Town of Minto
Community of Harriston

Infiltration and Inflow (I/I) Study

Report

August 2023

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ORANGEVILLE | FERGUS | HARRISTON

Contents

1.0 Introduction

On behalf of The Town of Minto (Town), Triton Engineering Services Limited (Triton), has prepared this Infiltration and Inflow (I/I) Study Report (Report) to document the findings of the I/I Study that has been completed for the sanitary sewage collection system serving the distinct urban area of Harriston.

Key components of this Report include the following:

- Introduction and background information
- I/I Study, Terms, and Methodology
- Extraneous Flow Analysis
- Data Gathering
- Analysis
- Conclusions
- Recommendations

1.1 Harriston Sanitary Sewage System

The Harriston sanitary sewage system consists of works for the collection, transmission, and treatment of sewage. The collection and transmission of sewage is via trunk sewers, separate sewers, sewage pumping stations and forcemains, with discharge to the Harriston Sewage Treatment Works (STW), which is a three-cell aerated lagoon system. Treated effluent from the STW is discharged to the Maitland River, via Municipal Drain No. 12, during the discharge period (October 1 through April 30). Treated effluent is stored in the lagoons during the non-discharge period (May 1 through September 30), until discharging to the Maitland River is permitted.

The sewage collection network, which comprises of approximately 15 km of sewer mains, services Harriston's developed areas within the urban boundary and provides a total of 996 service connections (904 residential and 92 Industrial/Commercial/Institutional (ICI)), according to Town records at the end of calendar year 2020. Sanitary sewer gravity main diameters range from 100 mm to 525 mm and forcemain diameters range from 100 mm to 200 mm, with sewers made of various materials throughout the collection system, including asbestos cement, concrete and PVC. It is expected that asbestos cement sewers, which comprise most of the collection system, will be approaching the end of their estimated service life; however, CCTV investigation of the sanitary sewer would need to be completed to assess the condition of the existing sewers.

The existing sanitary sewer collection network is presented in Figure 1 on the following page.

The Harriston Sanitary Treatment Works are in the northwest portion of Harriston's urban boundary, to the north of the Harriston Greenway Trail, in Part of Lots 83 and 84, Concession D, as shown on Figure 1. The sewage treatment works consist of an influent pumping station to transfer influent to the aerated lagoon system, which consists of three cells/lagoons, each equipped with fine bubble aeration systems. The rated capacity of the STW is 2,378 m^3/day.

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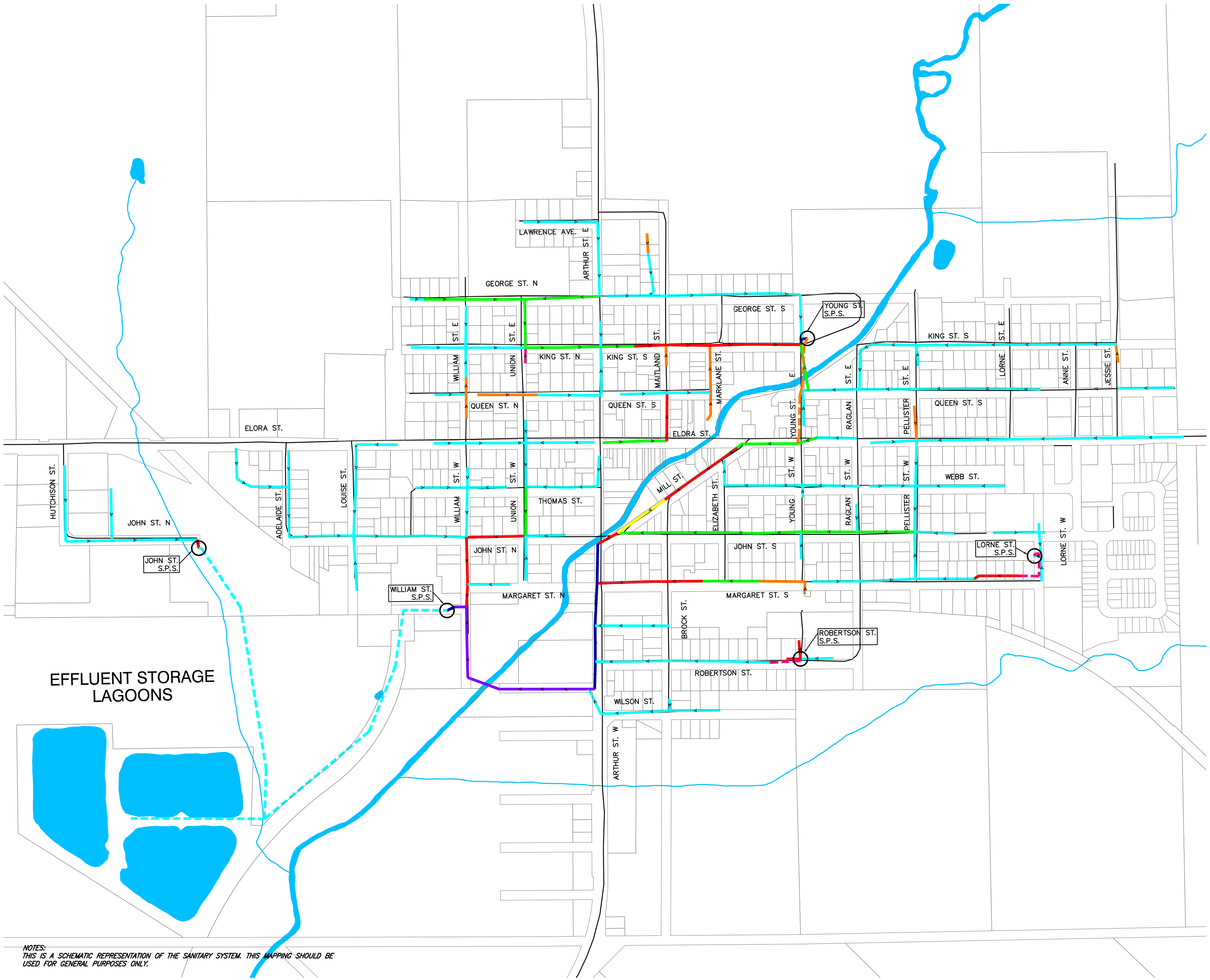

