drains to the river.

In pedestrian traveled areas, castings frames and covers must comply with current ADA requirements with a max opening of ½-inch. Utilize pick hole plugs as appropriate.

1. Metal Castings

   - Gray iron castings are recommended for metal castings.
   - Ductile iron may be required when design loading is greater than AASHTO H-20 loading. Consult the manufacturers when loads greater than AASHTO H-20 are required.
   - Exhibit MA5-1 lists the appropriate metal casting that corresponds to the inlet structure. And specifies the appropriate location for the various casting types.

2. Adjusting Rings

   - Precast concrete grade rings, manufactured in accordance with ASTM C478, are used to adjust the finish elevation of the metal casting. See standard detail STR-33-1 for appropriate thickness and height of the grade rings.
   - Grade rings are sealed with a preformed flexible rope joint sealant manufactured in accordance with ASTM C990 and AASHTO-M198. The following products are acceptable:
     a) EZ Stik by Press-Seal Gasket Corporation, or
     b) Kent Seal No. 2 by Hamilton Kent, or
     c) Approved equal
   - The exterior of the grade rings are sealed with a non-woven geotextile fabric. Fabric requirements are listed in Chapter MA4 – Common Materials and Testing Requirements.

3. Plastic Castings

   Plastic castings are used with plastic drainage structures. Ensure that the casting is compatible with the structure as per the manufacturer. Plastic castings are for yard drain applications and not for vehicle loading situations or within the public right-of-way.

MA5.16 Green Infrastructure

Green infrastructure is used to manage stormwater on site-constructed rather than factory constructed measures. For additional information regarding green infrastructure, see Chapter SW11 - Stormwater Management.

1. Bioretention

   Common to all bioretention systems is the use of amended soils and plants that provide a catalyst for infiltration, evapotranspiration and stormwater treatment. Material requirements for these systems are listed below.

   A. Underdrain Piping

      Underdrain piping material acceptable for bioretention construction is listed in Section MA5.10 Underdrains.

   B. Filter Aggregate

      Pipe filter aggregate is a 6-inch layer of washed INDOT #5 stone and a 4-inch layer of washed INDOT #11 stone. Stone gradation requirements are listed in Chapter MA4 – Common Materials and Testing Requirements. The stone cannot contain more than 1% silt, clay, or organic material, and cannot contain any Pre-Cenozoic limestone, dolomite, or stone containing phosphate.

   C. Revetment Stone

      Revetment stone is installed in sediment forebays, weirs and spillways. It consists of washed INDOT revetment stone and contains no more than 1% silt, clay or organic material.

   D. Geotextile Fabric

      Geotextile fabric acceptable for bioretention construction is listed in Chapter MA4 – Common Materials and Testing Requirements.

   E. Amended Soil

      Amended soil is a mixture of 50% coarse sand and 50% compost.

      - Sand for amended soil is clean construction sand, free of deleterious materials, and shall conform to the grading requirements of the ASTM C33, as shown in Figure MA5.16.
      - Compost for amended soil is aged leaf compost free of deleterious materials, including but not limited to clay,

silt, manure solids, woody debris, plastics, construction debris, or other material that may negatively affect infiltration.

- The compost pH shall range from 5.5 to 8.5, and all particles must pass through a one 1" screen or smaller.
- Compost that smells putrid, has an ammonia odor, or shows visible signs of mold is unacceptable.

Figure MA5.16- Amended Soil Sand Gradation Requirements

Sieve Size (in)	Percent Passing
3/8 in	100
No. 4	95 to 100
No. 8	85 to 100
No. 16	50 to 85
No. 30	25 to 60
No. 50	10 to 30
No. 100	2 to 10

Note: Table based on ASTM C33

F. Double Shredded Hardwood Mulch

- Mulch is composed of shredded hardwood bark and does not contain colored dyes or other chemical treatments.
- Mulch shall not contain any foreign material, debris, or compounds that may be detrimental to plant growth.
- The depth of mulch for bioretention shall be less than or equal to 3-inches.

G. Plants

Plants acceptable for bioretention are listed in Section MA5.19 Plant List.

H. Bioretention Quality Assurance

Installers shall be qualified laborers who have at least 3 years of experience with native planting and shall have successfully performed at least 5 native planting projects similar in size and scope to the current project. An on-site supervisor, experienced in native planting with a minimum 4-year degree in natural resources, biology, or related field, shall be required.

