Bureau de normalisation du Québec

CAN/BNQ 3682-420/2025

Existing Sanitary Sewer Systems — Inflow and Infiltration Reduction Program — Guidelines

SCC CCN

STANDARD

CAN/BNQ 3682-420/2025

Existing Sanitary Sewer Systems — Inflow and Infiltration Reduction Program — Guidelines

Réseaux d’égout sanitaire existants — Programme de réduction du captage et de l’infiltration — Lignes directrices

Bureau de normalisation du Québec

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FOREWORD

This standard was developed in compliance with the Standards Council of Canada (SCC)'s Requirements and Guidance for standards development organizations and approved as a National Standard of Canada by the SCC. Its publication was approved by a Standards Development Committee, whose members were:

Service Providers

BRASSEUR-CHIASSON, Julien	Enviroservices
DAUPHINAIS, Sophie	Simo Management
ENFINGER, Kevin	ADS Environmental Services
FEHR, Amy	Engineers and Geoscientists BC
JOHNSTON, Chris	Kerr Wood Leidal
ROY, Marcel	JFSA Québec

Public Utilities

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HACHEY, Normand	Ville de Montréal
LIU, Cassie (Vice-Chair)	York Region
SPAGNUOLO, Claudio	Peel Region
WELLS, Sarah	City of Vancouver

General Interest and Regulatory Authorities

BAYAT, Alireza	Canadian Underground Infrastructure Innovation Centre (CUIIC)
BEAUSÉJOUR, David	Centre d'expertise et de recherche en infrastructures urbaines (CERIU)

GRAY, Philip	Arcadis
RIAZ UL HAQ, Muhammad	Ministry of the Environment, Conservation and Parks (MECP) — Government of Ontario
SANDINK, Dan	Institute for Catastrophic Loss Reduction (ICLR)
SUDA, Yuko (Chair)	Independent expert

Bureau de normalisation du Québec (BNQ) Coordination Team

PINARD, Amélie

TREMBLAY, Carole

The collaboration or the participation of the following people is also worthy of mention:

DUMOUCHEL, Sabryna	JFSA Québec
HARDER, Susana	Metro Vancouver

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INTRODUCTION

Inflow/Infiltration (I/I) in sanitary sewer systems is a chronic issue throughout Canada. Negative consequences of I/I include increased risk of flooding associated with sewer backup, multiple risks to the environment and to the public health and safety.

I/I reduces capacity in sanitary sewers and pumping stations, hence limiting the potential for urban densification and additional developments in urban communities. Excessive I/I flow can greatly affect the ability of existing sanitary sewer systems to adequately serve growing populations by generating, among other things, sewer backups, flooding in basements, and environmental discharges of untreated wastewater. If the infiltration rate is too high, major work may be required, such as rebuilding a pumping station or increasing the capacity of a sewage treatment plant. From an asset management point of view, I/I occupies pipe capacity that was originally designed to service future developments. With this in mind, reducing I/I instead of financing such work could be economically efficient. On another note, sanitary sewer dilution reduces the concentration of pollutants in the sewage or lowers its temperature, making treatment more complex and expensive.

In Canada, sewer backup is a primary driver of insured loss associated with extreme rainfall events. From 2013 to 2021, the insurance industry reported $2 billion in insured losses directly attributed to sewer backup in residential buildings during urban flood catastrophe events.[1] Sewer backup typically causes more than half of the total insured losses during major urban flood events. In general, rainfall-derived I/I (RDII) is expected to increase with higher rainfall intensity/accumulation, and short duration high-intensity (SDHI) rainfall events are expected to increase in frequency and severity under changing climate conditions in many regions of Canada. These events increase operation and maintenance costs for sewage treatment plants and pumping stations, and are likely to reduce the useful life of these infrastructure, in addition to causing sewage overflows into public roads and watercourses.

Recent climate change resilience programs in Canada have fostered the development of multiple practical resources oriented toward practitioner guidance in the management of urban floods and related climatic hazards in Canada. These resources have come in the form of National Standards of Canada (NSCs), aimed at infrastructure practitioners and decision makers involved in local and regional infrastructure management, home building, and climate resilience program development and implementation.

Existing NSCs related to this standard include:

a) CAN/BNQ 3682-320 *Mitigation of the Risks of Inflow and Infiltration in New Sanitary Sewer Systems*;

1 Catastrophe Indices and Quantification (CatIQ) mentions on its website that this amount includes losses experienced in insured catastrophe events where total losses are $25 million or more [https://public.catiq.com].

b) CSA S900.1 *Climate Change Adaptation for Wastewater Treatment Plants*;

c) CSA W204 *Flood Resilient Design of New Residential Communities*;

d) CSA W210 *Prioritization of Flood Risk in Existing Communities*;

e) CSA W211 *Management Standard for Stormwater System;*

f) CSA Z800 *Guideline on Basement Flood Protection and Risk Reduction*.

This standard has been developed to enhance asset management already in place in municipalities by providing them with efficient and cost-effective tools to help them fully understand the impact of I/I on their sanitary sewer systems. This standard aims at helping municipalities assess risk correctly before spending large sums on studies and rehabilitation work. The guidelines proposed in this standard will help municipalities to prioritize initiatives and to find appropriate, cost-effective ways to reduce I/I issues.

1 PURPOSE

This standard establishes guidelines to implement a proactive program to reduce inflow and infiltration (I/I) in existing sanitary sewer systems of the municipalities in Canada.

This standard sets out guidance and recommendations related to:

a) data collection and data analysis relevant to I/I (see Chapter 4);

b) development of an I/I reduction program (see Chapter 5);

c) development of I/I reduction strategies on the public side (see Chapter 6);

d) development of I/I reduction strategies on the private side (see Chapter 7);

e) ongoing maintenance of the I/I reduction strategies (see Chapter 8).

2 SCOPE

This standard applies to existing sanitary sewer systems.

This standard does not apply to new sanitary sewer systems.

NOTE — A sanitary sewer system built to replace an existing system is not considered as an existing sanitary sewer system, but as a new sanitary sewer system.

This standard does not apply to sanitary sewer systems installed in special conditions such as permafrost or shallow bedrock (Canadian Shield).

This standard does not apply to combined sewer systems.

NOTE — Combined sewer systems are the type of sewer system showing I/I maximum rates. Therefore, since the I/I mitigation risks for this type of sewer system would require its complete replacement with separate sanitary and storm sewer systems, it would be considered as a new sewer system, which is not covered by this standard.

This standard does not cover all aspects related to inspection, testing and repair of new sanitary sewer systems.

NOTES —

1 Regulatory requirements in place in some provinces and territories may be similar, complementary or different from the recommendations described in this standard.

2 Users of this standard requiring information on other aspects related to the design, maintenance and operation as well as inspecting and testing of construction work of new sanitary sewer systems not identified in this standard should refer to other documents, namely the standard CAN/BNQ 3682-320.

This standard is intended for municipalities, regulatory authorities and administrators of public sanitary sewer systems.

3 DEFINITIONS

3.1 TERMS

For the purpose of this standard, the following terms are defined as follows:

authority having jurisdiction (abbrev.: **AHJ**): all government levels, organizations, or individuals responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, training or a procedure within a country, jurisdiction, or assigned territory (reference: ISO 20710-1 [adapted wording]). French: ***autorité compétente***.

building sewer: pipe that is connected to a building drain one metre outside a wall of a building that leads to a public sewer or private sewage disposal system (see Figure 3.2) [reference: *National Plumbing Code of Canada*]. French: ***égout de bâtiment***.

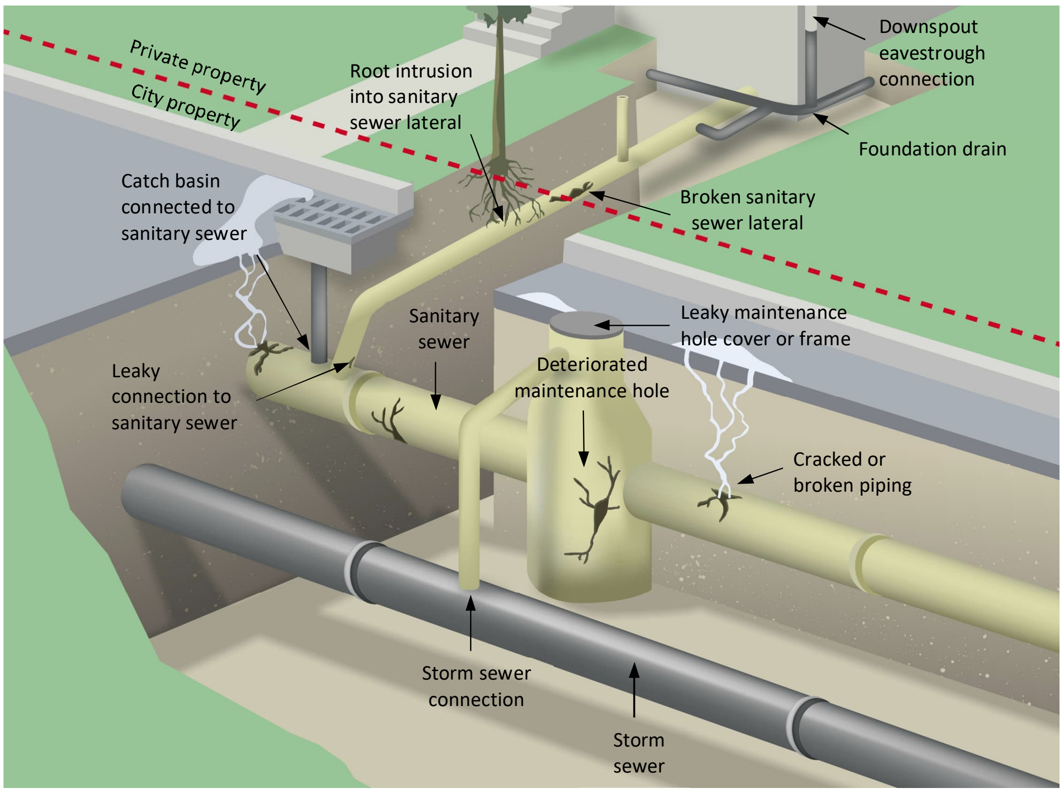
catch basin: well equipped with a drainage channel that captures runoff water and directs it either to a storm sewer line or a combined sewer line (reference: BNQ 2622-420). French: ***puisard***.

combined sewer: sewer that receives both stormwater and sanitary sewage. French: ***égout unitaire***.

NOTE — The authority having jurisdiction may include in the definition of the term *combined sewer* sewers that receive downspout and foundation drainage discharge from buildings (commonly referred to as *semi-combined* or *partially separated sewers*) in its definition of the term *combined sewer*.

groundwater level (abbrev.: **GWL**): upper level of subsurface water where soils are permanently saturated. French: ***niveau de la nappe phréatique***.

infiltration: water other than sanitary sewage entering a sewer system from the ground through defective pipes, joints, connections or maintenance holes (see an example of an inflow and infiltration illustration in Figure 3.1) [reference: *Wastewater Engineering: Collection and Pumping of Wastewater*]. French: ***infiltration***.



Source: Greater Sudbury's Website [https://www.greatersudbury.ca/live/water-and-wastewater-services/storm-water] (adaptation).

Figure 3.1 — Examples of potential sources of inflow and infiltration (I/I) illustration

NOTE — Colours of the pipes are not associated with any particular material.

inflow: water flowing directly into sanitary sewer systems, such as residential roof downspouts, storm catch basins that have accidentally been connected to sanitary sewer systems, leaky sanitary sewer maintenance hole covers and basement stairwell drains, among other factors (see an example of an inflow and infiltration illustration in Figure 3.1) [reference: *Wastewater Engineering: Collection and Pumping of Wastewater*]. French: ***captage***.

maintenance hole (abbrev.: **MH**): access well to sewer pipes of variable dimensions closed by a removable cover and equipped with steps, which allows a change of diameter, direction or slope of a line, to inspect or clean pipes. French: ***regard d'égout***.

sanitary building drain: building drain conducting sewage to a building sewer from the most upstream soil-or-waste stack, lateral or fixture drain serving a water closet (see Figure 3.2) [reference: *National Plumbing Code of Canada* (adapted wording)]. French: ***drain sanitaire du bâtiment***.

sanitary building sewer: building sewer transporting sanitary sewage (see Figure 3.2) [reference: *National Plumbing Code of Canada* (adapted wording)]. French: ***égout sanitaire de bâtiment***.

sanitary sewage: any sewage other than clear-water waste or storm water (reference: *National Plumbing Code of Canada* [adapted wording]). French: ***eaux usées sanitaires***.

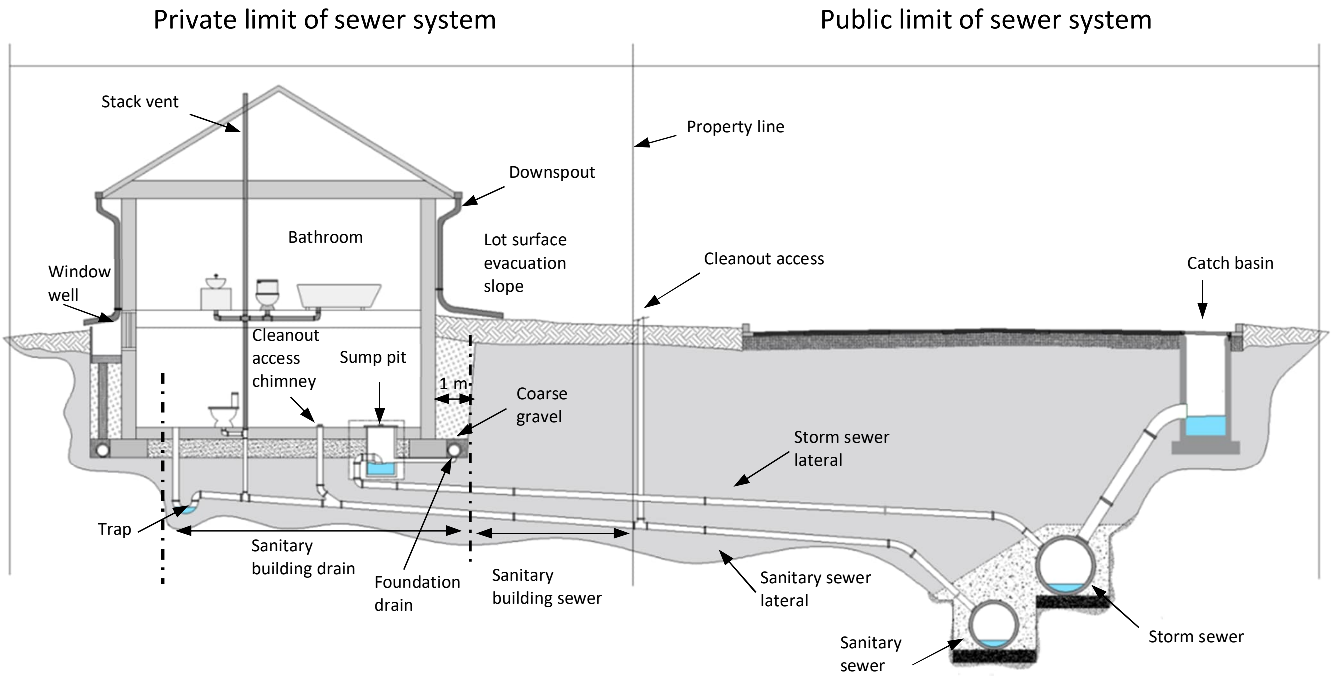
sanitary sewer: underground pipes collecting sewage from buildings and directing it to a central location for treatment and discharge to the environment (reference: CSA Z800 [adapted wording]). French: ***égout sanitaire***.

sanitary sewer lateral: underground sewer pipe connecting a private sanitary drainage system to a sanitary sewer main. This type of service is designed to collect sanitary sewage (reference: CSA Z800). French: ***branchement d'égout sanitaire***.

NOTES —

1 In existing systems, it is possible that sanitary sewer laterals conduct both sanitary sewage and stormwater. These types of connections may also be referred to as a combined sewer.

2 A sanitary sewer lateral may include the entire run of pipe, from a building's stack vent to the main public sewer connection, including the sanitary building drain and sanitary building sewer (see Figure 3.2).



NOTE — Figure 3.2 displays a gravity drainage system where foundation drainage is discharged into the storm sewer lateral.

