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MUNICIPAL DEVELOPMENT STANDARDS

SECTION 4 – SANITARY SEWER SYSTEMS

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Planning & Engineering

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4 SANITARY SEWER SYSTEMS

4.1 General

These standards cover the design and construction of sewer mains and accessories to be built or re-built in the City. All designs must conform to the City of Lloydminster Sanitary Sewer Master Plan. Detail drawings relating to sanitary sewer system construction, trenching and backfill are provided in the Standard Drawings, sections 3 (Manholes), 4 (Trenching and Backfill) and 7 (Service Connections).

These standards provide the minimum design criteria, general construction requirements and construction materials for Consulting Engineers to use in their preparation of specifications and drawings. These standards may be exceeded if warranted by the design consultant. Good engineering practices and designs must prevail on all projects.

4.1.1 Separation of Storm and Sanitary Systems

All new systems or extensions from existing systems are to be designed on a separated basis. Run off from roofs, lots, streets and other outside areas including yards and parking areas and infiltration water from foundation drains and other sources, is to be excluded from the sanitary sewer system.

4.2 Design Flow

The sanitary sewer system must be designed in accordance with the Water Security Agency of Saskatchewan's Sewage Works Design Standard EPB 503. The system must have sufficient capacity to convey the peak dry weather flow, plus extraneous flows, plus sanitary flow from all future contributing areas. Additionally, the Consulting engineer must supply a statement that the receiving stream is of sufficient capacity to convey the increased flows. This section outlines the methodology and design criteria that apply to the design of the sanitary sewer system.

Sanitary sewage systems must be designed on whichever of the following is greater:

- The ultimate subdivision design population in the Outline Plan or Land Use Bylaw; or
- Equivalent population subject to the peak day demand multiplier.

The equivalent populations are:

- Residential = 42 persons/ha
- Medium Residential = 90 persons/ha
- High Residential = 178 persons/ha
- Commercial/Industrial/Institutional = 48 persons/ha

Residential design populations can be further broken down as follows:

Residential-Low Density (RF1, RF2, RPL, RF3):

- Single detached dwelling 12 units/ha @ 3.5 people/unit
- Semi-detached or duplex dwellings 25 units/ha @ 3.5 people/unit
- Mobile home subdivision 17.5 units/ha @ 3.5 people/unit

Residential-Medium Density (RF4, RF5, RF6):

- Townhouses 37.5 units/ha @ 2.4 people/unit
- Semi-detached or duplex dwellings 25 units/ha @ 2.4 people/unit
- Triplexes 30 units/ha @ 2.4 people/unit
- Fourplexes 37.5 units/ha @ 2.4 people/unit
- Mobile home parks 17.5 units/ha @ 2.4 people/unit

Residential-High Density (RA7, RA8, RA9):

- Apartments — 74 units/ha @ 2.4 people/unit
- Townhouses — 37.5 units/ha @ 2.4 people/unit

The sewer main capacity must be designed to convey the peak hourly sewage contribution plus infiltration, without the use of holding tanks and based on the following sub-sections.

4.2.1 Domestic Contribution

The design flows for domestic contribution must be derived using the following parameters:

- Minimum average contribution of 320 litres per capita per day.
- Peak hourly flow for each contributing area calculated at an average flow multiplied by a peaking factor using the Harmon Formula:

$$\text{C Peak Factor} = 1+\frac{14}{4+P^{1/2}}$$

Where P = the population in thousands.

The minimum peaking factor will be 2.5.

4.2.2 Commercial/Industrial/Institutional Contribution

Commercial and Industrial design flows will be based on the gross developed area or the specific application, whichever generates the greatest flow. These design flows must be calculated using the following parameters:

- Industrial flows - minimum average contribution of 0.2 litres per second per gross hectare;
- Commercial and Institutional (churches, schools, etc.) flows - minimum average contribution of 0.2 litres per second per gross hectare. Lower contributions may be considered on a per case basis; and
- Peak dry weather flow for each contributing area calculated at average flow multiplied by a peaking factor of 3.0.

4.2.3 Infiltration & Inflow

The following must be adhered to in order to reduce or eliminate infiltration or inflow of water into, or exfiltration of water out of, the sanitary sewer system:

- The sanitary sewer and manhole system must be constructed to minimize infiltration. A maximum infiltration rate of 0.28 litres per second per gross hectare must be used;
- All new manholes are to be located out of “sags” (low points in the road profile); and
- In the event that a manhole must be located within a sag, or is placed in any grassed area, it must feature a watertight cover as described in Section 4.14.3.

