CHAPTER 5

Storm Sewer and Open Channels

A. Introduction

All proposed developments shall have a properly designed and constructed storm water conveyance system. This chapter deals only with the conveyance system. Storm water retention/detention is discussed in Chapter 4 of this manual.

Every subdivision shall have a separate storm system with an adequate outlet or connection to an existing storm system. Storm systems shall be provided to accept and convey storm waters entering the subdivision according to the requirements of the city.

B. Design Requirements

1. All storm drainage system construction plans, specifications, and drainage calculations shall be designed, prepared, stamped, and signed by a qualified professional engineer registered in the State of Wisconsin.

2. All storm sewers and appurtenances shall be designed to conform with the standard specifications.

3. All storm sewers shall be installed in the public ROW or easements, and shall be dedicated to the city upon subdivision acceptance.

4. Storm sewers located outside the ROW must be centered in a 25' wide permanent storm sewer or public utility easement. If the storm sewer is located in the same easement as another utility then the easement shall be increased to 25’ plus the distance between the utilities.

5. All sewers located inside the ROW but less than 10' from the lot line must have a 10' easement along the lot line.

6. Prior to storm sewer and drainage system acceptance, as-built drawings must be delivered to the City Engineer.

7. Any storm extension project shall include extending the storm sewer along the full length of the property.

8. Relief Swales

    a. Natural water courses or ditches and sodded swales are classified as relief swales if they convey the 100-year storm.

b. In areas where relief swales are not provided, the underground storm sewer system shall be designed with adequate capacity for 100-year storm conditions.

c. Relief swale capacity shall be determined using the Manning equation.

d. Roughness coefficients in the equation are as follows:

Material	Manning's n
Ordinary concrete or asphalt	0.013
Natural channels in good condition	0.03
Natural channels with stones	0.04
Earth	
Clean, recently completed	0.016 - 0.018
Clean, after weathering	0.018 - 0.020
With short grass, few weeds	0.022 - 0.027
Rock	
Design section	0.035
Actual section smooth & uniform	0.035 - 0.040
Actual section jagged & irregular	0.040 - 0.045
Channels Not Maintained	
Dense weeds, high as flow depth	0.08 - 0.12
Clean bottom brush on sides	0.05 - 0.08
Grass Channels & Swales	
Depth of flow up to 0.7 feet	
Mowed to 2"	0.07 - 0.045
Length 4" - 6"	0.09 - 0.05
Length about 12"	0.18 - 0.09
Length about 24"	0.30 - 0.15
Depth of flow 0.7 - 1.5 feet	
Mowed to 2"	0.05 - 0.035
Length 4" - 6"	0.06 - 0.04
Length 12"	0.12 - 0.07
Length 24"	0.20 - 0.10

e. If the roughness is not uniform across the relief swale, an average value based on the above table shall be computed.

8. Storm Sewer

   a. Storm sewer pipe design calculations shall be submitted for review, with a storm sewer system plan marked to indicate individual watersheds tributary to catch basins, or manholes with contributory areas. Each storm structure shall be numbered and the watershed acreage with the runoff coefficient shown on the plan.

   b. Unless indicated by the City Engineer, all storm sewers shall be designed based on the rational method design, Q=CIA

   c. The design storm shall be 10-year critical duration storm.

   d. The acreage (A) used in the design formula shall be the watershed area tributary to the point under consideration, including tributary areas lying outside the development not provided with storm water holding facilities.

   e. Duration time used in selecting a specific point on the curves shall be equal to the time of concentration. The time of concentration is defined as inlet time plus the flow time between the most distant inlet and the point under consideration. The minimum duration time shall be 10 minutes.

   f. Ten minute initial inlet time shall be used.

   g. The intensity value (I) shall be based on SEWRPC tables and data.

   h. Runoff Coefficient

      1) The runoff coefficient (C) is the ratio of runoff to rainfall.

      2) The runoff coefficient for impervious areas shall be 0.90.

      3) The runoff coefficient for pervious areas shall be 0.20.

      4) The runoff coefficient shall be the weighted average for the tributary watershed based on the above percentages, for commercial and industrial development.

      5) The runoff coefficient shall be computed assuming ultimate development within the tributary area.

      6) Where ultimate development plans are not available, the City Engineer shall select a coefficient based on zoning classification and knowledge of the specific development.

