Watertight Storm Sewer

Best Management Practices (BMP)

Design Manual

Watertight Storm Sewer BMP Manual

Introduction

A storm sewer is usually designed for many years of service life. How will stormwater requirements be different in ten years, or twenty? How will the systems installed today meet the needs of the future? How much will it cost to prematurely replace pavement when the drainage systems underneath fail? What can we do to maximize their performance, minimize their maintenance, and ensure that they yield lower total cost? What can you do now to prepare the system for stormwater treatment in the future?

Who wants to make storm systems watertight?

- <u>Government agencies</u> want reduction in non-point source pollution, groundwater contamination and de-watering of wetlands.
- <u>State DOT's & Municipalities</u> want to reduce underground structural failures related to leaking pipe joints and pipe-to-structure connections.
- <u>Public safety officials</u> want reduced roadway construction time.
- <u>Consulting Engineers</u> want improved systems without increased costs.
- <u>Taxpayers</u> want the best return on their infrastructure dollars.

What performance improvements do watertight storm sewers provide?

- Grossly reduced TSS in effluent
- Reduction in subsidence and settlement around the system, especially at street penetrations
- Control of water entering and exiting the system
- Accommodation of deflection at joints & structures
- Improved system performance and longevity at a comparable installed price
- "Plug and play" future stormwater treatment capability

What cost-benefits do watertight storm systems provide?

- Lower total labor and material costs
- Faster & less expensive installations
- Higher quality product at same cost
- Lower maintenance costs for municipalities
- Lower exposure for environmental problems
- Longer life for streets and roads

From the U.S. EPA National Pollutant Discharge Elimination System (NPDES)
"EPA Stormwater Phase II Menu of Best management Practices (BMP's)"

"…Once pollutants are present in a water body…it is much more difficult and expensive to restore it to an undegraded condition. Therefore, the use of a management system that relies first on preventing degradation of receiving waters is recommended. BMPs under each of the minimum measures—particularly the obvious category of pollution prevention, as well as outreach, education, and erosion and sediment control—focus on the prevention of pollutants from ever getting into storm water.

Watertight Storm Sewer BMP Manual

Table of Contents

Watertight Storm Sewer BMP Manual

System Component: Collection Structure Construction

Obsolete Practice(s):

- Structures constructed in-field from brick or block.
- Structures cast-in-place.

Recommended Practice(s):

- Specify and use precast concrete structures exclusively throughout the system.

Rationale:

1. Precast concrete structures have proven to be strong, durable, and watertight by their design and construction.
2. Precast concrete structures are manufactured in a controlled process, making their performance superior to others.
3. Precast structures are available everywhere.
4. Precast structures are designed and manufactured to widely accepted specifications.
5. Precast structures require no curing time or other delays in construction.

Applicable Standards and Specifications:

- *C 478 – Standard Specification for Precast Reinforced Concrete Manhole Sections*
- *C 789 – Standard Specification for Precast Reinforced Box Sections for Culverts, Storm Drains, and Sewers*
- *C 990 – Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants*
- *C 913 – Standard Specification for Precast Water and Wastewater Structures*

Watertight Storm Sewer BMP Manual

System Component: Collection Structure Joints

Obsolete Practice(s):

- "Seal" structure joints with mortar
- Use filter cloth on structure joints.

Recommended Practice(s):

- Specify Tongue and Groove joints between structure sections.
- Seal structure joints with preformed butyl joint sealant.

Rationale:

1. Tongue and Groove joints help maintain alignment of the precast concrete sections, even after settlement occurs.
2. Preformed butyl sealant provides a flexible, watertight joint in precast concrete structures.
3. Flexibility in structure joints prevents point loads from developing during settlement.
4. Preformed butyl sealant maintains both adhesion and cohesion between sections.
5. Preformed butyl sealant conforms to a wide variety of joint geometry, and can help fill imperfections.
6. Preformed butyl sealant maintains its seal, even after system settlement occurs.
7. Butyl Joint Wraps provides additional sealing on difficult joints.

Applicable Standards and Specifications:

- *C 877 – Standard Specification for External Sealing Bands for Noncircular Concrete Sewer, Storm Drain and Culvert Pipe*
- *C 990 – Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants*

Watertight Storm Sewer BMP Manual

System Component: Pipe Entry into Structures

Obsolete Practice(s):

- Designs with pipe entry into corners of square structures
- Designs with pipe entry through structure joints
- Designs with radical pipe entry angles

Recommended Practice(s):

- Enter square structures at near-ninety-degree angles
- Use round structures for odd angles
- Use elbows or bends to develop suitable entry angles
- Avoid designs where pipes penetrate structure joints
- Avoid oversized openings in structures

Rationale:

1. Pipes entering square structures at 90 degree angles are easily sealed with a variety of flexible connectors.
2. Pipe entry into structure joints and corners are impossible to seal with watertight flexible connectors.
3. Field practices of mortaring pipe into oversized holes or into corner penetrations are impossible to seal, prone to immediate cracking, and reduce the structural strength of the structure and system.

