City of Saskatoon

Design and Development Standards Manual

Section Four

Water Distribution System

Version 17

City of Saskatoon

City of Saskatoon

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1 Objective

The water distribution system shall provide water to the public that is safe for human consumption and has adequate pressure for use in domestic applications.

2 Submissions and Approvals

The Proponent is responsible for being aware of the regulatory requirements governing the development of the water distribution system, and for compliance with these requirements.

Regulatory and supporting documents that shall be referenced for the design and installation of the water distribution system include the following:

- *Waterworks Bylaw (Bylaw No. 7567)*, City of Saskatoon;
- *Standard Construction Specifications and Drawings: Roadways, Water, and Sewer*, City of Saskatoon;
- *Waterworks Design Standard EPB 501*, Saskatchewan Environment;
- *NSF/ANSI 61: Drinking Water System Components – Health Effects*, National Science Foundation; American National Standards Institute (NSF/ANSI);
- *NSF/ANSI 372: Drinking Water System Components – Lead Content*, NSF/ANSI;
- *Water Supply for Public Fire Protection*, Fire Underwriters Survey;
- *National Building Code*, Canadian Commission on Building and Fire Codes, National Research Council of Canada;
- *Distribution System Requirements for Fire Protection*, (M31), AWWA;
- *Concrete Pressure Pipe*, (M9), AWWA;
- *Steel Water Pipe: A Guide for Design and Installation*, (M11), AWWA;
- *PVC Pipe: Design and Installation*, (M23), AWWA; and
- *PE Pipe: Design and Installation*, (M55), AWWA.

2.1 City of Saskatoon

The City of Saskatoon (CoS) requires the submission of a *Water Distribution Plan* based on modelling of the proposed water distribution system.

At the development concept stage, an analysis of all pipes 150 mm or larger shall be carried out. The model shall be submitted to the CoS for verification. The conceptual *Water Distribution Plan* shall contain the following elements:

- A general description and site plan of the proposed development.
- Figures showing the proposed post-development site topography.
- A description of, and figures showing, the proposed staging of development and the associated construction of the water distribution system.
- A description of the population densities and flow rates that were used for modelling, together with an explanation of how these were calculated and assigned to the model.
- A description of boundary conditions and any other assumptions (pipe materials, pressures, Hazen-Williams coefficients, etc.) used for modelling, together with the rationale for their use.
- Figures showing nodes and demands.
- Figures showing node elevations, pipes, and any other hydraulic elements (i.e. hydrants, valves, etc.).
- A description of the simulation results.
    - Simulation results shall include a graphical representation of pressure variations under simulated conditions.
    - Actual model run data should be appended to the *Water Distribution Plan*.

For detailed design, modelling of all pipes 150 mm or larger shall be carried out for each stage of development. The staged *Water Distribution Plans* shall include the same elements as the conceptual plan, but shall be specific to each stage of development. Staged models shall also include locations and flow rates of water circulation huts. Models shall be submitted to the CoS for verification.

The CoS reserves the right to require resubmission of the *Water Distribution Plan* if there are any changes to the proposed development that significantly affect the water distribution system and/or hydraulic analysis. Resubmission shall be required at the discretion of the CoS and shall typically relate to changes in the configuration of the system and/or changes to proposed land uses.

2.2 Other Authorities

The Proponent shall be responsible for obtaining approvals from appropriate authorities in a timely manner.

3 Design Flows

Each water distribution system extension or modification shall connect appropriately with the existing distribution network, provide adequate capacity for the proposed development, and if applicable, shall include infrastructure and capacity provisions for adequate future developments as described in the sector plan for each development area.

The design of the water distribution system shall be based on supplying the greater of maximum daily demand plus fire flow, or peak hour demand.

3.1 Water Consumption Requirements

The daily average flow or average day demand is calculated from the land use densities and unit flow rate of 290 litres/capita/day as per below table.