Following review of the CCTV or visual inspection, an exfiltration test as described in Section 9.5.3 may be required to be performed when there is visible evidence of water entering the pipe, when the area features a high water table in the geotechnical report, or when environmental issues are a concern to the City. At a minimum, ten percent (10%) of all new pipe will be tested for exfiltration.

4.3 Pipe Flow Formula

All sanitary sewers must be sized using the Manning’s equation and an “n” value of 0.013 for all smooth walled pipes of approved material.

Application of a depth variable friction factor at a flow depth of 80% of the sewer diameter results in a flow rate of approximately 86% of the sewer's full flow capacity. Therefore, the required flow capacity for sizing of the sewer must be computed using the following relationship:

$$\text{Required full flow sewer capacity} = \frac{\text{estimated total design peak flow rate}}{0.86}$$

It is preferred that gravity flow be used where possible.

4.3.1 Gravity Sewers

The required flow capacity of a full flow sewer must be calculated using Manning's formula:

$$Q = \frac{AR^{0.667}S^{0.5}}{n}$$

Where: Q = Design flow in m^3/s
A = Cross sectional area in m^2
R = Hydraulic radius (area/wetted perimeter) in m
S = Slope of hydraulic grade line (m/m)
n = Roughness coefficient

4.3.2 Sewage Forcemains

The calculation of flow capacity of forcemains will utilize the Hazen-Williams formula:

$$Q = CD^{2.63}S^{0.54} \times 275.5$$

Where: Q = Rate of flow in L/s
D = Nominal internal pipe diameter in m
S = Slope of hydraulic grade line (m/m)
C = Roughness coefficient = 125 for all mains

4.4 Velocity

4.4.1 Minimum Velocity

Gravity sewers V = 0.6 m/s
Forcemains V = 0.76 m/s

4.4.2 Maximum Velocity

Unless specifically designed the maximum velocities are:

Gravity Sewers V = 3.00 m/s

Forcemains V = 1.5 m/s

4.5 Minimum Pipe Diameter (Gravity Sewers)

Sizing of pipes will adhere to the recommendations within the Sanitary Sewer Master Plan; otherwise the following minimum sizes will be used:

- Residential Areas D = 200 mm
- Commercial/Industrial Areas D = 250 mm
- Service Connections D = 100 mm (single family dwelling)
  D = 150 mm (industrial/commercial/multifamily)

Note: D = nominal internal pipe diameter.

4.6 Minimum Pipe Grade

While steeper grades are desirable, the minimum grades are in Table 4.1.

Table 4.1 – Minimum Pipe Grades

Internal Pipe Diameter (mm)	Minimum Grade (%)
200	0.40
250	0.28
300	0.22
375	0.15
450	0.12
525	0.10
600 and larger	0.10

The percentage grade must be increased for top ends/dead ends of sanitary systems to 1%.

The grade for curved sewers must meet the minimum slopes identified in Table 4.2, unless the Consulting Engineer submits calculations to demonstrate that increased slope is not required to achieve self-cleansing velocity.

Table 4.2 – Minimum Curved Pipe Grades

Internal Pipe Diameter (mm)	Minimum Grade (%)
200	0.60
250	0.47
300	0.38
375	0.27
450	0.23
525	0.20
600 and larger	0.15

4.7 Minimum Depth of Cover

Minimum cover is to be 3.0 m to top of pipe and must be of sufficient depth to satisfy the following requirements:

- Allow service connections to basements. Typically, the obvert of the sewer should be at least 1.0 m to 1.5 m lower than the proposed basement footing elevation;
- Prevent freezing;
- Clear other underground utilities; and
- Prevent damage from surface loading.

If it is not possible to achieve the minimum depth to prevent freezing, insulation must be specified to be installed as per Standard Drawing 4-101.

4.8 Manhole Spacing

The following criteria must be used:

- Manholes must be provided at the end of each line, at all junctions, and at all changes in pipe sizes, grades or alignment;
- The maximum allowable distances between manholes are 120 m for sewers up to 375 mm and 150 m for sewers 450 mm and larger; and
- For curved sewers, the allowable spacing of manholes is 90 m maximum for sewers up to 375 mm and 120 m for sewers 450 mm and larger.

4.9 Curved Sewers

For sanitary sewers aligned in a curve:

- Maximum joint deflection must have a radius greater than 60 m, unless otherwise recommended by the pipe manufacturer; and
- Curved sewers must be aligned parallel to the road centreline.