7) The runoff coefficients for residential zoning shall be in accordance with the following table:

Zoning C

ER	0.30
RS-1	0.35
RS-2	0.40
RS-3	0.45
RS-4	0.50
RD-1	0.50

i. Maximum gutter flow shall be determined and calculated according to State Standards.

j. Unless otherwise approved by the City Engineer, the minimum allowable pipe size is 12" in diameter, except for building service lines (laterals).

k. The minimum pipe velocity shall be 2.0 fps, flowing full. The maximum pipe velocity shall be 15.0 fps, flowing full.

l. Storm sewer pipes shall be designed using the Manning Formula.

$$V = \frac{1.486\, R^{2/3}\, S^{1/2}}{n}$$

where

n = 0.013, for concrete pipe
R = sewer cross section area divided by the wetted perimeter
S = slope of the hydraulic gradient
V = mean velocity

m. Sewers shall be laid straight in both horizontal and vertical planes between manholes unless otherwise approved by the City Engineer.

n. Where storm sewers of different diameter join, the invert elevations shall be set to maintain a uniform energy gradient.

o. When full-flowing sewers that produce velocities greater than 15 fps are approved by the City Engineer, special provisions shall be taken to prevent erosion or pipe displacement.

p. Any outfall storm sewer that drains into an existing open ditch or natural water course shall have a head wall or end section made of the same material as the pipe. Endwalls for polyethylene pipe must be constructed with an anchoring system.

q. Rip-rap, with underlying type HR geotextile fabric or other energy-dissipating device is required at all discharge points.

r. Minimum cover for storm sewers in non-pavement areas shall be 2'.

s. Minimum cover for storm sewers in paved areas shall be 1', measured from the top of the pipe to the subgrade.

t. All storm sewers greater than 18” diameter constructed under existing or proposed pavements shall be a minimum Class III reinforced concrete pipe with rubber gasket-type joints per Section 3.2.11 of the Standard Specifications.

u. Storm sewers, 18” or less in diameter that are to be constructed under existing or proposed pavements, or of any diameter that are to be constructed in non-paved areas may be polyethylene (smooth inner wall, externally corrugated) meeting AASHTO M294, Type S.

v. Individual driveway culverts may be CMP and shall have a minimum size of 12".

w. Trench backfill material shall be graded ¾” crushed stone per Section 6.43.7(c) of the Standard Specifications, mechanically compacted. This backfill shall be used in all trenches to 3' beyond the back of curb or shoulder edge, when no sidewalk is proposed, and to the ROW in urban section with sidewalk. Slurry shall be used for all existing street crossings.

x. A stronger class of pipe shall be used to provide protection against structural failure when subject to all future dead loads, live loads, and impact, as determined by the design engineer.

y. Live load plus impact shall be assumed to be less than that resulting from a surcharge at the ground surface of 250 pounds per square foot. The field-supporting strength of the pipe shall be the three edge-bearing test strength to failure multiplied by the load factor for the particular type of bedding or cradling used.

8. Storm Laterals

   a. All lots, except those in ER zoning, shall be served with a storm lateral.

   b. Storm sewer lateral lines with a storm lateral shall be designed to receive the storm water runoff from roof drains, areaways, window wells, footing drains, and sump pumps. Minimum diameter shall be 6”.

   c. When the storm sewer lateral line connection or connections to the storm sewer system are intended to receive other than pumped flow, inlet time assumed in determining the time of concentration will be reduced to 5 minutes.

   d. Storm sewer lateral lines shall meet all the requirements of the storm sewer system as detailed in this chapter except for materials, and their minimum diameter shall be 6".

   e. The minimum slope on laterals shall be 1/8” per foot (1%).

   f. The maximum slope on laterals shall be 1/2” per foot (4%).

   g. Minimum cover for storm sewer laterals in paved areas shall be 1’, measured from the top of the pipe to subgrade.

   h. A clay dam shall be constructed with all storm sewer laterals adjacent to pavement low points.