Table 3-1
Land use densities for system average day demand calculation

Land Use Category	Equivalent Population[1] (p/ha)	Comment
Low Density Residential	42	Typical single family residential
Low Density Multi Unit Residential	60-120[1]	Includes townhouses
Medium Density Multi Unit Residential	120-220[1]	Includes walk-up apartments, mixed use residential and commercial.
High Density Multi Unit Residential	220-460[1]	Includes medium to high rise apartments
Central Commercial	330[2]	Includes central business district, large hotels, and office towers.
Secondary Commercial and Local Commercial	160[2]	Includes wholesale and retail outlets, shopping centres, service stations, convenience stores, small and medium-sized hotels, motels, service establishments, institutions, clubs, and highway commercial.
Wet Industrial	530[2]	Includes food processors.
Dry Industrial	16[2]	Includes storage and light manufacturing.
Mixed Industrial	130[2]	Includes a combination of wet industrial, dry industrial, and commercial.

1) Maximum equivalent populations shall be used if population densities are not known.
2) Equivalent populations for non-residential land uses are used as guidelines. The actual or estimated Average Day Demand is site specific and if known shall be provided to the CoS for review and potential approval.

3.2 Fire Flow Requirements

The following table summarizes the design flows that the CoS will supply for various land uses. The minimum residual pressure for the required fire flow is 140 kPa (20psi).

Table 3-2
Fire Flows

Design Category	Typical Building Form	Fire Flow (L/s)
High Density Residential	High Rise Apartments over 125 units per gross hectare**	220
Medium Density Residential	Walk-up Apartments 50 to 125 units per gross hectare**	150
Low to Medium Density Residential	Townhouses 25 to 50 units per gross hectare**	120
Low Density Residential	Single Family, Duplex 12 to 25 units per gross hectare**	90
Institutional	Various	220
Commercial	Various	220
Industrial, heavy*	Various	Site Specific
Industrial, light	Various	150

*Fire flows for heavy industrial land uses shall be discussed with the CoS on an individual and site-specific basis
**Gross hectares includes all streets, lanes and municipal reserve.

On property fire flow requirements are the responsibility of the owner/builder.

3.3 Modelling

Hydraulic analysis shall be required for every development and for every change that significantly impacts a previous hydraulic analysis. The model and its results along with the water distribution plan shall be submitted to the CoS for approval.

The CoS has created a WaterCAD model of the city-wide water distribution system. Submissions for approval using alternate modelling software shall be pre-approved by the CoS.

- The CoS shall provide information for existing nodes that will be connection points for the proposed network.
- The CoS shall provide the datum for node elevations.
- The Proponent shall model the total design flow at each major stage of development.

Demands shall be distributed throughout the network in accordance with the planned land use surrounding each node. Overall, demands shall be distributed as evenly as possible across the entire network unless otherwise approved. The following multipliers shall be applied to calculate maximum day demand and peak hour demand from average day demand:

  - Maximum Day Demand = 2 x Average Day Demand
  - Peak Hour Demand = 3 x Average Day Demand

- All pipes 150 mm in diameter and larger shall be modeled.
- Runs shall include, at a minimum, a simulation of peak hour flows, maximum day flows, and maximum day flows plus simultaneous fire flows.
- The nodes for pressure and fire flow analysis shall be set at street elevations.

The model shall be submitted to the CoS for verification. The CoS shall map the development model to the citywide model to determine the impact of the development distribution system on the city-wide system. The CoS may require the Proponent to perform a transient flow analysis.

3.4 Pressure Flow

The Hazen-Williams Equation shall be used for the design and modelling of water mains.

$V = 0.85 \times C \times R^{0.63} \times S^{0.54}$

Where: V = Velocity (m/s)

R = Hydraulic radius = Area/wetted perimeter (m)

S = Slope of hydraulic grade line (m/m)

C = Coefficient of roughness ($m^{0.37}/s$)

A Hazen-Williams coefficient of 120 shall be used for modelling for all pipe materials.