Applicable Standards and Specifications:

- *C 270 – Standard Specification for Mortar for Unit Masonry*
- *C 923 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals*
- *C 1478 – Standard Specification for Storm Drain Resilient Connectors Between Reinforced Concrete Storm Sewer Structures, Pipes and Laterals*

Watertight Storm Sewer BMP Manual

System Component: Pipe-To-Structure Joints

Obsolete Practice(s):

- "Use brick and mortar to "seal" joints
- Use filter cloth around pipe entry points

Recommended Practice(s):

- Seal all pipe entries into structures with flexible connectors

Rationale:

1. Pipes entering structures are the primary point of infiltration and exfiltration.
2. Pipes and structures settle differently, quickly creating and voids in rigid joints.
3. Rigid joints create shear loads on pipe and structures, leading to failure.
4. Brick and mortar joints require excessive time for construction and delays in inspection and backfill.
5. Leaks around pipe-to-structure joints result in subsidence and loss of soil support for roadway.

Applicable Standards and Specifications:

- *C 923 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals*
- *C 1478 – Standard Specification for Storm Drain Resilient Connectors Between Reinforced Concrete Storm Sewer Structures, Pipes and Laterals*

Watertight Storm Sewer BMP Manual

System Component: Waterstops on Mortared Pipe Entry

Obsolete Practice(s):

- Install bare pipe into structure with mortar collar

Recommended Practice(s):

- When Mortared pipe entry *must* be used, always use a waterstop on pipe.

Rationale:

1. Inevitably, in almost every stormwater system, a mortar pipe-to-structure connection will have to be made.
2. The addition of a waterstop around the pipe where it is mortared will greatly improve the sealing of this connection.
3. The waterstop helps prevent infiltration between the pipe and the waterstop.
4. The waterstop will not provide flexibility to the joint, nor will it eliminate point loads.

Applicable Standards and Specifications:

- C 270 – Standard Specification for Mortar for Unit Masonry

Watertight Storm Sewer BMP Manual

System Component: Corrugated OD Pipe

Obsolete Practice(s):

Install unmodified corrugated into structures

Recommended Practice(s):

Obtain pipe adapters from pipe manufacturer or connector adapters from precaster or connector manufacturer to ensure a watertight connection between pipe and structure.

Rationale:

1. Pipe/structure connection is critical to system watertightness and pavement durability.
2. Common storm drainage pipe types include corrugated OD, making them difficult to seal without adaptation.
3. Adapters that create a smooth, sealable pipe OD are available for most pipe types, styles, and sizes from the pipe manufacturers, precasters, or connector manufacturers.
4. Adapters for flexible connectors are available for some pipe types and styles from the connector manufacturer, supplied through the precaster.

Applicable Standards and Specifications:

- *C 923 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals*
- *C 1478 – Standard Specification for Storm Drain Resilient Connectors Between Reinforced Concrete Storm Sewer Structures, Pipes and Laterals*

Watertight Storm Sewer BMP Manual

System Component: Underpavement Drainage

Obsolete Practice(s):

- Perforated pipe mortared into structures
- Open-joint pipe laid under pavement

Recommended Practice(s):

- Use solid pipe for at least a four-foot radius from all structures, then join it to perforated pipe
- Seal all pipe-to-structure connections with flexible connectors
- Keep invert of subsurface drain above structure outlet pipe to prevent surface water from infiltrating subsurface area

Rationale:

1. Open joints or perforated pipes adjacent to structures provide a direct path for infiltration from the road surface around the outside of the structure.
2. These paths remove soil support around the structure, allowing pavement to collapse.
3. By moving the drainage points at least four feet from structures, the infiltration path is far enough away from the structure that soil support is maintained.
4. Perforated pipe provides a regulated amount of subsurface water collection. Opening joints in pipe for drainage invites complete failure of the joint.