9. Storm Catch Basins

   All storm sewer structures designed to receive storm runoff shall have a minimum 1’ sump.

   a. Street catch basins shall have a maximum spacing of 400' and shall be located so that no surface water shall be carried across or around any street intersection.

   b. Side and rear lot catch basins shall be placed so that no surface water will be carried for a distance greater than 375 feet.

   c. Inlet capacity computations shall be determined according to the WDOT-FDM, or the Neenah Design Charts.

   d. A 10% maximum carryover flow may be permitted along pavement slopes in excess of 1%.

e. Channelized storm runoff in excess of 0.5 cfs shall discharge into a catch basin before crossing a sidewalk or curb.

f. The street catch basin rim elevations shall be located at least 1.5' above the hydraulic grade line.

g. Rear and side lot catch basin rim elevations must be at least 1' above the hydraulic grade line unless storage is provided at the catch basin.

h. Vertical or roll face curb catch basins shall be precast with internal dimensions of 20" x 24", and a minimum depth of 3' (flange line to invert) (see detail ST-26, in Appendix A.)

i. Catch basins intended for use with mountable curb shall be precast with internal dimensions of 24" x 30" and a minimum depth of 3' (flange line to invert) (see detail ST-26, in Appendix A.)

j. Field catch basins shall be precast with internal dimensions of 24" x 24" and a minimum depth of 2' (rim to invert.)

k. Steps shall be provided for any catch basin greater than 4' in depth, from flange to bottom.

l. Any catchbasin or inlet that includes the junction of pipes at angles other the 90 or 180, within 15 degrees shall be a 42” minimum diameter inlet manhole.

m. The maximum size pipe in a catchbasin shall be 15”. A 42” minimum diameter inlet manhole shall be used when the downstream pipe is larger than 15” diameter.

10. Manholes and Junction Chambers

a. Manholes or junction chambers shall be provided at the following locations:

1) At the termination of all sewers that do not terminate at a catch basin, inlet, or end section.

2) At all changes in size when the downstream or receiving sewer is greater than 12" diameter.

3) At all sewer connections, except when one sewer is at least 72" in diameter and the other is no greater than 12", in which case a direct tee connection may be made, and except for storm sewer lateral connections.

4) At a spacing no greater than 500'.

b. All manholes shall be precast unless they are of special design.

c. Manholes shall be sized as follows:

Downstream Pipe Size	Minimum Manhole Internal Diameter
Less than or equal to 27"	3'- 6"
Greater than 27" to 30"	4'- 0"
Greater than 30" to 36"	5'- 0"
Greater than 36" to 42"	6'- 0"
Greater than 42"	Special Design Required

d. All manholes shall be 5” precast reinforced concrete, with offset cone tops (precast corbel section.)

e. Where field conditions prevent the manhole construction with an offset cone top, a reinforced precast flattop (slab or deck) with an opening for the casting may be specified, with the City Engineer's approval.

f. Sidewall thickness shall be governed by the Standard Specifications.

g. Steps meeting the requirements of the Standard Specifications shall be installed in all manholes or catchbasin manholes deeper than 4', from manhole or catch basin floor to rim.

h. All storm sewer mainline manholes and inlet manholes shall have concrete benches poured to establish the flowline. Precast benches shall also be allowed.

11. Frames and Grates

a. Vertical and roll face curb inlet frames and grates shall be Neenah R-3222-1A, or equal as approved by the City Engineer on a 20" x 24" inlet (see detail ST-26, in Appendix A.)

b. Mountable curb inlet frames and grates shall be Neenah R-3501-R, or equal as approved by the City Engineer on a 24" x 30" inlet (see detail ST-26, in Appendix A.)

c. Field inlet frames and grates shall be R-3210-A, or equal as approved by the City Engineer on 24" x 24" precast catch basin structure.

d. Manhole frames and grates in field inlet applications shall be Neenah R-2577-1, or equal as approved by the City Engineer.

e. Manhole frames and grates in pavement applications shall be Neenah R-1661, or equal as approved by the City Engineer.

f. A safety grate with maximum bar spacing of 6” shall be installed on all storm sewer end sections 18” dia. or larger.

12. Frame Adjustments

a. Metal adjusting rings shall be used to adjust manhole rim grades for resurfacing projects and for surface placement in new developments. These rings shall be Neenah R-1979, or equal as approved by the City Engineer.

b. All other frame adjustments shall be made with precast adjustment rings, under the frame except that Tread Tech (or approved equal) rubber rings may be used provided the total thickness of rubber does not exceed 6”.

c. Maximum chimney height shall not exceed 12" from the top of the precast section to the bottom of the casting.

d. Minimum chimney height shall be 2" as specified above.

e. The minimum thickness of individual precast adjusting rings shall be 2". The maximum shall be 8".

f. Manholes shall be set ½” below the binder grade in new installations.