3.4.1 Velocity

The maximum design velocity shall be 1.5 m/s during peak hour operation. Maximum localized velocity shall be 3.0 m/s for maximum day demand + fire flow scenario. If fire flow velocities exceed 3.0 m/s contact the CoS for approval.

3.4.2 Pressure

Pressure within the distribution network shall meet the conditions outlined in the following table:

Table 3-3
Distribution System Pressures

Condition	Pressure (kPa)	Pressure (psi)
Maximum	690	100
Minimum Operating	275	40
Minimum Fire Pressure (Sprinklers)	275	40
Minimum Fire Pressure (Hydrant)	140	20

3.5 Staging and Interconnectivity

- The CoS will work with the Proponent to identify key points of connectivity between new and existing developments.
- In the short term (less than two years), any subdivision greater than 20 ha requires connection to at least two independent source nodes for water.
- In the midterm (two to five years), any subdivision greater than 10 ha requires connection to at least two independent source nodes for water.
- In the long term (more than five years), any subdivision greater than 2 ha requires connection to at least two independent source nodes for water.
- The water model shall show that standard pressure, fire flow, and velocity can still be achieved when any single independent interconnection is out of service.

- For every phase of construction, the proponent shall prepare a chlorination plan and submit to the CoS for approval. The plan shall demonstrate no impacts on existing water network when bringing online.
- Adequate fire flows shall be provided during all phases of staging.
  - If adequate fire flows cannot be supplied, Proponents must communicate with property owners and the Fire Department, and make provisions for fire safety as required.
- Water huts may be required to ensure the chlorine residual within the mains does not drop below 1.0 mg/L. The proponent needs to submit a WaterCAD model with the locations of huts for various stages of development. A locations plan shall be developed for the huts and submitted with the water and sewer design drawings for review and approval.

4 Design of System Components

Standards for the design of pipes, valves, and fire hydrants are presented in this section. A list of the standard drawings that should be referenced for the design of the water distribution system can be found in Appendix A.

4.1 Pipes

The distribution system consists of four types of water mains. Basic criteria for each of these mains are summarized in the following table:

Table 4-1
Pipe Description

Type	Water Path	Operating Pressure Range (kPa)	Diameter (mm)	Service Connections and Fire Hydrants	Comments
Water Supply Main (Fill Main)	From WTP to reservoirs, between reservoirs.	140-690	NA	Not Allowed	Connection to rest of system via check valves or normally-off valves only, no flow allowed from system to water supply main.
Primary Water Main	From reservoirs to neighbourhoods	400-690	Minimum 400	Not Allowed	Strategically located within the CoS
Secondary Water Main	Within neighbourhoods	350-690	Range 250-350	Allowed	Strategically located within a neighbourhood
Distribution Main	To service connections	275-690	Minimum (see comments) Maximum 350	Allowed	Minimum 150 mm in low density residential areas. Minimum 200 mm in all other areas.

4.1.1 Location

Mains shall be located in either a street or lane right-of-way. When this is not possible, an easement is required.

- The minimum easement width shall be six metres, unless otherwise approved, for mains less than 400 mm diameter.
- The minimum easement width shall be ten metres, unless otherwise approved, for mains 400 mm or greater diameter.
- The main shall be located at least three metres from the edge of the easement.

4.1.2 Sizing

Water mains shall be sized to accommodate design flows for the proposed development and, if applicable, to reasonably accommodate extensions to adjacent future development areas as described in the sector plan for each development area.

4.1.3 Network

The following criteria shall apply to the design of the water distribution system pipe network:

- Dead ends shall be minimized by looping mains as much as possible.
  - Where dead ends cannot be avoided, and with the approval of the CoS, a fire hydrant or other approved flushing device shall be installed at the end of the main to avoid stagnation.
  - The maximum length of a dead-end water main shall be 150 m.
- Interconnections of mains shall be designed in accordance with the following table.
  - Approval may be granted to vary connectivity based on modelling results.