Figure 3.2 — Drainage system (by gravity)

sanitary sewer system: elements forming the sanitary sewer such as main pipes, maintenance holes, laterals, lift stations. French: ***réseau d'égout sanitaire***.

sewage: water that carries waste products. French ***eaux usées***.

storm sewer: underground pipes conveying stormwater to surface water features, including rivers, creeks, ravines and wetlands, and stormwater-management infrastructure such as stormwater ponds (reference: CSA Z800 [adapted wording]). French: ***égout pluvial***.

storm sewer lateral: underground sewer pipe connecting a private storm and/or foundation drainage system to a storm sewer mainline (reference: CSA Z800). French: ***branchement d'égout pluvial***.

> NOTE — A storm sewer lateral may include the entire run of pipe, from its initial upstream connection to the public sewer mainline connection, including the sanitary building drain and the sanitary building sewer (see Figure 3.2).

stormwater: water, including rainwater, snow, and ice melt, street wash water, etc., discharged from a surface and water from foundation drain buildings, with the exception of sanitary and industrial sewage. French: ***eaux pluviales.***

trap: fitting or device that is designed to hold a liquid seal that will prevent the passage of gas, but that will not materially affect the flow of a liquid (reference: *National Plumbing Code of Canada*). French: ***siphon***.

3.2 ABBREVIATIONS

BSF: base sanitary flow

CCTV: closed-circuit television

GIS: geographic information system

GWI: groundwater infiltration

I/I: inflow and infiltration

PIEVC: public infrastructure engineering vulnerability committee

RDII: rainfall-derived inflow/infiltration

SDHI: short duration high-intensity

SSO: sanitary sewer overflow

4 UNDERSTANDING THE SANITARY SEWER SYSTEM AND I\I RELATED ISSUES

4.1 GENERAL

4.1.1 Basic considerations

The first step for municipalities in addressing I/I issues is to understand the design and operation of their sanitary sewer system.

In order to do this, municipalities should know all about:

a) the types of sewer present in their system (see Figure 1);

b) the contribution of the different types of flow (see Table A.1);

c) the types of flooding that can affect their system (see Chapter A.2).

Annex A provides necessary guidance to gain an adequate understanding of the system types and their exposure to excessive I/I.

4.1.2 Causes of inflow and infiltration

I/I entering a sanitary sewer system can occur at varying rates depending on a variety of contributing factors including:

a) natural aging of the sanitary sewer system;

b) lack of maintenance;

c) uncontrolled stormwater;

d) poor construction methods;

e) inadequate construction specifications or design;

f) cross connections.

NOTE — Cross connections, also referred as illegal connections, including roof leaders and foundation drains, are prohibited across Canada. Historically, these methods were in use, before being prohibited.

4.1.3 Predicted impacts of climate change

While it is widely accepted that the predicted impacts of climate change directly affect management for stormwater systems, sanitary sewer systems are also affected in the form of I/I. These impacts include:

a) rainfall-derived inflow/infiltration (RDII) increases with the higher intensity and quantity of precipitation. As RDIIs increase, so do the frequency and volume of sanitary and combined sewer overflows;

b) short duration high-intensity (SDHI) rainfall events increase in frequency and severity (see Figure B.1);

c) rising temperatures shorten frost periods and increase water infiltration into the ground during winter because frozen ground is less favourable to infiltration;

d) snowmelt leads to high flows in spring in many regions.

Where possible, municipalities should conduct a comprehensive climate change vulnerability assessment of all its public infrastructure assets to identify potential impacts of climate change on them, including identification of interdependencies that may affect the vulnerability of assets (e.g., energy supply, transportation or roadways that have implications for wastewater treatment plants, pumping stations, operations).

Such an assessment should be part of a comprehensive adaptation plan which includes an assessment of an adaptation to climate change impacts across the social, economic, natural, and built environment. However, it is recognized that resources may not allow for such an assessment.

Where comprehensive climate change vulnerability assessment is not possible, asset-specific vulnerability assessment may be conducted. Asset-specific options include:

a) a comprehensive asset-focus climate change vulnerability assessment (preferred), i.e., the application of a full Public Infrastructure Engineering Vulnerability Committee (PIEVC) vulnerability assessment process, involving input and guidance from a climate data specialist;

b) an expedited asset-focused vulnerability assessment, including the application of the *PIEVC High Level Screening Guide* by an experienced practitioner;

c) the application of an adjustment factor for future climate conditions using publicly available resources if the above options cannot be used. Ideally, climate data specialists should be involved in the identification of relevant climate change data.

NOTE — It is suggested that practitioners consult with the Canadian Centre for Climate Services (CCCS) help desk and/or with regional climate services organizations, including Pacific Climate impacts Consortium, Intergovernmental Panel on Climate Change, Ouranos, and related organizations for guidance on selection of appropriate climate change adjusted indices.

4.2 FLOWS IN PUBLIC SANITARY SEWER SYSTEMS

4.2.1 General

In order to identify abnormally high flows and thus potential sources of I/I, the following information should be reviewed:

a) the design flows (see Clause 4.2.2);

b) the operating flows (see Clause 4.2.3);

c) the comparison of both flows in the sanitary sewer system.

4.2.2 Design flows

The design sewage flows include:

a) residential flow (minimum, average and maximum), expressed in litres per capita per day (L/c/d);

b) industrial, commercial, and institutional flow (minimum, average and maximum), expressed in litres per capita per day (L/c/d);

c) I/I factor, typically expressed in litres per second per hectare (L/s/ha).

NOTE — Other units of measurement may also be used such as $l.m^{-2}.d^{-1}$ or $l.cm^{-1}.km^{-1}.d^{-1}$.

4.2.3 Operating flows

Operating flows are divided in two:

a) The dry weather flow, which comprises two components:

- base sanitary flow (BSF): dry weather flow that is persistent and not accessible for reduction from the sanitary sewer system (e.g., domestic flow, industrial, commercial, and institutional flow, unmetered sewage flow, design I/I);

- groundwater infiltration (GWI): dry weather flow that is accessible for reduction (e.g., leaking pipes, leaking joints from private or public sanitary and storm sewer systems, foundation drains, leaking maintenance holes);

b) The wet weather flow: flow pattern observed during precipitation and for some time afterwards when the sanitary sewer system is still responding to water in the ground. This flow is related to RDII and includes:

- I/I from the private side of a property (e.g., connected downspouts, foundation drains, laterals with deficiencies, drain connections);

- I/I from the public side, which include, but is not limited to, cross connections with the storm sewer system, non-conforming connections on the private side of a property, deficiencies (e.g., cracks, poor joints) in sewer systems and maintenance holes as well as groundwater infiltration in the public sanitary sewer system due to the elevation of the water table level.

Both dry weather and wet weather flows accessible for reduction flow can be reduced as part of an I/I reduction program.

NOTE — Flows from melting snow can raise the water table and possibly cause inflow.

Municipalities shall consider I/I issues occurring on the private side of a property and the impact of two-tier municipal structures on the ability to reduce I/I.

4.2.4 Periods of flow measurement and recording

Municipalities should use different flow measurement and recording periods to consider seasonal variability and identify and differentiate BSF, GWI and RDII (see Annex B).

NOTE — For more information on BSF, GWI and RDII, see Annex B.

4.3 COLLECTION OF DATA

4.3.1 General

Gathering all available information related to sanitary sewer systems and associated risk factors is essential for developing an effective and cost-efficient I/I reduction program as this process enables the identification of sections of the sanitary sewer system likely to be affected by I/I issues (see Clause 4.4). This includes incorporating physical and operational data into the process to enhance understanding of the system.

Municipalities should prioritize comprehensive data examination to ensure an effective I/I reduction program. This entails conducting flow measurement campaigns to evaluate current contributions of I/I, alongside with analyzing data from treatment infrastructure, public-side and private-side sewer systems and operational records.

Effective data management is crucial, necessitating robust protocols to facilitate informed decision-making and optimize investment strategies for a successful I/I reduction program.

4.3.2 Data to consider for assessment

4.3.2.1 General — Municipalities should consider all relevant data that may have an impact on I/I.

4.3.2.2 Data from water and sewage treatment infrastructure — Examining the relationship between water treatment plants treated water flows and sewage treatment plants influent flows is a valuable exercise for I/I initial screening.

Specific data likely to provide insights on I/I include:

a) drinking water production and distribution data (distributed and billed), if available;

b) sewage treatment plant data, including bypass information;

c) sewage pumping station data;

d) municipal rain gauges data, if available.

NOTES —

1 The sewage treatment plant data alone can be collected at various levels of detail and then be used to study the system’s response to various events, for example, wet weather events or snow melting periods.

2 The relevant sewage pumping station data to collect includes pump run times, up-to-date calibration data and pumped flow rates, if available.

3 The data collected by municipal rain gauges allows for correlating the variations in flows recorded at the sewage treatment plants and sewage pumping stations with rainfall events.

4.3.2.3 Public-side sanitary sewer system data — Municipalities should consider the following data related to the public-side sanitary sewer systems:

a) type, size and age of sewer pipes and maintenance holes;

b) location and condition of sewage pumping station, information on existing control, retention or regulation works, and year of the last inspection;

c) sewer shed areas, delineations and population served by each treatment plant and pumping station;

d) geographic information system (GIS) data, including how frequently GIS is updated;

e) collecting system flow diagram;

f) seasonal fluctuations of groundwater levels;

g) land use and environmental designation;

h) location and extent of any underdrain system;

i) number and frequency of overflows, bypasses and overloads in the system;

j) record of repair/rehabilitation work in the system;

k) topographic data;

l) capacities studies data;

m) historical, existing and projected flows;

n) analytical results for samples collected at the influent of the sewage treatment plants for parameters such as biochemical oxygen demand, total suspended solids, total phosphorus, and total nitrogen as low concentrations may indicate high I/I contributions;

o) closed-circuit television (CCTV) inspection results.

4.3.2.4 Sanitary sewer system operating data — Sanitary sewer system operating data and other available data are essential to develop an effective I/I reduction program.

Municipalities should consider the following sanitary sewer system operating data:

a) information owned by operating staff (including areas requiring frequent flushing or known for presence of sags or backups);

b) results from regular maintenance hole inspection program;

c) results from regular flushing program (including details of the program, such as frequency and efficacy) identifying especially problematic areas;

d) stormwater pond management practice;

NOTE — If stormwater ponds are not cleaned regularly, they may not provide the design level of service and, therefore, may represent an I/I risk to sanitary sewers.

e) pumping station operational data;

f) technical design data (e.g., pump curves, flow rate regulator curves), if available.

4.3.2.5 Private-side sanitary sewer system data — Much more difficult to obtain than public-side data, it is important to collect private-side data even if work on private properties is not feasible by a municipality.

Municipalities should consider data related to the private-side sanitary sewer systems, including the following measurable and unmeasurable data:

a) age of buildings connected to the sanitary sewer system;

b) flooding data, if any, including:

- frequency;
- magnitude;
- impacted areas;

c) sewer backup data;

d) flow monitoring data (industrial effluents, private pumping stations and wastewater pretreatment systems);

e) local policies concerning connection of foundation drains, area drains, catch basins, downspouts, etc. on the private side;

f) records of sanitary sewer laterals;

g) presence of sump pumps, and where possible, discharge locations from these pumps;

h) connection of eavestrough downspouts to sanitary sewers;

i) defects identified during inspections.

4.3.2.6 Flow measurement campaigns — Flow measurement campaigns help verify the data and define the following parameters, in particular:

a) time pattern and magnitude of dry weather flows;

b) dry weather infiltration contribution;

c) I/I in wet weather and snow melting periods;

d) sanitary sewer system overflow frequency and volume;

e) current and residual hydraulic capacity of system control elements.

A flow measurement campaign can span multiple periods throughout the year, allowing for an understanding of the hydraulic behaviour of the sanitary sewer system in the following various scenarios, among others:

a) during the spring high-water table period (typically saturated ground conditions), to quantify infiltration (taking into account the period during which regular overflows occur);

b) during summer, to better understand sanitary sewer system dynamics during heavy rainfall events;

c) during dry weather and low-water table periods, to estimate BSFs.

At the end of a flow measurement campaign, municipalities shall summarize the results in a report with the following minimum content:

a) location of measurement devices and details on their installation (exact positioning, pipe diameter, sketches, on-site observations, etc.);

b) summary of collected data and data analysis (synthesis of quality control performed, comments on the validity of measurements, technical explanation related to any outliers), if applicable;

c) summary of device calibration and maintenance visits;

d) hydrographs showing recorded flows and precipitations during the measurement period;

e) data losses or limitations in measurements.

A combination of instruments, such as flowmeters, rain gauges and other data acquisition equipment should be used to carry out flow measurement campaigns. These campaigns should aim at calculating I/I flows during both dry and wet weather conditions, for all seasons included in the campaign.

The analysis of data over several years from permanent measuring equipment provides additional information on the overall operation of a sanitary sewer system, in particular on the seasonal and annual variability of the different contributions and enables to assess the performance of overflow management measures and bypasses implemented.

4.3.3 Data sources identification

Identifying existing data sources is a fundamental step in collecting appropriate data (see Clause 4.3.2). Municipalities shall identify all direct and indirect relevant data sources so that they have all the necessary data to make an informed assessment of the situation.

Direct data sources may include the following:

a) data from the wastewater treatment plant;

b) asset management plans;

c) contingency plans;

d) master plans;

NOTE — The effects of densification due to zoning changes and provincial guidelines should be considered when defining the system capacity.

e) base mapping/GIS, including the quantity of different sanitary sewer systems the engineer has access to and the degree to which they are compatible;

f) land fragmentation layers or maps;

g) original construction plans of the sanitary sewer systems;

h) soil reports completed for design and construction projects related to water table elevations;

i) existing computer models of the collection sewer system;

j) tide maps for areas likely to be affected by tidal infiltration;

k) databases of abandoned secondary sanitary sewer systems, where available;

l) I/I studies.

NOTE — In the Province of Quebec, municipalities may consult a document called *Études d'eaux parasitaires par infiltration et captage* (Études EPIC) [studies of parasitic water by infiltration and infiltration]. These documents specific to municipalities and published in the 1980s may not be available online.

Indirect sources of information such as flood surveys or flood zone maps may also be useful.

To obtain actual data on community-specific flooding, municipalities should collect both structured and formal data from insurers and potentially affected residents.

NOTES —

1 In many cases, municipalities are not informed of the flooding experienced by their residents, whereas insurers usually are.

2 Local plumbers and restoration contractors are also excellent sources of information on private plumbing configurations and common problems in the area.

4.3.4 Data management

Managing the often-extensive data collected is a major challenge, but a necessary component for an effective I/I reduction program.

Even if the format and content of the inventories vary among municipalities, they should adopt a plan for data collection and storage to eventually allow a proactive and integrated management sanitary sewer systems.

When collecting data, municipalities should indicate the date on which it was recorded and the level of confidence it provides. Quality assurance and quality control (QA/QC) protocols should also be implemented and followed.

Data should be collected in a way permitting cross-referencing among the sanitary and storm sewer systems; consolidated in data management software; and, if possible, linked to a GIS or equivalent to facilitate spatial analysis.

Data identification, assembly and organization should be an iterative process.

4.4 ANALYSIS OF DATA SPECIFIC TO I/I

4.4.1 General

The objective of the data analysis is to identify sources of I/I and determine their magnitude to enable municipalities to target problem areas more accurately using existing data before engaging costs in field investigations.

Data analysis is carried out using the following steps:

1. Mapping of linear and discrete assets (see Clause 4.4.2).

2. Analysis of wastewater total hydraulic load (see Clause 4.4.4).
3. Comparison of data to locate problematic areas (see Clause 4.4.5).

4.4.2 Mapping of linear and discrete assets

Mapping linear and discrete assets provides a preliminary overview of the sanitary sewer system, facilitating the identification of possible sources of I/I and determining priority areas for inspection. For example, an area with an aging system that has not been systematically monitored could be highlighted as a priority in the program to identify and characterize I/I contributions. To map their linear and discrete assets, municipalities should consider a sanitary sewer system flow schematic as a starting point.

NOTE — Flow schematics or flow diagrams are usually held by engineering departments.

To enable proper data analysis, the mapping of linear and discrete assets should include the following information:

a) type of sanitary sewer system (combined, semi-combined or separate);

b) plan and profile drawings;

c) maintenance holes and pumping station wet wells;

d) length and slope of pipes;

e) age of the components of the sanitary sewer system;

f) operating mode of each component of the sanitary sewer system;

g) flow direction;

h) elevation of stormwater pipes.

NOTE — The objective is to identify the risk of reverse overflows in the stormwater pipes at high river levels. As well, in all overflow structures, there is a risk of infiltration of watercourses when the water level is high.