2. Green Roofs

A green roof or vegetated roof is a system consisting of waterproofing materials, growing medium and vegetation. Green roofs can be used in lieu of a traditional roof to reduce the roofs impervious area and help manage the runoff. Materials vary based on the roof structure and application

3. Cisterns and Rain Barrels

   Cisterns and rain barrels are structures used to intercept and store stormwater runoff from rooftops. The stored water is then reused for irrigation or plumbed into buildings per building codes. These systems are manufactured in many shapes and sizes and can either be above or below ground and drained by either gravity or pump.

4. Inlet and Outlet Controls

   Inlet and outlet controls are structures or landscape features that manage flow into and out of a storm water management facility. Flow splitters, level spreaders, curb openings, energy dissipaters, infiltration inlets, and curbless design are all examples of inlet controls. Outlet controls include risers and orifices, underdrains, permeable weirs, positive overflows, sub-thermocline basin release, and impervious covers. Inlet and outlet controls are typically design elements or proprietary structures.

5. Filters

   Filters are structures or excavated areas containing layers of sand, compost, organic material, or other filter media, and are used to reduce pollutant levels in storm water runoff. Filters can be site-specific design or proprietary structures.

6. Pervious Pavement

   Acceptable pervious pavement is listed in Chapter MA4 - Common Materials and Testing Requirements.

MA5.17 Underground Stormwater Storage

There are multiple different styles and types of underground storage structures that fit specific site footprints and applications. These underground storage systems can be used to store, infiltrate, facilitate infiltration and retain stormwater flows. Exhibit MA5-2 shows the acceptable types of underground storage. Refer to manufacturer's recommendations for installations and material requirements.

MA5.18 Manufactured Stormwater Quality Units (SQU)

SQUs are flow-through structures with a settling or separation unit that removes sediment and other pollutants. External power is not required, because the energy of the flowing water separates the sediment. There are many variations of these structures designed to fit specific needs. These units work best when the material to be removed from the runoff is heavy, which can be settled, or floatables, which can be captured.

SQUs can be used alone or in conjunction with other stormwater best management practices. These units come in various sizes designed to treat different flowrates. Exhibit MA5-3 lists approved offline SQUs and their treatment flowrates. Operations and maintenance manual and SWPPP requirements are listed within the checklist found in Exhibit MA5-4.

MA5.19 Plant List

City Utilities has developed a list that identifies plant types best suited for the climate and conditions in Fort Wayne. Refer to https://www.cityoffortwayne.org/images/stories/Utilities/docs/designman/PlantListFinal.pdf for a list of Fort Wayne native plant species that includes information such as salt tolerance, sun exposure, and plant height. This information is important to consider when choosing plants for green infrastructure applications.

MA5.20 Gabions and Mattress Linings

Gabions and mattress linings can be utilized for bank stabilization and erosion control. In general, gabions and mattresses shall be designed and installed per manufacturer's recommendations. Refer to standard details EROS-9-2, EROS-9-3, and EROS-9-4 for the various layouts of gabion boxes mattresses.

1. Gabion and Mattress Linings General Guidelines

   - Standard gabions and mattress linings shall be fabricated so as to be of a single unit construction - the base, lids, and sides shall be woven into a single unit.
   - The mesh sizes shall be clearly indicated. Standard sizes include 6 x 8 and 8 x 10. The mesh shall be hexagonal woven mesh with all joints formed by twisting each pair of wires through 3 ½ turns.
   - Lacing (connection) of the gabions and mattress linings shall be clearly specified. In general, lacing wire shall be secured at the corner of the gabion or mattress and the lacing wire shall be laced alternating with single and double loops every other opening at intervals of not more than 6-inches. Rings may be used in lieu of lacing wire.
   - Gabion and mattress linings shall be coated with zinc or, in aggressive environments, PVC. Zinc coated (galvanized) wire shall conform to ASTM A641. Coating specifications shall be detailed in the project specifications.
   - Geotextile filter fabric shall be specified at required gabion and/or mattress soil interfaces to prevent soil intrusion into the gabion. Refer to Chapter MA4 - Common Materials and Testing Requirements for geosynthetic fabric requirements.