Table 4-2
Interconnection of Distribution Mains

Diameter (mm)	Location	Maximum Interval (m)
150	Low density residential	600
200	Medium density residential	500
200	Medium density residential, industrial	500
250	High density residential, commercial	400

4.1.4 Depth

Minimum depths to obtain the required cover are:

- 2.9 m for mains less than 400 mm in diameter (surface to crown).
- 3.0 m for mains between 400 to 1050 mm in diameter (surface to invert).

- Mains, of any size, with less than the required minimum cover shall be insulated.
- Minimum depth, from surface to crown of the pipe, for insulated mains on arterial and collector streets and on all streets in commercial and industrial areas shall be 1.5 m.
- Minimum depth, from surface to crown of pipe, for insulated mains in all other areas shall be 1.0 m.
- Manufacturer's standards for insulated pipe shall be submitted to, and approved by, the CoS.
  - The submission shall include standard drawings and a calculation of pipe freezing time for a shutdown event.

4.1.5 Cathodic Protection

Cathodic protection is required as per the City of Saskatoon *Standard Construction Specifications and Drawings*.

4.1.6 Pipe Strength and Bedding

- Pipe strength and wall thickness shall be determined in accordance with AWWA standard design manuals for various pipe materials.
- Pipe bedding shall be determined as per the City of Saskatoon *Standard Construction Specifications and Drawings*.
- Backfill weight shall be 2,162 kg/m^3 unless a detailed geotechnical investigation indicates that a lesser value can be used.

4.1.7 Clearance

- Water mains shall pass over adjacent sanitary sewer mains.
- The minimum vertical clearance from the bottom of one pipe to the top of the next lowest pipe shall be 150 mm between the outer walls.
- The minimum horizontal clearance between the outer walls of adjacent pipes shall be 300 mm.
- Any water main that was originally installed in common trench with another main shall be relocated at least 1.5 m away from it when replaced, regardless of the vertical separation.

4.2 Valves

The following criteria shall be used in the placement of valves:

- All interconnections to mains 30 mm diameter and larger shall be valved.
- All mains located in easements or walkways shall be valved at both ends.
- All valves shall be located within the paved portion of the street right-of-way.
- No more than four valves shall be needed to shut down any main.
- Valves should be aligned with property lines in compliance with the CoS drafting standard.
- There should be a quantity of ‘N-1’ valves at an intersection where ‘N’ is the number of streets coming into an intersection.

Valves on water mains shall be placed in accordance with the following table:

Table 4-3
Valve Location on Water Mains

Main Type	Valve Location
Water Supply Main	• Valves shall be placed between all interconnections. • The maximum distance between valves shall be 1,500 m.
Primary Water Main	• Valves shall be placed between all interconnections. • When primary water mains meet at a tee, at least two of the three mains shall be valved. • When primary water mains meet at a cross, at least three of the four mains shall be valved. • The maximum distance between valves shall be 400 m.
Secondary Water Main and Distribution Main	• In low and medium density (three stories or less) residential areas, valves shall be placed at all intersections and additional locations so that not more than two hydrants are out of service as a result of a water main break. • In commercial, industrial, and high density (more than three stories) residential areas, valves shall be placed at all intersections and additional locations so that not more than one hydrant is out of service as a result of a water main break. • In residential areas, valves shall be placed at all intersections and at additional locations so that isolated sections contain no more than 25 single lots or approximately 50 dwelling units. • Valves shall be placed, at the discretion of the CoS, on either side of the service connection to lots that will contain high occupancy or special use buildings. • Valve shall be placed, on each side of the first hydrant at interconnections with primary water mains. • All mains connecting to a 300 mm or larger main shall be valved. • A maximum of four valves shall be required to isolate any segment of main.

4.3 Fire Hydrants

Distribution of hydrants shall be according to required fire flow as tabulated in the latest edition of *Water Supply for Public Fire Protection*.