4.4.3 Catchment-by-catchment assessment approach

In order to effectively target problematic areas using existing data, municipalities may adopt a catchment-by-catchment assessment approach. This approach aims at identifying whether a section of the sanitary sewer system is problematic and at determining the sources and types of I/I without investing additional resources to investigate.

Every catchment in a municipality should be assessed in order to understand the overall priority ranking of each catchment relative to each other and to the system as a whole. Where insufficient information is available, additional studies/investigations should be performed (see Figure 1).

4.4.4 Analysis of wastewater total hydraulic load

To analyze the wastewater total hydraulic load, municipalities should consider the following information including, but not limited to:

a) volume and flow measured at the sewage treatment plant;

b) volume and flow measured at each sewage pumping station;

NOTE — Since all pumping stations are not necessarily equipped with flowmeters, operating time of the pumps (e.g., storm water pumps) can be used as an indicator. However, pump calibration is essential for analyzing hydraulic loads.

c) all equipment failures (electrical failures, broken pumps, operation malfunctions, repairs);

d) needs for maintenance and malfunctions occurring specifically at sewage pumping station;

e) leakage from the drinking water system;

NOTE — Centralization of information from both the drinking water system and the sanitary sewer system is essential for conclusive analysis.

f) other sources of hydraulic loads (e. g., water treatment plant and public pool backwash, cleaning operations, fire fighting flows), records of overflows and bypasses.

NOTE — Municipalities should identify potential sources of occasional water inflow (one-off worksites) to rule out unjustified I/I risks.

4.4.5 Comparison of data to locate problem sections

To locate problem sections, municipalities should compare the information mentioned in Clause 4.4.4 to the following meteorological data:

a) intensity and duration of rainfall events (total volume and rate per event and duration);

NOTE — For the same volume of rain, the duration of the rainfall event impacts the inflow rate of the system.

b) volumes of snow on the ground and ambient temperature;

c) groundwater level from a well site.

NOTES —

1 An example of a correlation between rainfall events and monitored flow rates is shown in Annex C.

2 Municipalities can rely, among other things, on historical data presented on a webpage by Environment and Natural Resources of the Government of Canada.

3 Some provinces offer data on groundwater levels. For example, users of this standard may refer to the webpage by the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP).

4 Residential drinking water meters can complete the information from flowmeters of the sanitary sewer system to account for expected flows into it.

When a catchment area is subject to significant flow variations during rainfall events, snow-melting periods or high groundwater levels, it should be subjected to further investigation such as:

a) measurement of flow in pipes serving the pumping station;

b) measurement of flow at sewage treatment plant;

c) smoke testing;

d) camera inspection.

4.4.6 Desktop analysis of data

Municipalities can use a computer program to analyze data.

NOTE — Municipalities can refer to the following documents to analyze particular combinations of data sets:

a) *Guide for Estimating Infiltration and Inflow;*

b) *Assessment and Evaluation of Storm and Wastewater Collection Systems — A Best Practice by the National Guide to Sustainable Municipal Infrastructure;*

c) *Guidelines for Performing Infiltration/Inflow Analyses and Sewer System Evaluation Surveys;*

d) *Guide for Evaluating Capacity, Management, Operation, and Maintenance (CMOM) Programs at Sanitary Sewer Collection Systems.*

4.5 IDENTIFICATION OF DATA GAPS AND UPDATING OF DATA COLLECTION METHODS

During the process of data collection and analysis, municipalities may identify data gaps, which may fall into several categories:

a) The information is not collected or not sufficient.

b) The information collected does not cover all the required sectors.

c) The information is collected, but is not stored.

d) The information is collected, but stored in a medium that is difficult to operationalize.

e) The information is collected and stored, but in a way that is incompatible with other data being used.

The identification of data gaps allows municipalities to define the field studies that are needed to complete the collection of relevant data.

NOTE — An example of typical gap analysis is presented in Annex D.

4.6 DEFINING ALLOWABLE I/I RATE IN MUNICIPAL SANITARY SEWER SYSTEMS

4.6.1 General

Existing sanitary sewer systems often consist of diverse combinations of multiple components constructed at various times, following different specifications, which conditions may vary. This variability poses challenges in establishing comprehensive benchmarks for allowable I/I for the entire sanitary sewer system.

Municipalities should consider that:

a) the allowable I/I rate for sanitary sewer systems is influenced by the allowable I/I leakage rates required for construction acceptance of each public and private component of the system;

b) the allowable I/I rate for sanitary sewer systems encompasses the I/I leakage rate at the construction acceptance stage and the long-term allowable I/I rate used in the design. Thus, the actual I/I rate during operation should be between these specified values, gradually increasing as the pipe ages.

4.6.2 Sanitary sewer system levels of service

In considering a risk management approach, it is impossible to provide a sanitary sewer system that is designed to respond to all eventualities. Through policies, municipalities may establish a level of service for all sanitary sewer systems that provide conveyance of dry weather flows plus an allowable rate of I/I such that the hydraulic grade lines do not exceed established safe system operating levels.

EXAMPLES —

1 In Metro Vancouver Regional District (MVRD), the objective of the sewer system infrastructure management programs is to ensure the sustainability of the collection system so that expensive repair and rehabilitation are not deferred to future generations. The supporting policy stipulates

that long-term average daily I/I does not exceed 0.13 L/ha/s (11 200 L/ha/d) as a result of a one in five-year return storm event.

2 Excessive I/I can represent an obstacle to the approval of future development.

To measure the success of an I/I reduction program, municipalities shall establish the appropriate level of service that aligns with the goals of the wastewater utility. Since the costs associated with I/I are directly related to the level of service, the program should be designed to meet the level of service of the sanitary sewer system.

Municipalities may define specific targets such as sanitary sewer overflow (SSO) reduction, I/I volume reduction, reduced number of basements flooded, conformity within long-term I/I values, etc. Alternatively, municipalities may consider social, economic, and/or environmental targets that support the utility's wastewater master plan or asset management plan.

NOTE — An example of policies to reach the level of service is provided in Annex E.

4.6.3 Allowable I/I rate at design

An allowable I/I rate at design is established for all new sanitary sewer systems. It represents the I/I for the service life of the pipe or the expected long-term I/I peak.

Allowable I/I at the design stage may vary across jurisdictions. Table 4.1 presents allowable I/I rates applied during sanitary sewer design by various organizations across Canada.

NOTES —

1 Additional design I/I allowance rates are presented in Appendix C of the Federation of Canadian Municipalities and National Research Council's 2003 report: *Infiltration/Inflow Control/Reduction for Wastewater Collection Systems — A Best Practice by the National Guide to Sustainable Municipal Infrastructure*.

2 Generally, allowable I/I rates are used by municipalities to evaluate existing sewer systems as they represent long-term peak I/I at the end of the sewer's service life. The design of new sewers with watertight connections is expected to meet even lower standards at construction acceptance.

I/I contributions from new connections should be limited as they are likely to be complying with applicable bylaws and proper inspections.

Table 4.1 — Allowable I/I rates for sanitary sewer design used across Canada

Allowable I/I rates	References
Up to 0.28 L/s/ha (24 200 L/ha/d)	*Design Criteria for Sanitary Sewers, Storm Sewers and Forcemains for Alterations Authorized under an Environmental Compliance Approval* (Province of Ontario)
0.26 L/s/ha (22 400 L/ha/d)	*Sewer Capacity Assessment Guidelines* (City of Toronto)
0.13 L/ha/s (11 200 L/ha/d)	*Engineering Design Manual* (City of Vancouver)
0.14 L/ha/s (12 000 L/ha/d) or 225 L/cm.km.d	BNQ 3660-004 (Province of Quebec)
0.06 L/ha/s (5 184 L/ha/d)	*Development and Servicing Bylaw No. 7900, Schedule 4 — Design Standards* (City of Kelowna)

In the absence of such specific data, municipalities should consider following allowable I/I design rates ranging from 0.13 L/s/ha (11 200 L/ha/d) to 0.28 L/s/ha (24 200 L/ha/d). I/I rates above the allowable rates at design are considered excessive and should be addressed through I/I reduction programs (see Clause 5.4).

4.6.4 Allowable I/I rate at construction acceptance stage

Municipalities may set local design and construction requirements. Through bylaws and standards, municipalities should ensure sanitary sewer systems are constructed using materials and techniques protecting against future I/I problems. This includes specifying an appropriate I/I leakage rate for acceptance of newly constructed sanitary sewer systems. The allowable I/I leakage rate at the construction acceptance stage shall be consistent with municipal requirements and policies for construction of sanitary sewer systems on public and private properties.

NOTE — Users of this standard can refer to the standard CAN/BNQ 3682-320 for more details on the subject.

Quality control of construction is ensured through municipal inspection and permit programs. Critical to ensuring protection of sanitary sewer systems against future I/I problems is the correct and timely application of construction inspection procedures (frequency and control elements).

NOTES —

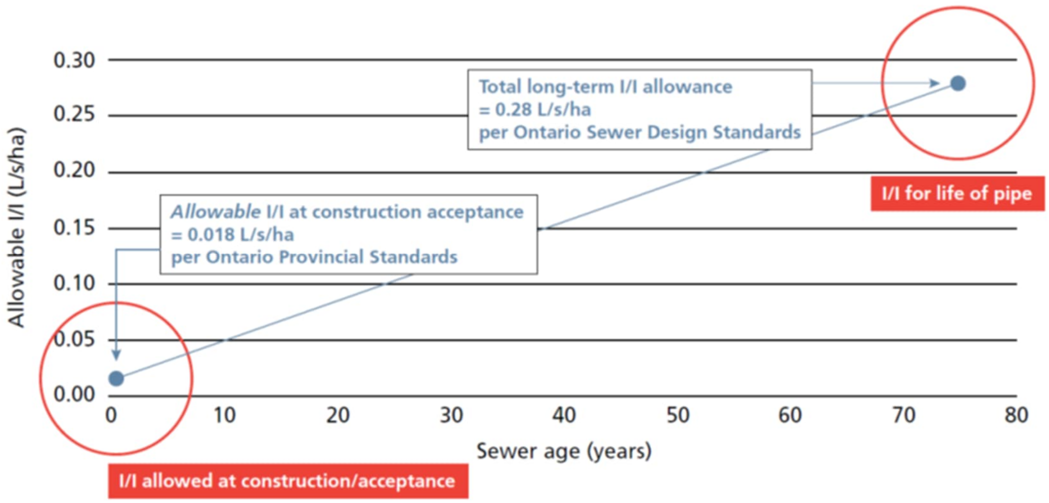
1 Findings by Robinson & Sandink (2019) determined that when inspection and testing of new works were incomplete, tests omitted, or defects were not identified, elevated I/I was often found in the finished construction.

2 When the I/I rate at the construction acceptance stage is within the values set by municipalities, it is considered “allowable”. Conversely, when the rate exceeds these values, it is considered “disallowable”.

Municipalities should clearly distinguish between the minimum and maximum allowable I/I rates:

a) The ultimate allowable I/I set at the design stage is considered the maximum (peak or total long-term) I/I allowance.

b) The allowable I/I at the construction acceptance stage is considered the minimum I/I attainable.



Source: *Developing an Efficient and Cost-Effective Inflow and Infiltration (I/I) Reduction Program*.

Figure 4.1 — Relationship between allowable I/I at construction acceptance and allowable I/I at design

4.6.5 I/I rate during operation stage

Sanitary sewer systems conveying dry weather flow will always convey I/I that is allowable and expected to increase as the sewer system ages. Over time the physical integrity of sanitary sewer system may deteriorate, and cause increased I/I flows to be conveyed and treated. Contributing factors can include:

a) design flaws;

b) material or construction defects;

c) cross connections;

d) root penetration;

e) pipe corrosion;

f) soil and/or groundwater conditions.

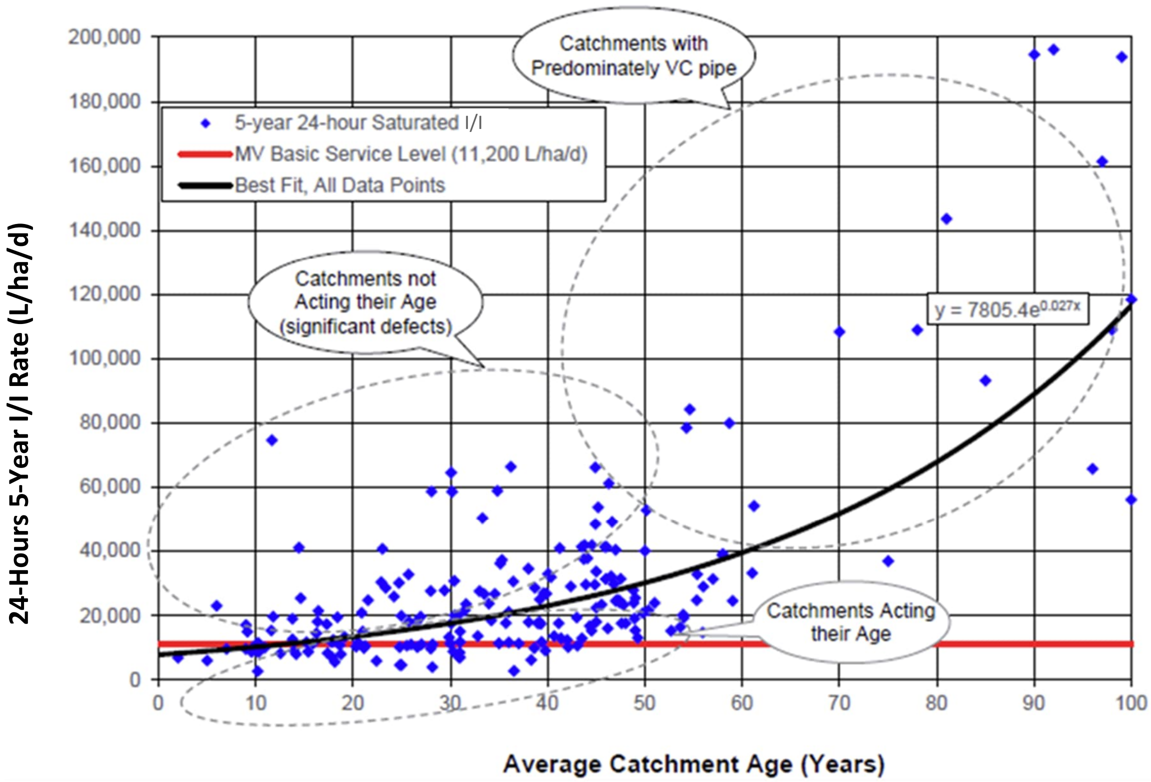
The increased I/I will result in increased hydraulic loading and can lead to negative consequences to the sanitary sewer system, such as a reduced system capacity to convey and treat sanitary flows, increased operating costs, and increased potential risks of overflows and/or sewer backups.

Extrapolating between the allowable I/I rate at construction acceptance stage and the ultimate allowable I/I rate set at design stage can provide a crude indication of the allowable I/I rate during the operational period. In the absence of a defined operational I/I rate, municipalities may estimate it based on the ultimate allowable I/I rate established when construction work was completed, considering degradation over time.

Municipalities may use an alternative approach based on data collected on sanitary sewer system (age, material, condition, and I/I rate), such as the concept of an I/I Archetype Classification System. The archetype classification provides municipalities a means to prioritize catchment areas for I/I rehabilitation work. This concept calculates the total I/I for each catchment area and plots it against the average age of the catchment area (determined by a pipe length-weighted average using a GIS calculation). Once sufficient data is collected, a fitted curve can be produced, which represents the average I/I response expected from a particular sanitary sewer system compared to the other catchment areas plotted. This provides municipalities a useful evaluation and planning tool. In addition to analyzing existing I/I conditions, municipalities can identify catchment areas where sewers are not acting their age, meaning the I/I rate is excessive compared to what it should be according to the age of the sewer, and organize rehabilitation efforts to concentrate on these catchment areas (see Clause 4.4.3).

In practice, the catchment areas would likely represent a specific municipality or sub areas within, but there may be benefits to grouping catchment areas with similar rainfall events and soil conditions.

> NOTE — Municipalities can refer to the document *Inflow and Infiltration Management Plan Template* for more information on the subject.