13. Roadside Ditches

a. Minimum distance from the ditch centerline to the shoulder edge shall be 8’.

b. Under no circumstances shall the top of bank be closer than 3' to the pavement edge.

c. Ditch depth shall be 24" minimum to 48" maximum as measured from the shoulder edge.

d. Ditch slopes shall be 1% minimum to 5% maximum.

e. Ditch side slopes shall be 4:1 maximum.

f. Ditch restoration shall be according to the contract documents. However, grades greater than 3% shall be sodded and staked, or stabilized by other means approved by the City Engineer.

g. Enclosing existing roadside ditches shall not be permitted in rural cross-section subdivisions, unless approved in writing by the City Engineer.

h. In unique cases, the City Engineer may approve enclosing roadside ditches for the following reasons:

1) Authorized drive approaches, public walks, or courtesy walks.

2) Protection of roots or trees in or near the ditch.

3) When temporary ditches are to be abandoned, the minimum size culvert shall be 15" meeting a 50-year design frequency.

4) When the ditch depth exceeds the maximum allowable as specified previously.

14. Culverts and Bridges

a. All new and replacement culverts and bridges over waterways shall be designed so as to accommodate, according to the categories listed below, the designated flood event without over topping the related roadway or railway track:

1) Local and minor streets, used or intended to be used primarily for access to abutting properties: a 10-year recurrence interval flood discharge.

2) Collector and arterial streets: a 50-year recurrence flood discharge.

3) Railways: a 100-year recurrence interval flood discharge.

The depth of flow over the top of any street shall not exceed 1' during the 100-year recurrence interval flood discharge.

b. All new and replacement culverts and bridges over waterways, including pedestrian and other minor bridges, in addition to meeting the applicable requirements above shall be designed so as to accommodate the 100-year recurrence interval flood event without raising the peak stage, either upstream or downstream, 0.01' or more above the peak stage for the 100-year recurrence interval flood, as adopted by the City of Oak Creek. Larger permissible flood stage increases may be acceptable for channel reaches having land use conditions which could accommodate the increase stage without damage to existing structures and meet the following criteria:

1) The land impacted is in public ownership and the change in flood profile is part of a public-sponsored project.

2) The land impacted is under single ownership of the project sponsor.

3) The project sponsors have acquired appropriate flood easements from all impacted landowners and municipalities.

c. The waterway opening of all new and replacement bridges shall be designed so to readily facilitate the passage of ice flows and other floating debris, and thereby avoid blockages. In locations where accumulation of floating ice or debris may cause significant backwater effect with attendant danger to life, public health or safety, or attendant serious damage to homes, industrial and commercial buildings, and important public utilities, the designer shall evaluate the impact of any blockage and provide necessary freeboard between the peak stage and the low concrete or steel in the bridge to prevent increases in flood profiles.

C. Inspection

An inspector shall be on the job site during the unloading of all materials and during construction of the storm sewer and laterals. The contractor is responsible for notifying the city 24 hours before the start of construction. Contractor shall supply material certification sheets prior to unloading of any material.

D. Construction Requirements

1. All existing field tiles must be repaired and connected to a storm sewer or have positive outfall provided.

2. All materials and installations shall conform to the Standard Specifications and General Specifications.

3. All storm sewers shall be free from sedimentation, and all other debris prior to City acceptance.

4. All precast barrel joints shall have mastic rope placed between them.

5. Excavation backfill shall be mechanically compacted in 12" lifts within the street ROW. No flushing of trenches shall be allowed. The backfill material will be as specified in the contract documents.

6. The contractor shall furnish and place a temporary 2” x 6” wood post, marked with green paint, at the end of each storm lateral.

7. All storm sewers shall be televised within 1 year prior to acceptance.

8. All adjusting rings, as well as the steel casting frame, shall be placed on an adequate mortar bed. Inside and outside faces shall be back plastered with mortar and troweled and brushed smooth.

9. Pipe to manhole connections shall be bricked and mortared inside and outside of connection shall be back-plastered with mortar and troweled and brushed smooth.

10. For new roads, all storm structures within the pavement shall be installed 2” below finished grade. Manholes within the pavement shall be brought up to finished grade with a 2” steel adjusting ring at time of final asphalt surfacing. Curb inlets shall be installed with temporary asphalt curb surrounding (“interim inlets”) and brought up to final grade with masonry and adjacent concrete curb at time of final asphalt surfacing (see Detail RO-8).