4.10 Hydraulic Losses Across Manholes

The design of manholes must conform to the following:

- Generally, for increasing pipe diameters, the obvert of the downstream pipe must match the obvert of the upstream pipe;
- A smooth transition will be provided between the inverts of incoming pipes and the outlet pipes. Extreme changes in elevation at manholes will be avoided;
- Minimum drop in invert levels across manholes to account for energy loss:
    - Straight runs – 20 mm drop minimum;
    - Deflections up to 45º - 30 mm drop minimum; and
    - Deflections 45º to 90º - 60 mm drop minimum;
- Deflection greater than 90º must be accommodated using two (2) or more manholes; and
- Where drops greater than 0.6 m cannot be avoided, a specifically designed drop manhole will be required to address the hydraulic requirements of the change of elevation. Considerations include:
    - The pipe must be of sufficient size so that it does not surcharge;
    - A smooth vertical curve must be formed between the inlet pipe and the drop shaft with no breaks in grade, projections, or edges;
    - The drop shaft diameter must be equal to or greater in size than that of the largest inlet pipe. For multiple connections, a larger drop shaft must be supplied;
    - An air vent is to be provided at the crown of the outlet pipe downstream as detailed in Standard Drawing 3-103;
    - The outlet must provide a hydraulic jump basin to dissipate energy, to convert the flow to sub-critical velocity, and to allow for air release;
    - The cover must be able to withstand pressures from air discharge and surcharging; and
    - The manhole shaft must be sized to attain a clear main entry access of 1.0 m or greater.

4.11 Pipe Location

Sanitary sewers must be installed on the centreline of the roadway, unless otherwise approved by the City. Where at all possible, water mains should cross above sewer mains. The minimum separation of the sanitary sewer main from water mains, storm sewer mains, and power/telephone/cable is as follows:

- Minimum 3.0 m horizontally unless sewer depth requires increased spacing;
- Minimum 0.6 m vertical clearance between the bottom of a sewer pipe and the top of the watermain, if the watermain is passing under; and
- Minimum 0.3 m vertical separation between the top of a sewer pipe and the bottom of the watermain, if the watermain is passing over.

Pipes being crossed must be supported as shown in Standard Drawing 4-300.

4.12 Service Connections

Service connections must be designed to conform to the following requirements:

- Trenching requirements:
  - In separate trench if larger than 200 mm; and
  - In a common trench with water service and storm sewer service laterals. For service connection details, see section 7 of the Standard Drawings;
- The minimum size of sanitary sewer service stubs to a single-family dwelling lot is 100 mm;
- Sanitary sewer service stubs for commercial, industrial, multi-family or institutional areas, unless otherwise approved by the City, must be 150 mm or greater;
- Sanitary sewer service connections must be designed as a single connection from the main to the property line, straight in to the building at a right angle to the main. The exception to this is service connections at the end of cul-de-sac bulbs, which may be connected directly to the manhole where a right angle connection to the main is not possible. See Standard Drawing 7-106;
- Sanitary sewer service stubs must be extended 4.0 m past the property line, or 2.0 m past the shallow utility easement, whichever is further;
- Sanitary sewer service stubs to single family dwelling lots from the main to property line must be designed for gravity flow with a minimum grade of 2.0%. All sanitary service connections must provide a minimum of 2.85 m of cover from top of pipe at property line;
- Sanitary sewer service connection materials must be polyvinyl chloride (PVC) SDR35 building service pipe conforming to CSA specification B182.2, latest revision thereof;
- It is preferred that sanitary service connections to PVC mains 300 mm or smaller be made by the use of in-line tees, otherwise saddles are to be used. Concrete mains require the use of inserted tees. See Standard Drawings 7-101, 7-102 and 7-103;
- Risers must be employed where the service connection at the main is 4.0 m or deeper;
- An inspection chamber located at 0.5 m inside the road right-of-way will be required on multifamily lot service connections, see Standard Drawing 7-202; and
- An inspection manhole located at 1.0 m inside the road right-of-way will be required on industrial and commercial sewer service connections, see Standard Drawing 7-203. This manhole may be either 900 mm or 1200 mm in diameter.

4.13 Service Connection Records

The Developer must provide detailed record drawings for all installed service connections with such drawings providing information related to pipe dimension, invert elevations at the property line, location of services relative to property line(s), manholes or watermain valves, and lot and block number. A standard service template is available from the City's website as detailed in Section 2.3.2.2.