Source: *Inflow and Infiltration Management Plan Template.*

Figure 4.2 — I/I rate vs. age of sewer catchment relationship curve

NOTE — Figure 4.2 presents the I/I versus age relationship curve developed for MVRD in 2021 using data collected over 32 years from 163 unique catchment areas located within MVRD and the Capital Regional District (CRD). The 24-hour 5-year I/I saturation is plotted against the average sewer age to generate an I/I vs. age relationship curve. The curve establishes whether a catchment area is 'acting its age' or not with respect to expected I/I response over time. Catchment areas plotted below the curve are considered to be acting their age, whereas catchment areas plotted well above the curve are not, and rehabilitation work is warranted. A separate analysis was performed involving newer catchment areas with primarily PVC pipe (greater than 95% PVC pipe for both public and private sewers). Given the advancements in sewer pipe material and construction practices, the I/I rates are anticipated to lower the relationship curve. In Figure 4.2, the red line represents the MVRD's I/I allowance of 0.13 L/ha/s (11 200 L/ha/d). As additional data is collected and plotted, this 'closing of the gap' is expected to show the region's I/I allowance of 0.13 L/ha/s (11 200 L/ha/d) can be maintained. While research behind the template has correlated increasing I/I rates with private sanitary sewer lateral age, it is believed that this correlation also reflects the era of construction which may have tolerated higher I/I rates, had different construction standards, or required combined private sanitary sewer laterals.

5 I/I REDUCTION PROGRAM

5.1 GENERAL

The I/I reduction program for sanitary sewer systems should emphasize a systematic approach, integrating cost-benefit analysis with robust reduction strategies. This program advocates a methodical, evidence-based decision-making process, aligning I/I reduction initiatives with overarching municipal objectives and ensuring long-term infrastructure sustainability. It offers technical guidance for municipalities to prioritize actions, optimize resource allocation, and ensure that I/I reduction efforts are financially strategic and technically sound.

5.2 KEY PERFORMANCE INDICATORS

Municipalities should identify key performance indicators (KPIs) to determine when to take action to reduce or mitigate I/I, select the appropriate method, and assess system performance after implementing I/I rehabilitation measures. The GWI and RDII present are important KPIs, but it is also important to consider other KPIs that characterize how the sewer system accommodates I/I. The following KPIs provide additional information to help assess the ability of a sanitary sewer system to accommodate observed I/I quantities:

a) **RDII rate** — The RDII rate is generally the first KPI used in I/I reduction programs, as consistent I/I analysis across catchments can be used to assess I/I rates between catchments.

b) **GWI rate** — The GWI rate is generally persistent in the sanitary sewer system and related to the seasonal groundwater level rather than to individual rainfall events. Although GWI rates are relatively smaller than that of other types of I/I, cumulatively they can be large over a period of months or years, as they occur at all times, and can add costs to the system (e.g., sewage treatment, sewage pumping station).

c) **Depth-to-Diameter (d/D) ratios** — Ratios of maximum flow depth to sewer diameter. d/D ratios are often calculated to describe dry weather and wet weather periods and they are used to assess sewer capacity utilization. Provincial and local sewer design guidelines often include d/D requirements for sewer design which serve as effective benchmarks to compare with observed d/D ratios.

d) **Peaking factors** — Ratios of maximum flow rate to average flow rate. Peaking factors can be calculated to describe dry weather and wet weather periods and are used to assess the observed variation in flow rate. Provincial and local sewer design guidelines often include peaking factor requirements for sewer design which serve as effective benchmarks to compare with observed peaking factors.

e) **SSOs** — A discharge of untreated sewage from a sanitary sewer system. The frequency and volume of SSOs are often proportional to the severity of I/I problems and serve as useful KPIs.

f) **Sewer backups** — A discharge of untreated sewage from a sanitary sewer system into a residential, commercial, industrial, or institutional facility due to capacity constraints. The number and frequency of sewer backups are often proportional to the severity of I/I problems and serve as useful KPIs. However, the cause of sewer backups shall be investigated and understood before using this as a KPI as backups can occur due to maintenance related issues as well as capacity issues.

g) **Maximum capacity and surcharging** — Gravity sanitary sewer systems are not generally designed to operate under surcharging conditions (d/D ratio > 100%). Therefore, when surcharging is observed, it represents a capacity concern. As surcharging can be used to predict areas where SSOs and sewer backups will occur, it is a KPI to focus on. In addition, when surcharging is observed, additional capacity assurance criteria may be used to identify sewers that surcharge above certain benchmarks (e.g., sewers that surcharge greater than X mm above the diameter [D] of the sewer [D + X] or that surcharge within Y mm of the maintenance hole rim [R − Y]). The risk of SSO is directly proportional to the magnitude of surcharging events, and capacity assurance criteria helps prioritize the degree of surcharging relative to SSO risk.

Once one or more KPIs have been identified, the municipality shall identify the data requirements to monitor those KPIs. Good KPIs have the following characteristics:

a) They are applicable over multiple years/program iterations.

b) They are applicable to different catchments.

c) They are measurable.

d) They can be used by various consultants and contractors.

NOTE — A good KPI will allow for better comparison of I/I reduction methods and their efficacy as municipalities continue to improve and develop its I/I reduction program.

5.3 PATHWAY AND DEFECTS IDENTIFICATION

Once portions of the sewage collection system (i.e., catchments or sub-catchments) have been identified as having problematic I/I, the specific pathway and defect causing the I/I should be identified for rehabilitation.

NOTE — This step differs from the initial I/I problem identification step (Clause 4.4), as it focuses on identifying the exact physical location of the rehabilitation and the type of repair to be completed.

The following diagnostic methods are commonly used to locate individual I/I sources:

a) **Maintenance hole inspection (including surface inflow)** — Is used to visually inspect and document the location and condition of a maintenance hole.

Maintenance hole inspection can be accomplished using confined space entry or non-entry techniques.

b) **Smoke testing** — Is used to locate and identify potential I/I sources within a sanitary sewer system. During smoke testing, a special non-toxic, non-staining smoke is blown into a selected portion of the system. Potential infiltration sources are evidenced by visible smoke.

c) **Dye testing** — Is used to locate and identify potential I/I sources. During dye testing, a special fluorescent dye is applied near the sanitary sewer system or storm sewer components to confirm the location of I/I sources.

d) **CCTV inspection** — Is used to visually inspect with video equipment and document the location, connectivity, and condition of a sanitary sewer system.

e) **Sanitary sewer lateral inspection** — Is used to visually inspect and document the location, connectivity, and condition of private sanitary sewer laterals.

f) **Building inspection** — May include catch basins, sump pits, downspouts, under grade plumbing, backflow preventors, drain tiles, etc. This information can be compared to the property service cards to confirm accuracy or changes made that have not been recorded to the service card.

Other inspection methods such as zoom camera inspections, sonar inspections or laser inspections may also be available and considered by municipalities, when appropriate.

Municipalities should apply a combination of inspection methods to locate I/I and characterize I/I sources to identify appropriate rehabilitation methods and estimate rehabilitation costs.

5.4 DECISION-MAKING FRAMEWORK

5.4.1 General

The approach to I/I reduction is unique to each municipality depending on the severity of the I/I issues, the available budgets and other considerations. When an I/I reduction program is necessary, the following considerations enable to organize efficiently the reduction program.

Based on available data and background investigations, a municipality should identify high priority areas with the greatest potential for I/I reduction. However, it is important to understand the sources of I/I in these high priority areas to determine the likelihood of successful reduction.

NOTE — For example, if the source of I/I is primarily on the private side, rehabilitation on the public side will have little impact on I/I rates. Alternatively, if the sources are linked to public side issues, such as defective pipe joints or cross connections, addressing these issues is likely to result in significant success in I/I reduction, making this area a high priority.

As I/I reduction is an ongoing challenge, it is typically managed by municipalities as an ongoing program with annual funding to identify and correct sources of I/I. This ongoing program usually follows an initial targeted I/I reduction program that established priorities, set targets and developed a comprehensive I/I reduction strategy.

As part of an annual program, municipalities should define the priorities for each year based on investigative work or feedback on I/I reduction measures already carried out. Experience with I/I reduction in the local system is critical to setting future priorities and understanding when further I/I reduction is not financially warranted.

5.4.2 Work plan

A work plan is the series of actions the municipality plans to undertake to reduce I/I. It should clearly list the different problems that have been identified that can be cost effectively solved by I/I reduction as well as the KPI'S that will be used to measure progress. Once priorities are established, the work plan should list the activities that will be included in it.

The work plan should consider the maturity of the organization and its ability to undertake planned activities. For a municipality just starting out in I/I reduction, the problem could be a lack of data to set cost-efficient reduction goals. In that case, the short-term work plan could be data collection and problem identification.

Municipalities should revise their I/I reduction program periodically to make sure that planned activities are attainable and cost-efficient compared to alternative solutions.

Some activities may already be ongoing and should be included and monitored in the work plan such as:

a) sanitary sewer system inspection program;

b) asset management program:

- sewer lining;

  NOTE — For information on lining, refer to the standardized specification BNQ 1809-400.

- sewer replacement;
- point repair.

5.4.3 Cost-benefit considerations of reducing I/I

I/I reduction programs should be considered on a cost-benefit basis; that is how much a program or method would cost and the level of benefit that is derived from the investment. When considering options, the cost and risk of inaction shall also be considered as well, as the cost to reduce the I/I may outweigh the consequence cost (e.g., ongoing costs related to managing and treating excessive I/I or the cost of clean-up of a sanitary system overflow).

The costs of reducing I/I are multifaceted: they encompass initial costs for identifying I/I sources, and extend to the expenses involved in data collection, organization, and analysis. Municipalities should understand these multifaceted costs to effectively plan and allocate resources for sustainable I/I reduction efforts.

Estimation should consider the immediate expenses of implementing these strategies and account for the ongoing operational costs such as maintenance, periodic reassessments, and potential system upgrades.

5.4.4 Risks and negative consequences of I/I in the absence of intervention

Where possible, municipalities should estimate the risks and negative consequences of not implementing measures to reduce I/I, including but not limited to the following:

a) impact to the environment and to human health due to release of untreated wastewater into the environment;

b) reduced development capacity due to sanitary sewer capacity constraints, and related loss of development charges and property taxes;

c) accelerating the need to upsize systems and associated capital costs;

d) costs associated with treatment of I/I (treatment chemicals and power);

e) legal and administrative costs associated with management of impacts of I/I and development/implementation of programs designed to manage I/I (e.g., additional staff/staff time required to implement I/I management programs);

f) impacts on residents and building occupants, including uninsured losses associated with flooding, long-term impacts on home livability (e.g., long-term health, mould issues), loss of irreplaceable items due to flood damage, impacts of the flood recovery process on residents;

g) costs that may be associated with compassionate grants, among other things, offered to residents with uninsured flood damage.

NOTE — For example, urban flooding costs may include both insured and uninsured damage, costs to institutions, businesses, residents, and local government, and these impacts may intensify under changing climate conditions in many regions of Canada due to increasing frequency and intensity of extreme rainfall events that drive regional flooding associated with I/I and sewer backups.

Municipalities should also consider soft costs that may not be readily quantifiable, such as:

a) reputation;

b) exposure to legal risks associated with flood impacts to the built and natural environment;

c) impact on credit rating.

It shall be acknowledged that there are inherently many uncertainties in I/I reduction programs. Success of a program is not guaranteed; I/I may not be reduced to an acceptable or desirable level or within the budgeted cost. Therefore, this uncertainty, and thus risk, shall be taken into consideration when developing and assessing an I/I reduction program. If a program has not met its objectives or has exceeded the initial cost estimate, the reasons shall be understood and assessed within an I/I reduction program.

Questions that municipalities should consider in developing an I/I reduction program include:

a) How likely is that the I/I reduction solutions will work?

b) For the cost of I/I reduction, will there be a return on investment?

c) What is the probability and degree of success?

d) Could there be unintended consequences?

Although the greatest uncertainty with an I/I reduction program is the cost vs. success, there are other uncertainties to consider in crafting an I/I reduction program. The following highlights other potential uncertainties:

a) **Reduction in capacity** — Where lining is used, there is a potential reduction in sewer capacity that needs to be considered. To reduce the risk, hydraulic modelling or capacity calculations that include the reduced diameter should be considered.

b) **Poor workmanship** — Repairs such as maintenance hole or sewer lining requires high quality workmanship, and therefore poor workmanship can lead to poor I/I reduction results. Post-installation inspection is essential to ensure repairs have been completed as per specifications to avoid workmanship-related failures, for example checking to ensure the lining material has cured properly.

c) **Over schedule, over budget** — Controlling I/I reduction program schedule and budget requires experience as in many circumstances there are still unknowns about the sources and extent of I/I rehabilitation that is required. As well, I/I reduction programs can be delayed by unfavourable weather conditions. To reduce the risk, an I/I reduction program needs to adapt to changing conditions.

d) **Disruptions (and associated non-tangible costs)** — Planning for I/I reduction reduces the risk of disruption in the system. When maintenance holes or sewer pipes are subject to repair, local disruptions to service that need to be considered are likely to occur. Similarly, weather conditions may also play a role in scheduling I/I reduction.

5.4.5 Staged approach

A staged approach is often used by municipalities in their I/I reduction program. It usually entails dividing a larger I/I program into smaller ones, usually to address an uncertainty or constraint. A staged approach can be used between different catchments (i. e. going from one catchment to the next) or within the same catchment (e. g., using an initial method, assessing the impact, and then going back to either continue or change approaches based on the information collected).

A staged approach may be used primarily for two different reasons:

a) **Budget constraints** — By implementing the program in stages that includes periodic monitoring to measure I/I reduction, it is possible to determine if the I/I reduction has reached the level of service set out in the program. This type of strategic approach to minimize costs should focus on low costs and high reward I/I reduction measures that would best achieve the I/I reduction objective. Later stages of the program would tend to involve more costly I/I reduction measures with a lower probability of removing large quantities of I/I.

b) **Lack of information** — Municipalities may consider a staged approach when there is key information lacking that prevents the development of a full I/I reduction program. When information is lacking, there is a risk of not being able to achieve the targeted reduction levels for the budget allocated. Therefore, by adopting a staged approach, with a primary focus on collecting information, municipalities can make better informed decisions.

A pilot program is similar to a staged approach; however, it is usually smaller in scale and generally targeted to test out different techniques prior to full implementation. This type of program should be considered by municipalities with limited experience. Through a pilot program, municipalities gain experience with different techniques and are able to evaluate their effectiveness before making further commitment to specific I/I reduction strategies.

5.4.6 Prioritizing/decision-making

A significant challenge that municipalities encounter is the prioritization and decision-making step of the I/I reduction program development. This is primarily due to the high level of uncertainty and risks that exist in I/I reduction programs. The actual costs of an I/I program can vary significantly, and the level of reduction achieved with the program is not always proportional to the investment.

The prioritization and decision-making process varies by municipality, based on numerous factors, including:

a) experience level with I/I reduction programs;

b) past success with I/I reduction programs;

c) budget availability (operational and capital);

d) resource availability (experts, staff, equipment, etc.);

e) risk tolerance;

f) magnitude of the I/I issues (e.g., flooded homes vs overflows);

g) capacity needs;

h) other concurrent work (e.g., asset management);

i) regulatory framework.

5.4.7 Timeline and budget

Once the objectives of the program and activities have clearly been defined, municipalities should set schedules and prepare preliminary budgets. As an I/I reduction program includes a high level of risk and unknowns, it is important that the work plan be as specific as possible to be able to determine a reasonable timeline and budget required for the program.

Ideally, municipalities should allocate permanent funding for work to be carried out over the long term to manage I/I proactively.

5.4.8 Reporting

An I/I reduction strategy is a long-term initiative which can take years to yield the desired results. Reporting on the I/I reduction program is crucial to measure progress and revise strategies according to progress. Thus, reporting on the program should be done not only at the end of the work plan, but periodically to follow progress.

As with asset management strategies, regular reporting enables all stakeholders to adjust the work plan, budgets and timelines to optimize results. Municipalities should periodically prepare a written report focusing on two aspects:

a) measuring the rate of progress of the work plan through the following aspects:

- activities;
- timeline;
- budget;

b) validating the following objectives and results through KPIs:

- volume of I/I;
- cost of I/I on operations and asset management;
- I/I reduction;
- cost-benefit of reduction strategies.

At this point in the I/I reduction program development, municipalities should be able to summarize the findings to date and determine the most appropriate next steps as:

a) a summary of preliminary findings, including likely problems, sources, opportunities, and constraints;

b) a re-examination of previously defined I/I reduction goals;

c) a measure of KPIs that have been defined in the work plan.

5.5 I/I STRATEGY IDENTIFICATION AND SELECTION OF THE APPROPRIATE METHOD

5.5.1 General

This clause provides guidance in selecting appropriate repair methods to reduce I/I. The selection process considers the specific source and magnitude of I/I to effectively address the problem while optimizing cost, performance, and environmental impact.