SEWER SIZING

- 525mm
- 450mm
- 375mm
- 300mm
- 250mm
- 200mm
- 150mm
- 100mm

FORCEMAIN SIZING

- 525mm
- 450mm
- 375mm

LEGEND

- DIRECTION OF FLOW
- SEWAGE PUMPING STATION

FIGURE 1
EXISTING SEWAGE COLLECTION SYSTEM

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1.2 Reserve Capacity/Water and Sanitary Systems Servicing Strategy

The Town completed a Water and Sanitary Systems Servicing Strategy (Servicing Strategy) (Triton, January 26, 2022) to assist with infrastructure planning for its three urban centers of Palmerston, Harriston and Clifford. The Servicing Strategy provides guidance for upgrades, expansions, and operation changes to the Town's horizontal and vertical infrastructure for each of the municipal water and sanitary systems to service the existing and future populations.

Municipal wastewater treatment plants/facilities have rated flow capacities dictated by their Environmental Compliance Approval (ECA) or Certificate of Approval, issued by the Ministry of Environment, Conservation and Parks (MECP), that are not only based on the design of the plant, but also the ability of the watercourse receiving the treated effluent to assimilate the flows without causing significant damage or harm to the environment. Without completing significant studies, and/or plant improvements, a municipality has a set capacity (Reserve Capacity) to treat municipal sewage, and a maximum amount of development that can be serviced based on the available Reserve Capacity.

As part of the Servicing Strategy, Triton completed a review of the reserve capacity for the Harriston STW, based on information to the end of calendar year 2020. This information was used to estimate sewage flows for future population growth projections to assess the hydraulic reserve capacity of the STW. Based on the population growth projections for Harriston and the associated projected sewage flow, the design capacity of the existing WWTP is expected to be sufficient beyond the calendar year 2051 planning horizon; however, the existing per person average day flow (ADF) rate (631 L/day) is significantly higher than what is expected for communities of similar size (typically in the range of 300 to 500 L/day/person). It is assumed that the per person ADF in Harriston is inflated and not reflective of actual domestic sewage flow due to sewage generated by the ICI connections; however, it is expected that infiltration and inflow also contribute to the inflated ADF. Although the rated capacity of the STW is expected to be sufficient beyond the 2051 planning horizon, moderate/heavy sewage output from ICI customers and extraneous flows result in increased operation and maintenance costs for the Town.

Therefore, given the inflated ADF, and based on a recommendation from a previous I/I Study (2007, BM Ross), the Town initiated an I/I study to identify extraneous flows within the collection system, which the results are to be considered in the Town's planning and prioritizing of rehabilitation and reconstruction projects.