4.14 Materials and Specifications

Pipe materials must be selected using a rational design method, considering local conditions such as the character of industrial wastes, possibility of septicity, soil characteristics, exceptionally high external loadings, superimposed live, dead, and frost induced loads, abrasion and similar problems, with the information in the following sections as a guide. Proper allowance for loads on sewer pipes must consider soil, type of pipe, width and depth of the trench and the need for special bedding, haunching and initial backfill, concrete cradles, or other special construction techniques must be used to withstand anticipated potential superimposed loading or loss of trench wall stability. Joining of dissimilar pipe materials (e.g. PVC to concrete) must be made by means of manholes.

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4.14.1 Gravity Sewers

Table 4.3 - Acceptable Pipe Materials for Gravity Sanitary Sewers

Preferred Materials	General Size Range (mm)	Standard
Polyvinyl Chloride (PVC) (smooth wall)	100 to 900	ASTM D3034, maximum SDR 35 (CSA B182.2)
Reinforced Concrete	≥ 900†	CAN/CSA A257, 65D min.‡
Steel Reinforced PE (DuroMaxx)	750 to 3000	ASTM D3350, ASTM F2562, CSA B182.15

†Typical. Smaller pipe may be used, if economical.
‡Pipe must conform to the design requirements, but regardless of design requirements, pipe must not be less than 65D.

4.14.2 Forcemains

Table 4.4 – Acceptable Pipe Materials for Sanitary Sewer Forcemains

Preferred Materials	General Size Range (mm)	Standard
Polyvinyl Chloride (PVC)	150 to 300	AWWA C900, maximum DR18 or as approved
Polyvinyl Chloride (PVC)	400 & larger	AWWA C905, DR25 or as approved
High Density Polyethylene (HD PE)	75 & larger	AWWA C906, maximum DR-17, PE3608, minimum ASTM D3350 cell classification 345464C or as approved

Alternate materials will be evaluated on individual presentations (including justification for deviation) by the Developer to the City.

For all pressure pipe, the designer must rationalize the pipe material chosen, using the standard Hazen-Williams equations in Section 4.3.2, to meet the governing condition for sustained pressure, short term under/over-pressure and, for PVC only, fatigue. The designer is required to demonstrate hydrostatic pressure exposure (pump operating against a closed valve) as part of the sustained pressure checks.

4.14.3 Manholes

All manholes are to be 1200 mm inside diameter or larger for pipes up to 600 mm, and 1500 mm inside diameter or larger for pipes 600 mm to 900 mm in diameter, as per section 3 of the Standard Drawings. Manholes for pipes 1050 mm inside diameter or larger will utilize a t-riser manhole, as per Standard Drawing 3-102. Manhole selection and design must conform to the following:

- Manholes must be large enough to accommodate the maximum intersecting pipe size. The minimum distance between openings for pipes will be 225 mm or one half of the largest pipe's outer diameter, whichever is greater. See Standard Drawing 3-207;
- Manholes must be designed with sufficient inside dimensions to perform inspection and cleaning operations, allow for proper channel construction without difficulty, and minimize hydraulic losses through the manhole;
- Buoyancy calculations must be provided to the City for all manholes that have half or more of their vertical depth below the surrounding water table elevation;
- Manholes must be manufactured using sulphate resistant Type HS cement;

- Manhole sections must be precast reinforced concrete sections conforming to ASTM C478 and CSA A257.4;
- Manhole steps must be standard safety type, aluminum forged of 6061-76 alloy having a minimum tensile strength of 200 MPa;
- All joints must be sealed with confined rubber gaskets conforming to ASTM C443;
- Manholes must be fitted with the appropriate cast-iron frame and cover conforming to Class 20 ASTM A48 as shown in Section 3 (Manholes) of the Standard Drawings. Manholes installed in roadways, unless otherwise specified, must utilize an F-80 floating frame as detailed in Standard Drawing 3-202 and a TF-80LSAN Sanitary Sewer Cover as detailed in Standard Drawing 3-204;
- Manholes requiring watertight covers must use 600 mm cast iron covers and Lifespan frame assemblies, as manufactured by Hamilton Kent, or approved equal. See Standard Drawing 3-206;
- Pre-benched manhole bases must be used wherever possible with pre-cored connection holes and water-tight Duraseal or G-Loc joints or an approved equivalent;
- Tee-riser manholes must conform to CSA 257.2/ASTM C76 (pipe components) and CSA A257.4/ASTM C76 for the manhole riser component; and
- Aluminum safety platforms must be installed in all manholes with a depth greater than 5 m. See Standard Drawing 3-201.