I/I reduction programs often occur concurrently with or are informed by asset management programs to enhance the efficiency and longevity of municipal sanitary sewer systems. By integrating these efforts, municipalities may simultaneously address the immediate issues of excess water entering the sanitary sewer system and strategically manage the maintenance and replacement of infrastructure assets.

This concurrent approach allows for the identification and prioritization of problem areas, optimizing resource allocation for repairs and upgrades. Asset management programs provide comprehensive data on the condition and performance of sanitary sewer system components, enabling targeted I/I reduction measures that align with long-term maintenance plans. This approach not only improves system reliability and reduces operational costs, but also ensures compliance with regulatory standards and minimizes environmental impacts.

5.5.2 Considerations for the selection of an I/I reduction method

See Tables 1 and 2 for I/I reduction methods available to municipalities. The following criteria may be considered when selecting an I/I reduction method:

a) Condition assessment:

- If a poor condition score is assigned to the pipe, the method to repair the pipe to a better condition score may trump the method to reduce the I/I rate.

b) Remaining service life:

- For assets nearing the end of their service life, prioritize strategies that provide long-term durability and extend service life of the infrastructure.

c) Integration with asset management plans:

- Consider the implications of repair decisions on asset lifecycle management, risk mitigation, and financial sustainability.

d) Pipe material:

- Consider the compatibility of pipe material with various repair methods.

e) Accessibility of pipe:

- Evaluate the accessibility of the pipes requiring repairs, considering factors such as location, depth, alignment, and proximity to surface structures and utilities.

- Identify any accessibility constraints that may limit the use of certain repair methods, such as confined spaces, restricted easements, or challenging terrain.

- Assess the need for specialized equipment, tools, and techniques to access and repair pipes in difficult-to-reach locations. Consider strategies such as trenchless technologies and remote-controlled equipment to overcome accessibility challenges.

f) Cost effectiveness:

- Consider both the initial investment and long-term maintenance costs.

- Compare the projected costs of implementation, operation, and maintenance against the expected benefits and performance improvements.

g) Environmental considerations (groundwater contamination, soil stability, and ecosystem impacts):

- Select strategies that minimize the environmental footprint, promote sustainability, and comply with regulatory requirements.

h) Regulatory compliance:

- Select repair methods complying with local, provincial, and federal regulations governing sewage management, construction, and environmental protection.

- Select repair methods meeting relevant standards and specifications.

i) Available resources and expertise:

- Evaluate the feasibility of each repair method based on available resources, equipment, and expertise. Municipalities should consider the skill level and experience required for each method.

j) Long-term performance:

- Consider the long-term performance and durability of each repair method.
- Select methods that offer sustainable benefits, minimize the need for future interventions, and provide reliable performance over the lifecycle of the infrastructure.

k) Community impact:

- Assess the potential impact of repair activities on the surrounding community, including disruption to traffic, noise, and odours.
- Communicate with stakeholders, address concerns, and implement mitigation measures to minimize negative impacts.

Municipalities should select the most appropriate repair method based on the evaluation and selection criteria established, considering the unique characteristics and needs of the specific I/I source.

See Tables 1 and 2 for a summary of potential I/I reduction strategies that could be used.

5.5.3 Documentation of the selected method

The rationale for the chosen repair method, including the evaluation criteria and selection process, should be documented to ensure transparency and accountability.

6 REDUCING I/I ON THE PUBLIC SIDE OF SANITARY SEWER SYSTEMS

6.1 GENERAL

This chapter specifies the recommendations needed to implement reduction works identified as part of the reduction program on the public side of the sanitary sewer system.

NOTE — For any sewer system or section of a sewer system undergoing a replacement, refer to the standard CAN/BNQ 3682-320.

6.2 REDUCTION STRATEGIES

6.2.1 General

Works comprised in the I/I reduction program include, but are not limited to, the following reduction strategies (methods):

a) chemical grouting;

b) grout injection;

c) mechanical sleeves;

d) polyethylene patch liner;

e) pipe bursting;

f) slip lining;

g) cured-in-place plastic pipe;

h) pipe coating;

i) open-cut replacement;

j) maintenance hole adjustment;

k) plugging lifting maintenance holes;

l) maintenance hole replacement.

Reduction works shall be performed by qualified contractors with relevant experience and expertise.

6.2.2 Responsibilities

Responsibility for testing, verification, and controls that are part of inspection and testing may be shared between the contractor and the owner of a public sanitary sewer system. The owner may also choose to delegate, in whole or in part, this responsibility to a third party, such as a company specializing in inspection and testing, and control laboratories.

6.2.3 Post-rehabilitation inspection and testing

6.2.3.1 General — All components of I/I reduction works should be inspected to ensure the integrity of the sanitary sewer system and reduction of I/I. The contractor shall rectify all defects and other necessary work discovered by the municipality as a result of the inspection. After any defects discovered have been corrected, affected sections of the sewer system should be re-inspected at the contractor’s expense and to the satisfaction of the municipality.

Inspection and testing should be performed by qualified staff with relevant experience and expertise as per the municipality's specific operating procedures and requirements.

The selection of repair methods and materials are subject to approval by the municipality. All inspection reports and results should be provided in the format specified in the contract document or appropriate document.

6.2.3.2 Post-rehabilitation pipe inspection process — Testing and inspection should be conducted following the methods required by the municipality.

Steps for inspecting the pipes of the sanitary sewer system for I/I should include:

a) high-pressure water cleaning until the pipe is clean;

b) CCTV inspection and applicable testing in compliance with the AHJ procedures;

c) corrections of any deficiencies identified during the CCTV inspection.

6.2.3.3 Post-rehabilitation maintenance hole inspection process — Testing and inspection should be conducted following the methods required by the municipality.

Steps for inspecting the maintenance holes of the sanitary sewer system for I/I should include:

a) high-pressure water cleaning to appropriately evaluate success of rehabilitation and identify any remaining deficiencies;

b) inspection and applicable testing;

c) correction of any deficiencies identified during the inspection.

6.2.3.4 Leakage testing — Where specified, a leakage test shall be performed on the I/I reduction work. Prior to leakage testing, risks and hazards shall be identified, and appropriate safety measures shall be taken.

6.2.3.5 Documentation — The contractor shall provide a redline drawing of the repairs completed, and the extent of the repair, including areas where repairs may not have been fully completed or areas needing additional work.

7 REDUCING I/I ON THE PRIVATE SIDE OF SANITARY SEWER SYSTEMS

7.1 GENERAL

The quantity of I/I originating from the private side of the sanitary sewer system (as depicted in Figure 3.2) can vary based on factors such as geographical location, climate, and age of infrastructure. Studies have shown that private side I/I can constitute a significant portion (up to 80%) of the total I/I flow in sanitary sewer systems.

Where private side I/I is confirmed to be excessive, municipalities shall implement a private side I/I reduction program as part of overall strategies to address sewage system challenges related to I/I. These challenges may include increased operational and maintenance costs, frequent overflows, and environmental risks associated with I/I. Moreover, factors such as aging infrastructure, urban redevelopment, regulatory obligations, public health concerns, climate change and urban flood risks may prompt needs to address I/I that originates from the private side of the property line.

Common sources of I/I from the private side of the property line include roof drains improperly connected to sanitary sewers, downspouts, sump pumps, foundation drains, cracked or deteriorated sanitary sewer lateral pipes, inadequately sealed cleanout caps, among a multitude of other sources. Addressing and reducing private side I/I requires collaborative efforts between municipalities, utilities, and property owners.

This chapter specifies the recommendations needed to implement repair works identified as part of the reduction program on the private side of the sanitary sewer system.

Common components in most low-rise residential systems include:

a) private sanitary sewer laterals, which generally include the pipe connection from a building sewer to the property line;

b) cleanout(s), which are provided in some sanitary sewer systems at the property line as a direct access point;

c) an inspection chamber, which is typically located at the property line with a larger diameter than the sewer pipe to allow for visual inspection;

d) sanitary building drain, sewer, plumbing, and drainage components, which are located on the private side of the property line within the footprint of the building (see Figure 3.2).

NOTE — This clause is intended for predominantly low-rise residential buildings, but may also address I/I problems in industrial, commercial and investment properties and high-rise residential buildings.

7.2 SANITARY SEWER LATERAL CONDITION ASSESSMENT

Currently, there are no established industry standards for certification programs dedicated to sanitary sewer lateral condition assessment. Drawing upon knowledge and best management practices, the following presents an overview of essential steps to guarantee sanitary sewer lateral condition assessment.

For more information on this aspect, users can refer to the following documents:

a) CAN/BNQ 3682-320;

b) CSA Z800;

c) *Reducing the Risk of Inflow and Infiltration (I/I) in New Sewer Construction*.

Step 1: Desktop study prior to field-testing

a) Check that there is a separate sanitary and storm service connection that is connected to the public sanitary and storm main sewer system respectively. This may involve a desktop evaluation using a municipal GIS or record drawing, but should be checked (if possible) from historical CCTV inspections of the public sanitary and storm sewer to verify that services separately connect to the public sewer systems, for example.

b) If there is not a separate sanitary and storm connection, proceed to Step 2B.

c) Check the installation date and material type of the sanitary sewer lateral. If the age of the sanitary sewer lateral or material exceed the threshold trigger (e.g., age of pipe is 30 years or greater), proceed to Step 2A.

d) Check the recent mainline CCTV inspection report for GWI at this location (if available). If GWI is present, a fixture leak or defect in the sanitary sewer lateral is possible. Advise the building owner to check for fixture leaks then schedule an inspection of the cleanout. If cleanout shows GWI, proceed to Step 2A.

e) If Step 2A or 2B is not required, no field testing or alternative program is required at this time.

Step 2A: Field-testing of separate sanitary connections

a) Advise the building owner that a field-testing program is required.

b) The building owner will need to hire a CCTV contractor that has been certified in Lateral Assessment Certification Program (LACP) surveys.

c) Prior to the inspection, the contractor will need to flood the sanitary trench with a continuous water flow prior to the CCTV inspection.

d) The contractor will check the cleanout at the property line for signs of GWI.

e) Conduct the CCTV inspection using LACP survey format.

f) If the results of the survey score are higher than prescribed or if there are signs of GWI at the cleanout, the sanitary sewer lateral will need to be replaced. Otherwise, the sanitary sewer lateral can be recertified for a number of years to be determined.

Step 2B: Program for combined connections

a) Check that a main storm sewer is available in the public right-of-way or easement next to the lot.

- If a storm sewer main is not available, the building owner needs to construct a separate sanitary and storm sewer laterals as per AHJ. If and when a main becomes available, the combined sanitary and storm sewer lateral shall be separated and connected.

- If a storm sewer main exists, check that the connection invert of a proposed storm water lateral is lower than the building foundation. If the storm sewer main is higher than the building foundation, an alternative storm water lateral is required. If the municipality has developed a policy relating to this aspect, the building owner should refer to this policy.

NOTE — Alternative storm water lateral can be a sump pump.

7.3 REPAIR AND REPLACEMENT

Property owners are typically responsible for repairs and replacement of the private portion of the sanitary sewer lateral that extends to the property line (see Figure 3.2). In some instances, property owners are also responsible for the entire length of the sanitary sewer lateral, from the building trap to the main public sewer.

Municipalities shall ensure that regulatory instruments including construction, building, and/or plumbing codes, and any applicable municipal bylaw requirements related to sanitary sewer laterals (including the sanitary building drain and sewer) are consulted.

Potential options for rehabilitation could include:

a) open cut replacement: traditional method involving excavation and complete replacement of the old pipe with a new one;

b) cured-in-place pipe lining: trenchless method using a resin-saturated liner to create a durable inner pipe, avoiding the need for excavation;

c) pipe bursting: trenchless method breaking apart old pipes while simultaneously installing new ones, reducing the need for extensive excavation;

d) directional drilling (boring): trenchless technology drilling horizontally to install pipes along a predetermined underground path.

When a private sanitary sewer lateral is rehabilitated or replaced, there is a critical opportunity to correct I/I-related deficiencies such as foundation drainage.

NOTE — Municipalities can consult the standard CAN/BNQ 3682-320 as it provides detailed design, construction, inspection and testing guidance for traditional installation of private-side sewer systems involving excavation.

The municipality should update all relevant documentation indicating the location, extent, and type of repair completed. Documentation may include record drawings, updates to the GIS database, and updates to property service cards.

7.4 PRIVATE SEWER SYSTEM MANAGEMENT PROGRAMS

7.4.1 Regulatory approaches

7.4.1.1 General — Municipalities should set up a legal framework or impose requirements to ensure the implementation of I/I reduction programs.

7.4.1.2 Municipal bylaws — They provide a legal framework for managing the private side I/I and can be an effective tool for enforcing regulations that help protect the integrity and efficiency of the public sanitary sewer system. Bylaw requirements may vary by jurisdiction, but common elements often include connection standards, sump pump discharge regulations, stormwater management standards, private sanitary sewer lateral inspection and repair or replacement requirements, illegal connections enforcement, etc.

NOTE — Examples of different types of local bylaw requirements that have been successfully applied in Canada and elsewhere include:

a) mandatory inspection of a building's sanitary sewer when selling a private property;

b) requirements that trigger CCTV or related inspections of sewer connections for new construction, and/or when building permit applications are made;

c) private sanitary sewer lateral certification bylaws;

d) sewer use bylaws;

e) lot grading and drainage bylaws.

7.4.1.3 Standards — They may contribute to I/I management through unified guidelines, construction (building and plumbing) codes and regulations, stormwater management requirements, reporting protocols, permitting and inspection procedures, etc.

For example, municipalities may:

a) require additional inspection and testing during permitting stage to ensure watertightness of private sanitary sewer lateral connections;

b) enhance requirements to properly seal the old or abandoned sanitary sewer laterals for redevelopment properties;

c) provide I/I management tools and/or template through online platforms. These can include CCTV equipment requirement and standard scoring.

7.4.1.4 Sanitary sewer lateral replacement — New construction and building permit bylaws — This approach aims at setting out a trigger associated to the obtention of a building permit. From this point on, a set of conditions and actions apply so that connections are either operating within reasonable limits or replaced.

NOTE — Some Canadian jurisdictions, such as the City of Surrey and the City of Vancouver, have successfully implemented sanitary sewer lateral inspection and replacement requirements: the property owner assumes responsibility for the performance of the building's sanitary sewer, and therefore its maintenance. This also enables municipalities to systematically upgrade aging or problematic private side sewer infrastructure. However, there is possible increased costs on sanitary sewer lateral inspection and replacement impacting the overall cost of development.

7.4.2 Incentive approaches and insurance

Incentives and insurance may be used to encourage building owners maintaining and replacing sanitary sewer laterals such as:

a) property tax exemption (property taxes or utility fees) could be discounted for qualifying properties, likely requiring some form of certification for drainage systems;

b) provincial tax exemption could involve a reduction in property transfer taxes or other provincially administered tax at the time of a property sale for qualifying properties, likely requiring some form of certification;

c) potential incentives offered by their insurance provider that may facilitate I/I reduction at the property level. For example, insurers may provide incentives for sump pump installation, backup power for sump pumps, effective lot grading and drainage, among other private-side measures. These incentives are typically made available following loss events associated with insured perils. Depending on the policy, insured perils may include sewer backup, overland/stormwater flooding, seepage.

   NOTES —

   1 Residents should be encouraged to explore these possibilities with their insurers.

   2 Residents should be encouraged to discuss covered perils and incentive options with insurance brokers and agents.

d) coverage for buried service pipes offered by several insurers across Canada. Municipalities or local authorities may consider developing buried sewer pipes insurance programs for property owners where private options are not available.

   NOTES —

   1 Though policy details vary, coverage may apply to significant (i.e., noticeable by the property owner) damage to buried pipes, but does not necessarily apply to address ongoing/chronic infiltration of groundwater. Replacement of buried pipes, however, provides a window of opportunity to apply sanitary sewer lateral condition assessment, and/or to ensure they are replaced or reinstalled using best available practices.

   2 Residents should be encouraged to purchase buried water and sewer service pipes coverage.

7.5 PUBLIC EDUCATION AND OUTREACH

Public education and outreach are critical components of addressing the private side I/I. Municipalities should conduct awareness campaigns to educate the public about the impact of I/I on the sanitary sewer system. These campaigns may include distributing information materials such as Guidelines and Frequently Asked Questions, organizing workshops, and utilizing online platforms such as social media to reach private property owners. Basement flood events provide discrete opportunities to engage residents in education and awareness programs for I/I reduction.