1.3 Previous Studies and Rehabilitation Programs

B.M. Ross and Associates Limited (BM Ross) completed an I/I Study in Harriston in 2007, which made five recommendations to improve operation of the Harriston sanitary system:

1. Rehabilitation at and associated with the Young St sewage pumping station (SPS), including forcemain replacement and capacity expansion in sewers influent to Wiliam Street SPS.
2. Increase capacity and improve overflow facilities at the William St SPS.
3. Regulate industrial sewage flows through updating the Town's Sewer Use By-Law.
4. Implement a CCTV inspection program for the sewage collection system, including service laterals. Complete repairs as necessary based on the CCTV inspection.
5. Develop and implement a program to inspect structures within the sewage collection system during a major flood event.

BM Ross prepared a memorandum in January 2012 to provide a status update on the progress the Town had made in completing the recommendations in the 2007 I/I Study. The memo concluded that recommendations No. 1 through 4 of the 2007 I/I Study had been addressed and the Town was planning to address recommendation No. 5. The Memo provided a figure with details of Harriston's sewage collection system, including structure IDs, sewer sizes and direction of sewage flow to assist with the development of the maintenance hole inspection program.

In 2016, The Town initiated an inspection of their sanitary maintenance hole inventory in Harriston. The inspection found varying degrees of infiltration and inflow in several maintenance holes as well as the need for rehabilitation efforts in specific areas:

- Joints between cone and barrel
- Joints between barrels
- Joints between barrel and base
- Around pipe and benching
- Through the precast concrete

In 2018, the Town retained D.M. Robichaud Associates Limited to provide rehabilitation services to 11 sanitary maintenance holes in Harriston. Rehabilitation efforts included the following:

- Application of concrete repair mortars to address structural cracks and fractures.
- Rebuilding of benching to improve sewage flow.
- Grout curtaining and migrating to address leaks at joints.
- Cleaning and deposits extraction to address deposits (i.e., calcite, etc.).
- Vacuum removal of debris and sewer cleaning flushing truck to address loose deposits (i.e., construction debris).
- Replacement of corroded steps in maintenance holes.
- CCTV inspection of the sewage collection system, including lateral services and structures.

In 2019, the Town requested quotations to provide rehabilitation services to mitigate or eliminate the infiltration and inflow identified within six sanitary laterals, seven mainline sanitary sewers and 20 sanitary structures. Capital Sewer Services Inc. was awarded the project by the Town and the scope of work completed to rehabilitate or repair components of the sewage collection system was similar to the 2018 rehabilitation efforts.

In addition to the rehabilitation and spot repair programs completed by the Town, street reconstruction projects, including repairs and or replacement of existing sewage collection system infrastructure, have been and continue to be completed by the Town, in priority sequence, in accordance with its Asset Management Plan and Road Needs Assessment.

1.4 Town of Minto Asset Management

In accordance with Ontario Regulation 588/17, the Town adopted Policy Number 3.3 “Strategic Asset Management Policy” on June 18, 2019, to guide the Town’s approach to asset management activities. Per the Policy, an Asset Management Plan was developed in 2019 to identify the state of the Town’s infrastructure and to document progress towards a defined level of service. The following is an excerpt from the updated 2022 Asset Management Plan that details its mission statement:

> *The goal of asset management is to minimize the lifecycle costs of delivering infrastructure services, manage the associated risks, while maximizing the value ratepayers receive from the asset portfolio.*

With respect to sanitary sewer infrastructure within the Town (i.e., Palmerston, Harriston and Clifford), the average condition is rated as fair (57%) for all sanitary infrastructure assets within the Town. The Harriston STW is rated as poor (36%), and the Town’s sewer mains, maintenance holes, and forcemains are rated as good (75%), fair (53%) and good (77%), respectively.

Conditions of the assets are assessed through CCTV inspections, Supervisory Control and Data Acquisition (SCADA) system and other metrics for linear assets including age, material, location, diameter, and CCTV inspection results. The Town’s Lifecycle Management Strategy to management of asset deterioration is through a proactive approach and includes an annual inspection/maintenance program (using various methods), and rehabilitation or replacement efforts, which are each triggered by the condition of the asset. The Levels of Service identified for the Town’s sanitary sewer assets are based on scope (connection to system within the urban boundaries) and reliability (I/I, backups, and effluent quality) attributes.