2. Gabion Fill Material

   - Gabion box shall be filled with clean, hard, dense, durable stone, rounded and angular shape that shall not disintegrate on exposure to water of weathering during the life of the structure.
   - No stone shall pass through the mesh.
   - Provide INDOT Uniform A rip rap in accordance with INDOT Section 904.04(d), stone with the following gradation requirements:

Figure MA5.17- INDOT Rip Rap Uniform A- Gradation Requirements

Gradation Requirements (Percent Smaller)	
Size, in	Uniform A
8	100
6	35-80
3	
1	0-20

Table Based on INDOT Standard Specification Section 904.40(f).

3. Reno Mattress Fill Material

   - Mattress shall be filled with clean, hard, dense, durable stone, rounded and angular shape that shall not disintegrate on exposure to water of weathering during the life of the structure.
   - No stone shall pass through the mesh.
   - Provide INDOT Uniform B rip rap in accordance with INDOT Section 904.04(d), stone with the following gradation requirements:

Figure MA5.17- INDOT Rip Rap Uniform B- Gradation Requirements

Gradation Requirements (Percent Smaller)	
Size, in	Uniform B
8	-
6	95-100
3	35-80
1	0-20

Table Based on INDOT Standard Specification Section 904.40(f).

MA5.21 Channel Protection Systems

Channel protections systems covers a wide range of materials that are used to reinforce and stabilize channel banks, stormwater outfalls and other locations that require erosion control. In general, the channel protection systems shall be designed and installed per manufacturer's recommendations.

1. Cellular Confinement System

   Cellular confinement system shall be polyethylene stabilized black and a perforated textured cell, and shall control shearing lateral and vertical movement of the surface. Carbon Black content shall be 1.5 to 2 percent by weight, through addition of a carrier with certified carbon black content. The cellular confinement system, GeoWeb, or similar, is manufactured by Presto Geosystems.

Utilize cellular confinement systems as channel erosion control, to create channel wet weather storage area.

Select the cell size and appropriate anchorage system based on project conditions, coordinate with the manufacturer. Fill the cells with an appropriate aggregate topsoil, concrete or vegetation.

2. Concrete Cloth

Concrete cloth is a flexible, cement impregnated fabric that hardens with hydrated to form a thin, durable, water and fire resistant concrete layer. The concrete cloth, or similar, is manufactured by Miliken.

Utilize concrete cloth as channel bank stabilization, outfall protection, or various locations where hard armoring is required.

Select the thickness and appropriate anchoring system based on project specific requirements, soil conditions and intended use. Coordinate with manufacturer as needed.

Prepare a smooth subbase to avoid any rips or tares in the fabric during installation. Use appropriate tools to unroll and place the cloth, do not overstretch or drive on the material. Once installation is complete and appropriate anchorage installed.

3. Concrete Filled Fabric

Concrete filled fabric forms are filled in place with fine aggregate concrete to form hard armoring and provide erosion control. The concrete filled fabric, Hydrotex, or similar, is manufactured by Geostar Corporation.

Utilize concrete filled fabric as channel bank stabilization, outfall protection, or various locations where hard armoring is required.

Select the appropriate fabric pattern based and anchoring system based on project specific requirements, soil conditions and intended use. Coordinate with manufacturer as needed. The fine aggregate concrete fill shall be pumpable with a water cement ration between 0.65 to 0.75 and be supplied from a concrete batch plant.

Prepare a smooth subbase to avoid any rips or tares in the fabric during installation. Install a permeable filter fabric underlayment, select the required fabric type based on subgrade soil layer. Once installation is complete and appropriate anchorage installed, fill the fabric with the fine aggregate concrete.

4. Interlocking Concrete Units

Interlocking concrete units are pre-determined concrete blocks that conform to ASTM D 6684 to form hard armoring and provide erosion control. The interlocking concrete units, A-Jacks, or similar, are manufactured by Armortec.

Utilize concrete filled fabric as channel bank stabilization, outfall protection, bridge pier scour protection or various locations where hard armoring is required.

For streambank protection utilize the AJ-240inch concrete block unit. Based on project specific requirements include a subbase geosynthetic separation layer. Coordinate with manufacturer as needed.

Prepare a smooth subbase to ensure proper contact between the concrete units and the slope face. Install a permeable filter fabric underlayment, select the required fabric type based on subgrade soil layer. Install a minimum of 2-inches of clean aggregate bedding (INDOT No. 8, or similar). Place units in a consistent and repeatable pattern, while orienting the exposed projecting unit arm in the downstream direction. installation is complete and appropriate anchorage installed, fill the fabric with the fine aggregate concrete.