Communicating the responsibilities of property owners in maintaining their sewer connections, and awareness of regulations as well as potential consequences of non-compliance should be considered as part of awareness programs.

Public education alone is not typically sufficient to motivate residents to engage in sometimes costly and inconvenient I/I management practices, including maintaining sanitary sewer laterals and disconnecting foundation drains from sanitary sewer system. Education programs should be a component of a comprehensive approach to engaging residents in I/I and basement flood management, which may include:

a) education and awareness (e.g., notifying residents of the need to manage I/I, implications of I/I for them, their neighbourhoods, and the environment);

b) incentives (e.g., rebates to assist residents to implement measures outlined in public education and regulation);

c) regulation (development and enforcement of mandatory measures to engage residents in I/I reduction practices, e. g., require residents to install a sump pump).

NOTE — Municipalities may also engage the provincial and federal code development agencies to address recurrent design issues that result in I/I over the life of private-side sewer connections and buildings.

7.6 COMPARISON OF THE PRIVATE SIDE I/I REDUCTION METHODS

Effectiveness of private side I/I reduction methods outlined above may vary depending on local conditions, existing infrastructure, and the extent of cooperation from property owners. A comprehensive approach that combines multiple strategies and involves ongoing education and communication is often the most successful in mitigating private-side properties I/I (see Table 2).

8 MONITOR AND ADJUST

8.1 GENERAL

Continuous monitoring, follow-up and management of sanitary sewer systems helps improve overall system performance and reduce the costs and risks of excessive I/I.

Once the I/I reduction program has been finalized, municipalities should undertake the following steps:

1. Conduct flow monitoring and field studies (I/I analysis phase).
2. Undertake the necessary work and follow-up.
3. Repeat the process.

During the re-evaluation of data, some problem areas may have been identified. If that is the case, these should be addressed by further interventions, which may include:

a) flow monitoring;

b) groundwater monitoring;

c) rainfall events monitoring;

d) source detection;

e) input of data from new pipes as the sewer system extends;

f) hydraulic modelling.

In cases where the I/I reduction program does not cover all the work required to eliminate the risk of flooding and diversions, municipalities should hold public information sessions on the impact of I/I on the private sides of their system and, therefore, on properties (see Clause 7.5).

8.2 INTEGRATING I/I REDUCTION PROGRAM DATA INTO THE ASSET MANAGEMENT PLAN

Municipalities with an asset management plan should use the I/I reduction program to:

a) inform the asset management plan with relevant data from the I/I reduction program (see Chapter 5);

b) align levels of service with those defined in the I/I reduction program (see Clause 5.4);

c) re-evaluate asset intervention classes to incorporate I/I risks.

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Table 1
Comparison of the public-side I/I reduction methods
(Clause 5.5.2)
[pane 1 of 3]

C/I reduction methods	Type(s) of repair	Types of I/I sources (defects) addressed	Advantages/benefits	Disadvantages/ downsides	Estimated costs (per meter) $: $0-$500s $$: 500s to $2 000s $$$: 2 000s+	Additional notes
Sewer mainline and lateral						
Chemical grouting	Point	Cracks and fractures, joints, annular space sealing, pipe abandonment.	Quick to apply, low cost, minimal disruption.	Not appropriate for large defects, may require regular maintenance to ensure long-term performance.	$	Chemical grouting involves injecting chemical grout into cracks, joints, and defects in the pipe to seal leaks and reduce infiltration.
Grout injection (sub-type of chemical grout)	Point	Void filling, cracks and joints sealing, annular space sealing.	Quick to apply, low cost, minimal disruption.	Not appropriate for large defects, may require regular maintenance to ensure long-term performance.	$	Not Applicable
Mechanical sleeves	Point	Cracks and fractures, joints, holes/punctures, root intrusion.	Minimal excavation, can be installed on many pipe materials.	Effectiveness depends on condition of the existing pipe, may not be compatible with all pipe materials.	$$$	Not Applicable
Polyethylene patch liner	Point	Cracks and fractures, joints, holes/punctures, root intrusion.	Minimal disruption, fast installation and curing.	Not appropriate for extensive damage.	$	Not Applicable
Pipe bursting	Linear	Cracks and fractures, corrosion and deterioration, joints, root intrusion.	Replaces entire pipe, minimal disruption on surface, can increase hydraulic capacity, can be used with various pipe materials.	Requires access pits.	$$	Not Applicable

Table 1
Comparison of the public-side I/I reduction methods
(Clause 5.5.2)
[pane 2 of 3]

C/I reduction methods	Type(s) of repair	Types of I/I sources (defects) addressed	Advantages/benefits	Disadvantages/ downsides	Estimated costs (per meter) $: $0-$500s $$: 500s to $2 000s $$$: 2 000s+	Additional notes
Slip lining	Linear	Cracks and fractures, corrosion and deterioration, joints, root intrusion.	Minimal surface distributions, extends lifespan of pipe, can address moderate structural defects.	Not suitable for severe structural defects, limitations based on pipe curvature and alignment.	$$	Slip lining involves inserting a smaller-diameter pipe into the existing pipe and grouting the annular space between the two pipes to create a new structural liner.
CIPP (cured-in-place pipe)	Point & linear	Cracks and fractures, corrosion and deterioration, joints, root intrusion.	No excavation required, full rehabilitation of pipe, extends lifespan of pipe.	May reduce diameter slightly, initial setup costs can be high, not suitable for severely damaged/collapsed pipes.	$$	CIPP involves inserting a flexible liner coated into an existing pipe, inflating it, and curing it in place using heat or ultraviolet light.
Pipe coatings	Point & linear	Sealing leaks.	Good for corrosion protection, can improve hydraulic flow, suitable for various pipe materials.	Limited applicability for structural defects, effectiveness is dependent on surface preparation.	$ - $$	Not Applicable
Open-cut replacement	Point & linear	Cracks and fractures, corrosion and deterioration, joints, root intrusion.	Long-term solution, can incorporate capacity improvements.	Highly disruptive and costly, may require bypass during construction, longer schedule.	$$$	Open-cut replacement involves excavating and replacing the damaged or deteriorated sections of the pipe with new pipes.
Maintenance holes (MHs)						
Chemical grouting	Point	Voids, cracks and joints.	Relatively quick and cost-effective, effective for sealing leaks and stabilizing soil.	Limited effectiveness for structural defects, may require access to both interior and exterior of MH.	$	Not Applicable

Table 1
Comparison of the public-side I/I reduction methods
(Clause 5.5.2)
[pane 3 of 3]

C/I reduction methods	Type(s) of repair	Types of I/I sources (defects) addressed	Advantages/benefits	Disadvantages/ downsides	Estimated costs (per meter) $: $0-$500s $$: 500s to $2 000s $$$: 2 000s+	Additional notes
Grout injection	Point	Voids, cracks and joints.	Relatively quick and cost-effective, effective for sealing leaks and stabilizing soil.	Limited effectiveness for structural defects, may require access to both interior and exterior of MH.	$	Not Applicable
Maintenance hole adjustment	Point	Inflow from pooling water on lid, joint offset.	Depending on the depth of the joints, can be a cost-effective and quick implementation.	May not address structural problems or more sever infiltration	$$	Not Applicable
Coating — Interior and exterior	Point	Joints, cracks, fractures.	Provides protective barrier against corrosion and water infiltration.	Exterior coating requires excavation	$ - $$	Not Applicable
Plugging lifting maintenance holes	Point	Inflow from surface water/run-off.	Low lying areas, flooded spots.	Need to consider potential odour/gas build-up.	$$	Not Applicable
Replacement	Point	Voids, cracks, joints, fractures.	Long-term solution and can address other issues.	Highly disruptive and costly, may require bypass during construction, longer schedule.	$$$	Open-cut replacement involves excavating and replacing the damaged or deteriorated sections of the maintenance hole with new sections.

Table 2
Comparison of the private side I/I reduction methods
(Clauses 5.5.2 and 7.6)
[pane 1 of 3]

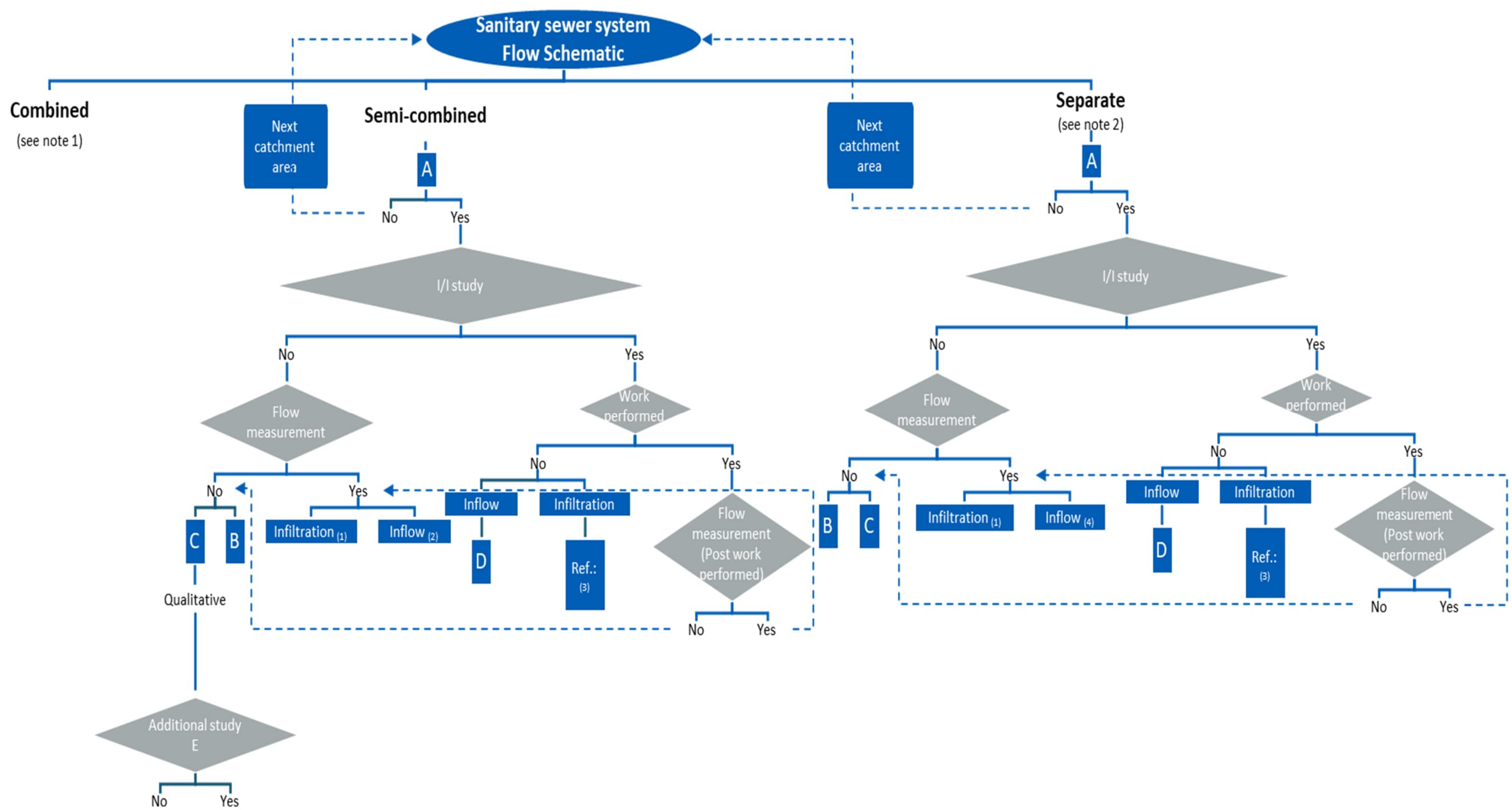
I/I reduction methods	Advantages/benefits	Disadvantages/downsides	Estimated costs (per residential property) $: $0-$500s $$: 500s to $2 000s $$$: 2 000s+	Additional notes (municipal efforts vs. property owner's efforts required)
Proper roof drain management	Prevents direct stormwater entry into sewers during rainfall events. Comparatively straightforward retrofit option for homes with potential for significant inflow reduction.	Requires property owner cooperation for proper connections. Property/lot grading and drainage characteristics have to accommodate downspout discharge.	$	Regular maintenance needed to ensure proper function; may involve upfront costs for rerouting drains.
Sump pump discharge control	Prevents excess groundwater from entering sanitary sewer system.	Requires proper installation and regular maintenance.	$$	Property owners have to be educated on proper discharge locations; potential need for backflow prevention devices.
Foundation drain sealing	Minimizes GWI into sewer pipes.	Retrofitting existing systems can be labour-intensive.	$$$	Regular inspections to identify and address any sealant degradation or failures.
Cleanout cap installation	Reduces direct entry points for surface water.	May require property inspections for compliance.	$	Education needed to ensure property owners understand the importance of maintaining sealed cleanouts.
Sanitary sewer lateral inspection	Identifies infiltration due to cracks or damaged sanitary sewer laterals.	Property owners have to volunteer to participate/requires access to interior of homes.	$	Regular inspections can prevent major failures; may require financial assistance programs for property owners.
Sanitary sewer lateral repair	Addresses infiltration due to cracks or damaged sanitary sewer laterals.	Property owners have to volunteer to participate. Resources intensive.	$$$	Not Applicable

Table 2
Comparison of the private side I/I reduction methods
(Clauses 5.5.2 and 7.6)
[pane 2 of 3]

I/I reduction methods	Advantages/benefits	Disadvantages/downsides	Estimated costs (per residential property) $: $0-$500s $$: 500s to $2 000s $$$: 2 000s+	Additional notes (municipal efforts vs. property owner's efforts required)
Stormwater system separation	Diverts stormwater away from sanitary sewer systems.	Retrofitting can be complex and expensive.	$$$	Collaboration with local authorities is crucial; may involve phased implementation for large-scale separation projects. Public storm sewer elevation/capacity need to be checked for proper connection.
Sewer backup protection	Minimizes the risk of sewer backups.	Installation costs may be high for interior/mainline valve installation. Newer valves may have lower maintenance needs, but maintenance is still recommended.	$ - $$$	Proper installation is critical; routine inspections to ensure functionality; periodic inspection, maintenance, and possible repair may be necessary.
Education and outreach programs	Raises awareness and promotes responsible practices.	Requires ongoing effort to maintain awareness. To date, education programs alone have demonstrated limited effectiveness at engaging residents in physical I/I reduction options. Effective programs require careful development and ongoing collaboration with relevant/local participants.	$	Collaboration with community groups enhances reach; continuous updates to adapt to changing demographics and infrastructure.

Table 2
Comparison of the private side I/I reduction methods
(Clauses 5.5.2 and 7.6)
[pane 3 of 3]

I/I reduction methods	Advantages/benefits	Disadvantages/downsides	Estimated costs (per residential property) \$: \$0-\$500s \$\$: 500s to \$2 000s \$\$\$: 2 000s+	Additional notes (municipal efforts vs. property owner's efforts required)
Mandatory building sanitary sewer inspection at the time of sale of a private property	Assumes responsibility for the performance of the building's sanitary sewer, and therefore its maintenance. Raises awareness for all stakeholders of the impact of private section connections on sanitary sewer systems. Implements mandatory measures to overcome low participation in voluntary I/I initiatives.	The introduction of such a requirement at the time of sale is likely to increase property owners' willingness to maintain the building's sanitary sewer so as not to adversely affect the property's resale value. Possible critics will argue to political bodies that sellers will add the repair costs to their selling price, impacting affordability, which is already challenging in Canada, especially for first-time buyers.	\$	Not Applicable
New construction and building permit trigger bylaw	Enables municipalities to systematically upgrade aging or problematic private side sewer infrastructure.	Increased costs on sanitary sewer lateral inspection and replacement impacting overall cost of development. Resistance from homeowners and developers.	Not Applicable	Not Applicable
Private sanitary sewer lateral certification bylaw	Not Applicable	Lack of standardized private sanitary sewer lateral condition assessment process and industry recognized certification programs.	Not Applicable	Not Applicable



NOTES —

1 This standard does not apply to combined sewer systems.

2 It is important to note that, when separating combined systems, most municipalities do not disconnect drains from residential foundations. Consequently, it is common to end up with a semi-combined sewer system, which generally still has a significant concentration of I/I.