4.14.4 Bedding Materials

Unless otherwise specified by the analysis of pipe loading and/or soil conditions, granular material for the bedding of pipes in sound dry soils will be Class B, using Bedding Sand, as detailed in Standard Drawing 4-200, conforming to the gradation in Table 4.5, below. Any anticipated need to utilize special bedding or construction techniques must be clearly identified in the drawings, and the Developer must supply any calculations and design rationale to the City for their review and records.

Table 4.5 – Acceptable Bedding Material Gradation

Standard Sieve Size (mm)	Percent Passing		
	Bedding Sand	Bedding Stone	Washed Rock
25			100
20		100	
16		75 – 100	
12.5		65 – 90	
10	100		30 – 55
5	50 – 100	35 – 55	
2.5	30 – 90	0	5 – 25
0.315	10 – 50		0 – 5
0.080	0 – 10		

In high water table areas with poor soils, Bedding Stone or Washed Rock must be used.

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Appendix 4A - SANITARY SEWER SPECIFICATIONS

4A.1 Pipe Installation

Installation of pipes will conform to the following subsections.

4A.1.1 Bedding

For Class A bedding, the sewer pipe will be bedded and cradled in 32 MPa concrete to the depths shown on Standard Drawing 4-200.

For Class B bedding, the sewer pipe will be bedded in compacted granular material, which will have a thickness as shown on Standard Drawing 4-200. The granular material will be compacted to 95% Standard Proctor Density for the full width of the trench up to 300 mm above the crown of the pipe.

4A.1.2 Pipe

Concrete pipe lifting holes are to be sealed with pre-fabricated plugs after installation of the pipe.

PVC pipe age is not to exceed two years at the time of installation.

Pipes and fittings are to be clean of debris and water before installation. Pipes are to be laid and joined as per the manufacturer's recommendations. Whenever work is suspended, install a removable water-tight bulkhead at the open end of the last pipe laid to prevent the entry of foreign materials.

Make watertight connections to manholes, and existing pipes. Use non-shrink grout when suitable gaskets are not available.

Service connection pipes are not to protrude into the main.

Pipes being crossed must be supported as shown in Standard Drawing 4-300.

4A.2 Manhole Installation

Installation of manholes will conform to the following and Standard Drawings 3-100, 3-101, and 3-102.

Concrete for benching and bases will be to ASTM A3000 Type HS high sulphate-resistant cement. Cast-in-place concrete will develop a compressive strength of not less than 32 MPa in 28 Days. Manhole bases that are poured in place will be 200 mm thick and rest on undisturbed soil.

Both the inside and outside of each manhole barrel joint will be finished smooth with non-shrink grout. Spacing of manhole steps is to be no more than 400 mm on center for full depth of manhole, and no more than 600 mm from the top step to the rim of the manhole. Steps are to be aligned with the frame and cover. Safety platforms are to be installed as per Standard Drawing 3-201 on manholes greater than 5.0 m in depth. Two (2) safety platforms are to be installed on manholes greater than 10.0 m in depth.

Openings for connections made in the field must not be greater than the outer diameter of the pipe by more than 50 mm in any direction and must be cored or cut, see Standard Drawing 3-207. Existing manhole floors will be rechanneled and properly benched, and the junction area will be grouted to form a smooth joint.

When pre-benched manholes aren't used, the benching will be placed by hand. Manhole benching will ensure good footing for workers and adequate space for minor tools and equipment. Benching will be sloped toward the channel at 1.0% (10 mm/m). The benching will provide a u-shaped channel as a continuation of the incoming pipe(s), with a side height of 0.75 times the full diameter of the sewer. Channelling and benching will be finished to trowel smoothness to provide an unobstructed flow. Branch lines entering the manhole will be channeled to join the main line at an acute angle. Sanitary service connections made directly to a manhole must extend to discharge directly to the channel within the manhole, not onto the benching. See Standard Drawing 7-106.

Set the frame and cover to the required elevation using no more than three concrete grade rings. Grade rings must be sealed either with non-shrink grout or RAM-NEK or approved equal. All frame and cover castings must be true to form and dimensions, free from faults, sponginess, cracks, blowholes, or other defects affecting their strength.

4A.3 Testing and Inspection

Trench backfill compaction will be tested as per Section 9.3. Sewers will be inspected and tested as per Section 9.5.

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