4.3.1 Location

Fire hydrants shall be located as follows within the distribution network:

- At all street intersections.
  - When the distance between intersections is less than 50 m, measured from centre to centre, only one hydrant is required.
- At all street bends in excess of 40 degrees of deflection.
  - Where the bend is part of a large radius curve, the hydrant shall be located as close to the centre of the curve as possible.
- At the end of culs-de-sac greater than 45 m in length.
  - A cul-de-sac that is 45 m or less in length does not require a hydrant if the main serving the cul-de-sac is looped.
  - The length of the cul-de-sac shall be measured from the centre of the intersection to the centre of the bulb/bubble along the street centre line.
- At other locations as required to meet area and spacing requirements.
- At lot corners wherever possible.
- At all interconnections with primary water mains.
  - Following the interconnection valve.
  - Prior to any service connections.
- The location of hydrants relative to Fire Department connections for sprinkler systems and principal entrances to buildings shall be as specified in subsection 3.2.5 of *The National Building Code* (NBC).

4.3.2 Spacing

Maximum spacing between hydrants measured in any direction shall be in accordance with the latest edition of *Water Supply for Public Fire Protection*.

The CoS-preferred maximum spacing for fire hydrants are:

- In low and medium density residential areas, the recommended maximum spacing of hydrants is 140 m.

- In commercial, industrial, institutional, and multi-family residential areas, the recommended maximum spacing of hydrants is 90 m.

4.3.3 Dead End Mains

- The minimum diameter of dead-end mains, with fire hydrants, in low and medium density (less than three stories) residential areas is 200 mm.
- The minimum diameter of dead-end mains, with fire hydrants, in commercial, industrial, and high density (more than three stories) residential areas is 250 mm.

4.3.4 Hydrant Leads

- Any hydrant lead greater than 30 m in length shall be considered to be a dead end water main, and the minimum diameters for dead end water mains shall apply.
- All hydrant leads connected to mains 300 mm or larger, and all hydrant leads in commercial, industrial, and high density (more than three stories) residential areas, shall be valved.

5 Future Developments

In the event that water main stubs are provided for future developments:

- Stubs shall be valved so that any existing fire hydrants or service connections do not need to be taken out of service to accommodate future construction.
- Any stub not in service for more than one year shall be isolated from the rest of the system and left de-energized.

City of Saskatoon

Appendix A Applicable Standard Drawings

Proponents shall be responsible for referencing standard drawings that are applicable to their development. Drawings are available from the City website.

Drawings are subject to revision, addition, or deletion. Revised drawings shall be renamed using the date of latest revision. Proponents are responsible for ensuring that they are referencing the latest version of any standard drawing.

Drawings that are applicable to the Water Distribution System include the following:

Drawing Number	Title
Water Mains	
102-0012-001	Copper Dead End Water Main Flusher
102-0012-002	Reaction Blocking and Water Main Anchoring
102-0012-003	Fire Hydrant Standard Installation
102-0012-004	Square Hydrant Guard
102-0012-005	Pumped Drain Structure
102-0012-006	Manual Air Release C301/303 Pipe
102-0012-007	Typical Pipe Insulation
102-0012-009	Welded Type Tapping Saddle for Large Diameter Steel Watermains
102-0012-010	Valve Anchoring Details, 300 mm & Larger Valves
102-0012-011	Manual Air Release C905 Pipe
102-0012-012	Circular Hydrant Guard
102-0012-013	Water Circulator Service Connection
102-0012-014	Polyethylene Dead End Water Main Flusher
102-0012-015	Restraint Joints on C905 PVC Pipe
102-0012-016	Fire Hydrant Standard Locations
102-0012-017	Type ‘C’ Valve Box Top and Lid
102-0012-018	Type ‘C’ Lifter Rings
Cathodic Protection	
102-0014-001	Multiple Impressed Current Anode Ground Bed Vertical
102-0014-002	Multiple Impressed Current Anode Ground Bed Horizontal

Source:
http://www.saskatoon.ca/business-development/development-regulation/specifications-standards