Figure 1 — Sanitary sewer system flow diagram
(Clauses 4.1.1, 4.4.3 et 6.2.3.2)

A	Indicators of a problematic area may include, but not be limited to, the following: a) repeated backups; b) frequent overflows from one or more overflows and/or overflow structures; c) abnormal behaviour of the pumping station(s) [overuse, frequent exceeding of design capacity]. NOTE — The date of each problem is important for the analysis.
B	Information that may be available concerning infiltration is as follows: a) CCTV inspections listed; b) age of system; c) groundwater level table data; d) theoretical flow rates; e) proximity of the system to a river and/or watercourse.
C	Information that may be available concerning the infiltration is as follows: a) smoke tests; b) dye tests; c) inspections (visual and/or tests).
D	Infiltration areas reported in I/I studies: a) sinked maintenance hole covers; b) collapsed maintenance holes; c) street grates; d) driveways; e) streets draining to a counter-sloping driveway; f) roof drains; g) flat roofs; h) land drains (permeable and impermeable surfaces); i) ditches or basins; j) maintenance holes in ditches or depressions; k) sloping ground.
E	Examples of additional studies: a) flow measurements; b) CCTV inspections of maintenance holes and pipes; c) groundwater level measurements; d) surface and residential inspections.
1	It is recommended to compare sanitary flows measured during dry weather conditions with theoretical sanitary flows (based on population and major users).

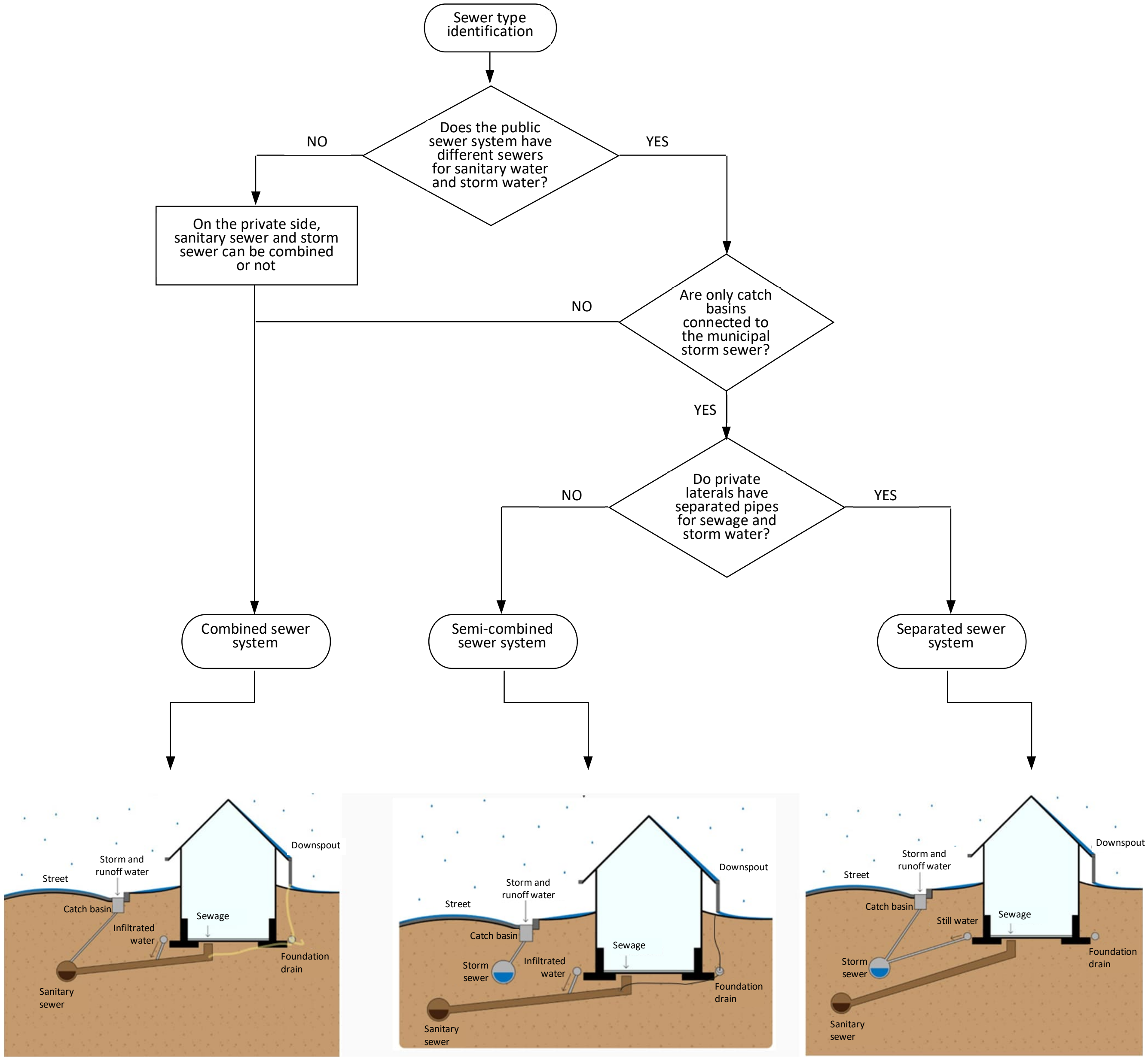
2	It is recommended to evaluate the catchment rate per surface area. In this way, it is possible to estimate the volume of water generated per catchment for a rainfall event (m^3/mm). This unit makes it easier to carry out an in-depth analysis of possible solutions. Catchment flow can occur during and after precipitation, and can have both short- and long-term impacts. In a semi-combined system, catchment sources may include, but are not limited to, the following: Short-term: a) catch basins (catchment areas); b) reverse operation from overflows; c) maintenance holes positioned in a flow corridor; d) maintenance holes in depressions; e) gutters connected to the sanitary sewer system; f) access to ditches and/or watercourses; g) sloping garages; h) streets draining to sloping garages. Long-term: a) French drains; b) slopes toward French drains; c) absence of gutters to direct rainwater away from the foundation.
3	Numerous references are available to classify the intensity of infiltration (refer to Annex E).
4	It is recommended to evaluate the catchment rate per surface area. In this way, it is possible to estimate the volume of water generated per catchment for a rainfall event (m^3/mm). This unit makes it easier to carry out an in-depth analysis of possible solutions. Catchment flow can occur during and after precipitation, and can have both short- and long-term impacts. In a sanitary sewer system, catchment sources may include, but are not limited to, the following: Short-term: a) maintenance holes positioned in flow corridors or depressions; b) maintenance holes positioned in a ditch. Long-term: a) illicit connections to French drains (normally pumped), flat roofs and sloping garages.

ANNEX A
(informative)

Public sewer systems and flooding related to I/I
(Clause 4.1.1)

A.1 TYPES OF PUBLIC SEWER SYSTEMS

There are at most four main types of public sewer systems, but numerous combinations may exist in some municipalities, especially older ones (see Figure A.1). Depending on the type of municipal sewer system, the nature of water in these systems can significantly vary based on the configuration of private sewer systems (see Table A.1). The risks of inflow are associated with the types of sewer systems encountered locally.



Source: Avizo's website (free translation).

NOTE — Semi-combined sewer systems were once common in new construction across Canada as a means to provide foundation and basement drainage without requiring the construction of storm sewers. As a result, semi-combined sewers are sanitary sewers receiving combined private sanitary sewer laterals or that have extensive private-side cross-connections. They are believed responsible for chronic elevated I/I rates in many neighbourhoods serviced before their prohibition.

Figure A.1 — Flow chart to identify the type of public sewer system

Table A.1
Flow source related to types of sewer in public sewer systems

Types of water in the public sewer system	Types of public sewer system				
	Combined sewer system	Semi-combined sewer system		Separate sewer system	
	Combined sewer	Sanitary sewer	Storm sewer	Sanitary sewer	Storm sewer
Domestic sewage	+	+	-	+	-
Industrial process water	+/-	+/-	+	+/-	-
Storm water runoff (catch basin)	+	-	+	-	+
Foundation drainage	+	+	-	-	+
Roof leaders' discharges	+	+	-	-	+
Cooling water	+/-	+/-	-	-	+/-
Purge from cooling water recirculation system	+	+	-	+	-
Water from the network ditches	+/-	+/-	-	-	+

NOTE —

+: type of water transported acceptable for the type of system in question.

+/-: nature of transported water acceptable under certain conditions for the type of sewer system in question.

-: nature of transported water unacceptable for the type of sewerage system in question (use prohibited/to be prohibited/to be reduced).

A.2 CATEGORIES OF FLOODING RELATED TO I/I

There are two major categories of flooding that relate to I/I in inland (non-coastal) areas:

a) riverine (receiving water) flooding;

b) urban flooding.

Riverine flooding is associated with the hydraulic grade line of a nearby receiver that exceeds design values and causes back up into storm and sanitary sewer systems, resulting in flooding and environmental discharge of untreated sewage. If I/I is higher than it should be, riverine flooding may affect more properties since the hydraulic grade line in the sewer is starting from a higher point. This issue is largely masked during a major riverine flooding event.

Urban flooding is associated with any other cause of flooding, including:

a) lot-level issues, such as overland flow due to drainage issues, a defect with a privately owned sewer or protective plumbing equipment;

b) municipal issues, such as overloaded sewer systems, pumping station failure or poor maintenance.

NOTE — This standard covers only urban flooding issues. Municipalities should refer to the document CSA Z800 for more information on the causes and conditions of urban flooding.

SDHI events are one of the aggravating factors that contribute to flooding, in particular by:

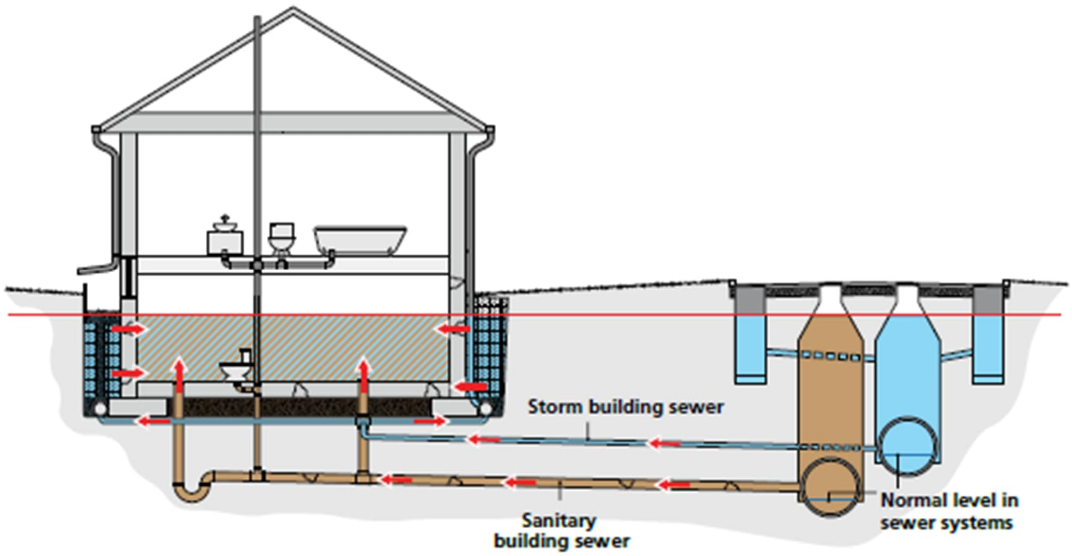
a) seepage of ground and surface water (water seeps into ground beside foundation walls causing water to enter through cracks, loose joints, etc. in basements, and/or groundwater enters homes through cracks in foundations);

b) sewer backup (water/sewage backs up into storm or sewage sewer connections);

c) overland flow of stormwater (stormwater surface flow enters buildings through above ground openings).

Many additional factors may affect flooding occurrence in a residential building, including sump pump failure, improperly installed, or maintained flood protection devices, blocked sewer connections and poor construction.

Figure A.2 illustrates the hydraulics or mechanisms of a sewer backup causing flooding.



Source: *Reducing the Risk of Inflow and Infiltration (I/I) in New Sewer Construction*.

Figure A.2 — Illustration of a sewer backup in a separate sewer system

A.3 IMPACTS OF SEWER BACKUPS

Urban basement flooding associated with SDHI rainfall events is one of the most significant drivers of disaster loss in Canada. The vulnerability of urban communities was highlighted following the July 8, 2013, urban flood event in the Greater Toronto Area. At over $1 billion (2019 CAD) in insured losses, this event remains the most expensive insured loss event in Ontario's history and the most expensive urban SDHI flood event in Canada's history. Though multiple flood drivers contributed to damage, including a combination of insured and uninsured storm/overland flow, sewer backup, infiltration flooding and various household-scale plumbing issues, insurance industry loss data indicated that over 60% of the insured losses and 70% of the claims were attributed to sewer backup and water damage in residential buildings.

Aside from property damage, impacts of sewer backup flooding include health risks associated with flooded basements (e.g., mould, introduction of raw sewage into residential buildings), reduced livability of residential buildings and loss of irreplaceable and sentimental items, among other effects. Households may also experience negative impacts on insurance coverage conditions and availability for future events. Examples of municipal impacts include damage to infrastructure, operational costs and threats of lawsuits following SDHI-related flood events.

A 2017 review of climate change adaptation for the built environment by the Infrastructure and Buildings Working Group (part of Canada's Climate Change Adaptation Platform) indicated that municipalities in many regions of Canada are concerned that the risk associated with urban and basement flooding will intensify as a result of increasing urban development and density, aging private- and public-side infrastructure, sewer construction issues, and increasing frequency and intensity of extreme rainfall events associated with climate change, among other factors. As discussed later in this standard, homeowner behaviour (e.g., lack of maintenance) and building designs that result in use of basements as living space may be additional factors that increase basement flood risk. A general trend toward using basements as living space and the related trend toward deepening of basements to increase livability further increase vulnerability of residential buildings and households to significant flood damages.

ANNEX B
(informative)

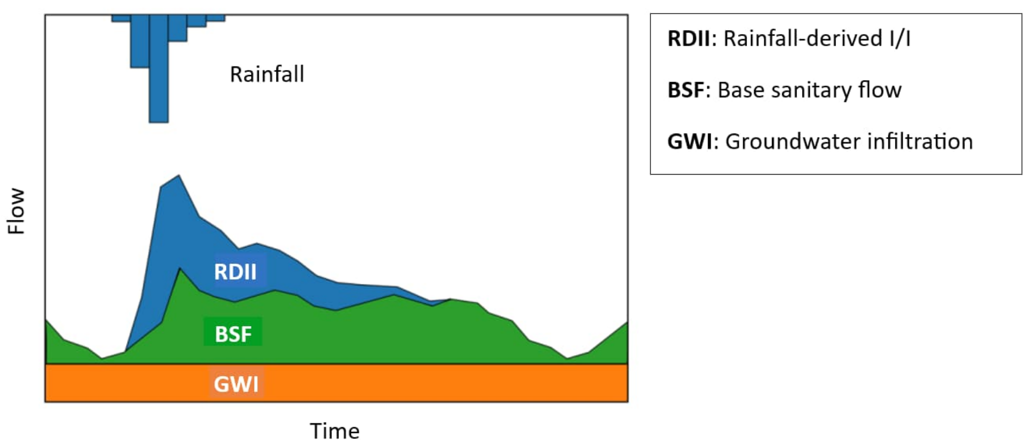
Types of flows
(Clause 4.2.4)

GWI refers to water that infiltrates the sewer system through cracks, pipe joints, and maintenance holes. The amount of infiltration varies from one location to another based on the system's condition, age, and groundwater table level. Infiltration can fluctuate significantly throughout the year and is often highest during spring thaw.

BSF represents the flow of sewage from various sectors (residential, commercial, institutional and industrial) that varies based on water usage patterns. Meter records provide useful data for defining this type of flow.

BSF and GWI together constitute the inflow to sewer systems during dry weather periods and are typically always present.

RDII represents the hydrological response of the sewer system during rainfall events. This flow is usually responsible for overflows and often form the major component of hydrographic systems that need to be controlled. RDII can be categorized as direct and indirect infiltration. During dry weather period, this flow is minimal. During a rainfall event, it increases to a maximum value and then gradually returns to dry weather values (BSF and GWI). If rainfall is light, there may be no significant hydrological response.



Source: *Guide de gestion des débordements et des dérivations d'eaux usées* (free translation).

Figure B.1 — Types of water found in a sanitary sewer system

Infiltration flow rates depend, among other factors, on the groundwater levels, which vary throughout the year, and within the day for areas influenced by tides.

NOTE — Groundwater levels generally reach their maximum during spring and their minimum during summer or winter, depending on the region.