Applicable Standards and Specifications:

- *C 923 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals*
- *C 1478 – Standard Specification for Storm Drain Resilient Connectors Between Reinforced Concrete Storm Sewer Structures, Pipes and Laterals*

Watertight Storm Sewer BMP Manual

System Component: Pipe Joints

Obsolete Practice(s):

- Use mortar or mastic to create seals in pipe joints
- Lay pipe with open joints
- Use filter cloth around pipe joints

Recommended Practice(s):

- Seal all pipe joints with rubber gaskets designed for a watertight seal

Rationale:

1. Pipe joints present many points of infiltration and exfiltration if they are not sealed.
2. Contaminants in surrounding soils quickly enter systems through open pipe joints.
3. Pipe joints sealed with rubber gaskets maintain their seal even as the pipe sections settle over time.
4. Sealed systems require much less maintenance because fines and surrounding soils remain outside the system.
5. All types and styles of pipe are available with rubber gasket sealing systems.

Applicable Standards and Specifications:

- *C 361 – Standard Specification for Reinforced Concrete Low-Head Pressure Pipe*
- *C 443 – Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets*
- *D 3212 – Standard Specification for Joints for Drain and Sewer Plastic F 477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipes Using Flexible Elastomeric Seals*

Watertight Storm Sewer BMP Manual

System Component: Accurate Installation of System

Obsolete Practice(s):

- Install pipe and structures in conventional manner

Recommended Practice(s):

- Use modern technology to align pipe and structures, accurately establishing locations, grades, and flows.

Rationale:

1. Conventional installation practices permitted approximate alignment of pipe and structures.
2. Mortar and brick were commonly used to fill in openings around pipe.
3. With gasketed pipe, flexible connectors, and formed structure openings, pipe and structures can be installed with greater care.
4. The result of this installation is a better system, where design flows are achieved, and system components are able to function as intended.

Applicable Standards and Specifications:

- *C 924 – Standard Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method*
- *C 969 – Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines*
- *C 1103 – Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines*
- *C 1214 – Standard Test Method for Concrete Pipe Sewerlines by Negative Air Pressure (Vacuum) Test Method*

Watertight Storm Sewer BMP Manual

System Component: The 80/20 Rule

Obsolete Practice(s):

- "Sealing stormwater systems is impossible. There's always something that can't be changed or gasketed without extraordinary expense."

Recommended Practice(s):

- In most systems, 80% of the pipe-to-structure entries, 90% of the structure joints, and almost 100% of pipe joints can be sealed without changing design.

Rationale:

1. System sealing is a cumulative process. If 80% of pipe entries, 90% of structure joints, and 100% of pipe joints are sealed, the result is a dramatic reduction in infiltration, exfiltration, and system degradation.
2. Pipe joints can be sealed by specifying rubber gasketed pipe on all runs, regardless of pipe type or size.
3. Structure joints can be sealed by specifying butyl sealants/wraps on all joints.
4. Pipe entries can be sealed by specifying flexible connectors, or as a last resort, waterstops.
5. By using watertight sealing throughout the system, time, labor, and inspection efforts can be concentrated on those few connections that require waterstops and mortar.
6. The result is a system sealed 90% tighter than typical construction, with no changes in design.

Watertight Storm Sewer BMP Manual

Standards and Specifications:

- *C 76 – Standard Specification for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe*
- *C 270 – Standard Specification for Mortar for Unit Masonry*
- *C 361 – Standard Specification for Reinforced Concrete Low-Head Pressure Pipe*
- *C 412 – Standard Specification for Concrete Drain Tile*
- *C 443 – Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets*
- *C 478 – Standard Specification for Precast Reinforced Concrete Manhole Sections*
- *C 497 – Standard Test Methods for Concrete Pipe, Manhole Sections or Tile*
- *C 506 – Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe*
- *C 507 – Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe*
- *C 789 - Standard Specification for Precast Reinforced Concrete Box Sections for Culverts, Storm Drain, and Sewers*
- *C 877 – Standard Specification for External Sealing Bands for Noncircular Concrete Sewer, Storm Drain and Culvert Pipe*
- *C 923 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals*
- *C 924 – Standard Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method*
- *C 969 – Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines*
- *C 990 – Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants*
- *C 1103 – Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines*
- *C 1214 – Standard Test Method for Concrete Pipe Sewerlines by Negative Air Pressure (Vacuum) Test Method*
- *C 1244 – Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test*
- *C 1478 – Standard Specification for Storm Drain Resilient Connectors Between Reinforced Concrete Storm Sewer Structures, Pipes and Laterals*
- *D 3034 – Standard Specification for Type PSM PVC Sewer Pipe and Fittings*
- *D 3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals*
- *F 477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe*
- *F 679 – Standard Specification for PVC Large Diameter Plastic Gravity Sewer Pipe and Fittings*
- *F 697 – Standard Specification for Large Diameter Corrugated Polyethylene Pipe and Fittings*
- *F 794 – Standard Specification for PVC Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter*
- *F 1803 – Standard Specification for PVC Closed Profile Gravity Pipe and Fittings Based on Controlled Inside Diameter*