Combined inflow related to RDII in the sanitary sewer system can be categorized into two types and are associated with different periods:

a) direct infiltration (from inflows immediately following a rainfall event);

b) indirect infiltration (from inflows observed over several days after a rainfall event when the flow takes time to decrease).

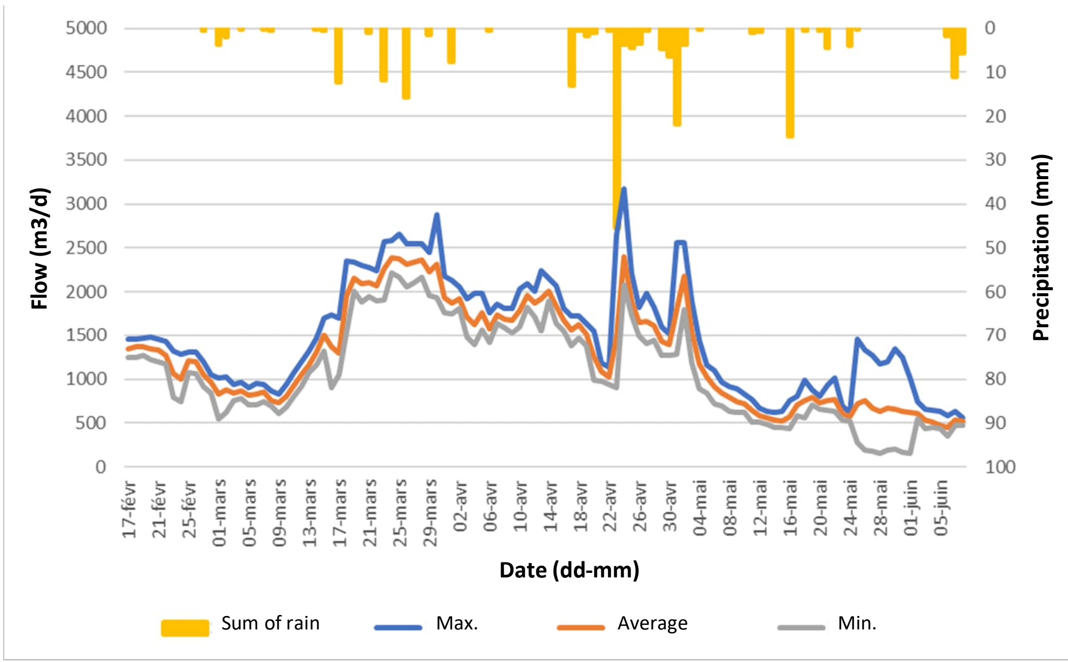
NOTE — The speed of indirect infiltration varies based on soil characteristics.

ANNEX C
(informative)

Correlation between rainfall events, runoff water and monitored flow rates
(Clauses 4.4.5 and 4.6.3)

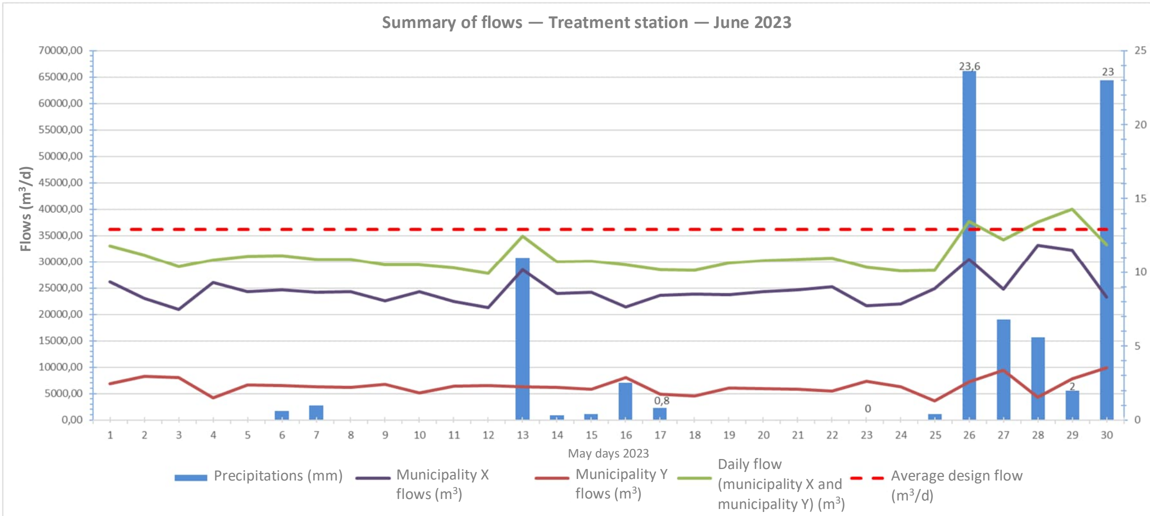
The correlation between rainfall events and runoff water, and flow rates can be analyzed by plotting the flow rate on a graph to which the precipitation curve is added.

Figure C.1 illustrates the correlation between meteorological records and flow rates monitored on a sanitary sewer system.



Source: Simo Management.

Figure C.1 — Illustration of input data from a sewage treatment plant over a period of several weeks



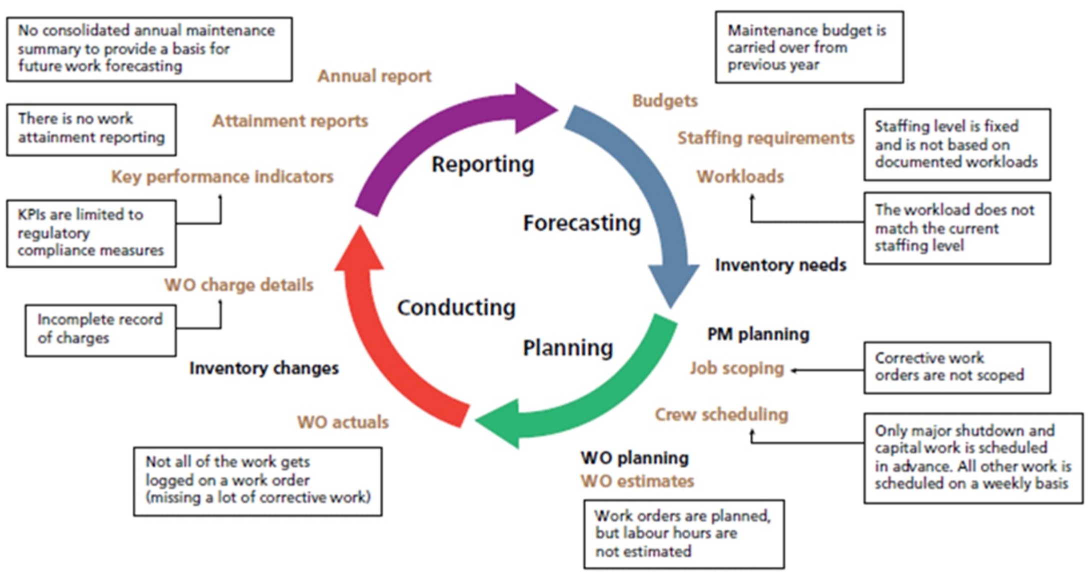
Source: Simo Management (adaptation).

Figure C.2 — Illustration of input data from a sewage treatment plant over a period of several days

ANNEX D
(informative)

Example of a gap analysis for implementing and maintaining an I/I reduction program
(Clause 4.5)

Figure D.1 shows a visual representation of a typical gap analysis. The Regional District of Nanaimo, BC, undertook an overall gap analysis for the systems supporting their efforts to complete the process of forecasting, planning, conducting and reporting. The analysis also identifies the process and data collection gaps that prevented the district from having a full understanding of their systems. This analysis gave the district an opportunity to improve the background data collection in support of improved understanding of their systems.



Source: *Developing an Efficient and Cost-Effective Inflow and Infiltration (I/I) Reduction Program*.

Figure D.1 — Visual representation of a gap analysis

ANNEX E
(informative)

Examples of policies to reach levels of service
(Clause 4.6.2)

E.1 LEVELS OF SERVICE BY THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (U.S. EPA)

The U.S. EPA suggests the following potential goals (e.g., levels of service) for an I/I reduction program:

a) reduce ratepayer costs for transporting and treating sewage by implementing all cost-effective I/I reduction projects within ten years;

b) minimize liability from water pollution and public health risks by eliminating SSOs in storm events;

c) eliminate enough I/I to avoid the capital costs of sewage treatment plant capacity expansion in anticipation of 10% population growth over the next 20 years;

d) eliminate enough I/I to avoid the capital costs of interceptor expansion, which will be needed to support the build-out of certain neighbourhoods;

e) eliminate enough I/I to offset the environmental and regulatory impact of sewer system expansion and increased water demand over the next 15 years.

E.2 LEVELS OF SERVICE BY THE CITY OF LONDON (ONTARIO)

The City of London has defined levels of service based on the asset management requirements set out in Ontario's new asset management legislation (O. Reg. 588/17). London's approach has applied the requirements of the asset management legislation, which has specifications for developing an asset management plan into sewage levels of service under the categories of both "customer" and "technical" metrics. Figure E.1 describes how these are set out.

Customery levels of service use qualitative descriptions to describe the scope or quality of service delivered by an asset category.

Technical levels of service use metrics to measure the scope or quality of service being delivered by an asset category.

Customary Level of Service	Technical Level of Service
• Description, which may include maps, of the user groups or areas of the municipality that are connected to the municipal wastewater system.	• Percentage of properties connected to the municipal wastewater system. **(94%)**
• Description of how combined sewers in the municipal wastewater system are designed with overflow structures in place which allow overflow during storm events to prevent backups into homes.	• # of events per year where combined sewer flow in the municipal wastewater system exceeds the system capacity compared to the total number of properties connected to the municipal wastewater system.
• Description of the frequency and volume of overflows in combined sewers in the municipal wastewater system that occur in habitable areas or beaches.	• The number of connection-days per year due to wastewater backups compared to the total number of properties connected to the municipal wastewater system.
• Description of how stormwater can get into sanitary sewers in the municipal wastewater system, causing sewage to overflow into streets or backup into homes.	• The number of effluent violations per year due to wastewater discharge compared to the total number of properties connected to the municipal wastewater system.
• Description of how sanitary sewers in the municipal wastewater system are designed to be resilient to avoid events described in the previous paragraph.	
• Description of the effluent that is discharged from sewage treatment plants in the municipal wastewater system	

Source: *Developing an Efficient and Cost-Effective Inflow and Infiltration (I/I) Reduction Program* (adaptation).

Figure E.1 — City of London's levels of service "metrics" for sewage

E.3 LEVELS OF SERVICE BY METRO VANCOUVER, BC

Metro Vancouver establishes a basic level of service capacity for all District sanitary sewers that provides for the conveyance of measured dry weather flows plus a wet weather allowance for infiltration and inflow of 11 200 litres per hectare per day, such that the hydraulic grade lines do not exceed established safe operating levels.

E.4 LEVELS OF SERVICE BY THE CITY OF LETHBRIDGE, AB

The City of Lethbridge defines levels of service's objectives that combine soft and hard goals, described in Figure E.2. Lethbridge's levels of service includes a hard target associated with surcharging that causes sewer backup (99.5% of homes protected). This approach directly links the relationship between I/I and basement flooding, which, though difficult to quantify, is direct and absolute.

Level of service requirements have been defined based on a customer focus group formed during the 2000 Underground Infrastructure Master Plan. The City of Lethbridge Wastewater Utility has adopted a set of level service requirements and as such they will form a basis for these principles of functionality. The following level of service objectives have been set:

- Provide sewage collection adequate to meet the dry weather demand of the proposed development with appropriate allowances made for wet weather inflows based on current sanitary sewer construction practices.
- Provide sanitary sewer capacity so that surcharging does not occur for design dry weather peak flows and so 99.5% of homes are protected from sewer backup during peak wet weather flow events.
- No additional or new homes will be added to the "at risk" list as a result of any new development. "At risk" is defined as locations where surcharging of the sanitary sewer occurs to a level less than 2 m below the manhole rim for the design wet weather event.
- Limit wet weather inflows to less than 5% of the total volume of rainfall in the system during wet weather periods.

Source: *Developing an Efficient and Cost-Effective Inflow and Infiltration (I/I) Reduction Program*.

Figure E.2 — City of Lethbridge levels of service objectives

ANNEX F
(informative)

Informative references

F.1 GENERAL

The reference below is cited for information purposes in this standard.

It should be noted that a dated informative reference refers to that specific edition of the reference, while a non-dated reference refers to the latest edition of the reference in question.

F.2 DOCUMENTS FROM STANDARDS BODIES

BNQ (Bureau de normalisation du Québec) [https://www.bnq.qc.ca]

BNQ 1809-400	*Travaux de réhabilitation sans tranchée — Conduites d'eau potable et d'égout — Partie I : Clauses administratives particulières — Partie II : Revêtement projeté pour les conduites d'eau potable — Clauses techniques générales — Partie III : Chemisage des conduites d'eau potable — Clauses techniques générales — Partie IV : Chemisage des conduites d'égout — Clauses techniques générales*.
BNQ 3660-004	*Manuel de conception des réseaux d'égout municipaux.*
CAN/BNQ 3682-320	*Mitigation of the Risks of Inflow and Infiltration in New Sanitary Sewer Systems*. (Atténuation des risques de captage et d'infiltration dans les nouveaux réseaux d'égout sanitaire.)

CSA Group [https://www.csagroup.org]

CSA Z800	*Guideline on Basement Flood Protection and Risk Reduction*. (Lignes directrices sur la protection des sous-sols contre les inondations et la réduction des risques.)

ISO (International Organization for Standardization) [https://www.iso.org]

ISO 20710-1 *Fire Safety Engineering — Active Fire Protection Systems — Part 1: General Principles*.
(Ingénierie de la sécurité incendie — Systèmes de protection active contre l'incendie — Partie 1 : Principes généraux.)

F.3 LAWS, REGULATIONS AND SIMILAR DOCUMENTS

CANADA. *National Plumbing Code of Canada*.

ONTARIO. *Asset Management Planning for Municipal Infrastructure* (O. Reg. 588/17).

F.4 GOVERNMENT DOCUMENTS

CITY OF KELOWNA. *Development and Servicing Bylaw No. 7900, Schedule 4 — Design Standards*, [Online], 2024, 148 p.

CITY OF VANCOUVER. *Engineering Design Manual*, 1st Edition, 2019, 346 p.

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TORONTO WATER INFRASTRUCTURE MANAGEMENT. *Sewer Capacity Assessment Guidelines*, 1st edition, 2021, 24 p.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (U.S. EPA). *Guide for Evaluating Capacity, Management, Operation, and Maintenance (CMOM) Programs at Sanitary Sewer Collection Systems*, 2005, 126 p.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (U.S. EPA) WATER INFRASTRUCTURE OUTREACH. *Guide for Estimating Infiltration and Inflow*, 2014, 7 p.

F.5 OTHER DOCUMENTS

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ROBINSON, B. (Norton Engineering), D. Sandink (Institute for Catastrophic Loss Reduction) and D. Lapp (Engineers Canada). *Reducing the Risk of Inflow and Infiltration (I/I) in New Sewer Construction*, A National Foundational Document for the Development of a National Standard of Canada, ICLR Research Paper Series — No. 64, Institute for Catastrophic Loss Reduction, Toronto, Ontario and Standards Council of Canada, Ottawa, Ontario [Online], 2019, 58 p.

ANNEX G
(informative)

Bibliography

The reference below can be consulted for more information on the topics covered in this standard.

DOCUMENT FROM A STANDARDS BODY

BNQ (Bureau de normalisation du Québec) [https://www.bnq.qc.ca]

BNQ 3680-125 *Inspection télévisée des conduites et regards d'égout — Partie I : Inspection télévisée par caméra à téléobjectif — Partie II : Inspection télévisée par caméra conventionnelle — Partie III : Nettoyage et travaux connexes.*

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a) the number and title of the document (CAN/BNQ 3682-420 *Existing Sanitary Sewer Systems — Inflow and Infiltration Reduction Program — Guidelines*);

b) your comments or suggestions (e.g., to report an error, to suggest a modification, to suggest a new document on a related matter, or other);

c) your name and contact details.

Bureau de normalisation du Québec

QUÉBEC
333, rue Franquet
Québec (Québec) G1P 4C7
T 1 844 474-6367

MONTRÉAL
1201, boulevard Crémazie Est, bureau 1.210
Montréal (Québec) H2M 0A6
T 1 844 474-6367

www.bnq.qc.ca
bnqinfo@bnq.qc.ca