The Plan recommends that infiltration and inflow issues continue to be monitored as part of its Risk Management Strategy, and that risk-based decision-making is implemented as part of the asset management planning and budgeting processes.

2.0 Inflow and Infiltration Study

Extraneous flow from I/I sources reduces the capacity and capability of sewage collection systems and treatment facilities to transport and treat wastewater. Studying the respective impacts of inflow and infiltration on the sanitary collection system allows for the identification and prioritization of measures to rehabilitate the system.

Inflow is stormwater that enters the sanitary sewer system by direct connections. It is divided into direct inflow that results from immediate surface runoff due to precipitation and delayed inflow that leeks into the collection system from pipes and structures temporarily submerged in groundwater or from erroneous sanitary connections with larger response times (i.e., sump pumps, large parking lots, etc.).

Infiltration is water that enters the sanitary system from surrounding groundwater through cracks and/or leaks in the infrastructure.

An I/I study measures the performance of the sanitary sewage collection system and identifies sanitary infrastructure experiencing the highest I/I. This allows for the prioritization of remedial measures (i.e., rehabilitation or replacement of sewers, removal of illegal connections, etc.) implemented to reduce wastewater flows to the WWTP. The Town initiated an I/I study in 2021 as recommended by the Servicing Strategy (Triton, January 26, 2022) and supported by the Town's Asset Management Plan (2022).

2.1 Sources of Inflow & Infiltration

Sources of inflow are commonly divided by their connection to the sanitary collection system. Connections from private property such as footing/foundation drains, roof drains or leaders, drains from window wells, outdoor basement stairwells and basement sump pumps can all cause inflow. These connections can be improperly or illegally connected to the sanitary system with discharges often into sinks and tubs connected to the sanitary sewers. This water should be directed to the stormwater system or allowed to soak into the ground. I/I from public sources includes municipal storm sewer connections improperly connected to the sanitary system. Public connections like maintenance hole covers, erroneously connected storm infrastructure, and sanitary pipes in poor condition can all cause inflow.

Infiltration to sewers and maintenance holes may be caused by age-related deterioration, loose joints, construction errors or tree root intrusion. Groundwater can enter these system deficiencies where sewers and services are beneath the water table or where the soil is saturated from rainfall events. Average sewer pipes are designed to last between 40 and 70 years depending on the type of pipe material. Sanitary service laterals are also a frequent source of I/I as these can often be poorly constructed and are rarely inspected by private property owners following installation unless there is a failure with the service. Service laterals can also be damaged by penetration of roots from trees and shrubs planted in proximity of the service lateral. Identifying the source of I/I as well as the severity of its impact on the sanitary system is crucial to prioritizing the direction of remedial efforts.

2.2 Infiltration Analysis

Quantifying infiltration requires the ability to isolate infiltration flows from all sources of demand in a sanitary system. This is accomplished by **identifying periods of time where infiltration is at a maximum while all other sources of demand are at a minimum.**

2.2.1 *Calculating Infiltration from Hourly Sewage Flows*

The following paragraph is an excerpt from the 2014 *EPA Guide for Estimating Infiltration and Inflow* (the Guide) which summarizes the process for identifying periods of high peak infiltration in sewage flow data collected from a sanitary maintenance hole in at least hourly increments.

> *During seasonal high groundwater, which usually occurs after snow melt and soil thaw, infiltration will be at its highest. During this period, the infiltration rate can be quantified by averaging the nighttime flows (midnight to 6 am) over several days, during dry weather conditions. The nighttime flows can be assumed to be mostly groundwater (after subtracting significant industrial or commercial nighttime flows).*

The Guide provides several generalizations that can be refined to estimate infiltration more precisely. Where flow data is available in intervals of minutes or hours, analysis of extraneous sanitary flows against temperature in the System can provide insights into when infiltration reaches an annual maximum. Collecting precipitation data in parallel allows for the identification of dry weather periods when inflow is likely to be negligible. The intersection of these time periods results in the **selection of a dry weather analysis period where infiltration is at its most isolated from other sources of sanitary demand.** Analyzing sanitary flows from a flow monitor recorded during the dry weather analysis period provides the highest probability that infiltration flows can be accurately isolated. Per the guide, separating sanitary flows into on- and off-peak periods allows for the calculation of three key parameters: **average day flow, infiltration,** and **base sanitary flow**.

Figure 2 provides a visual reference for each of these parameters for a sample flow monitor.

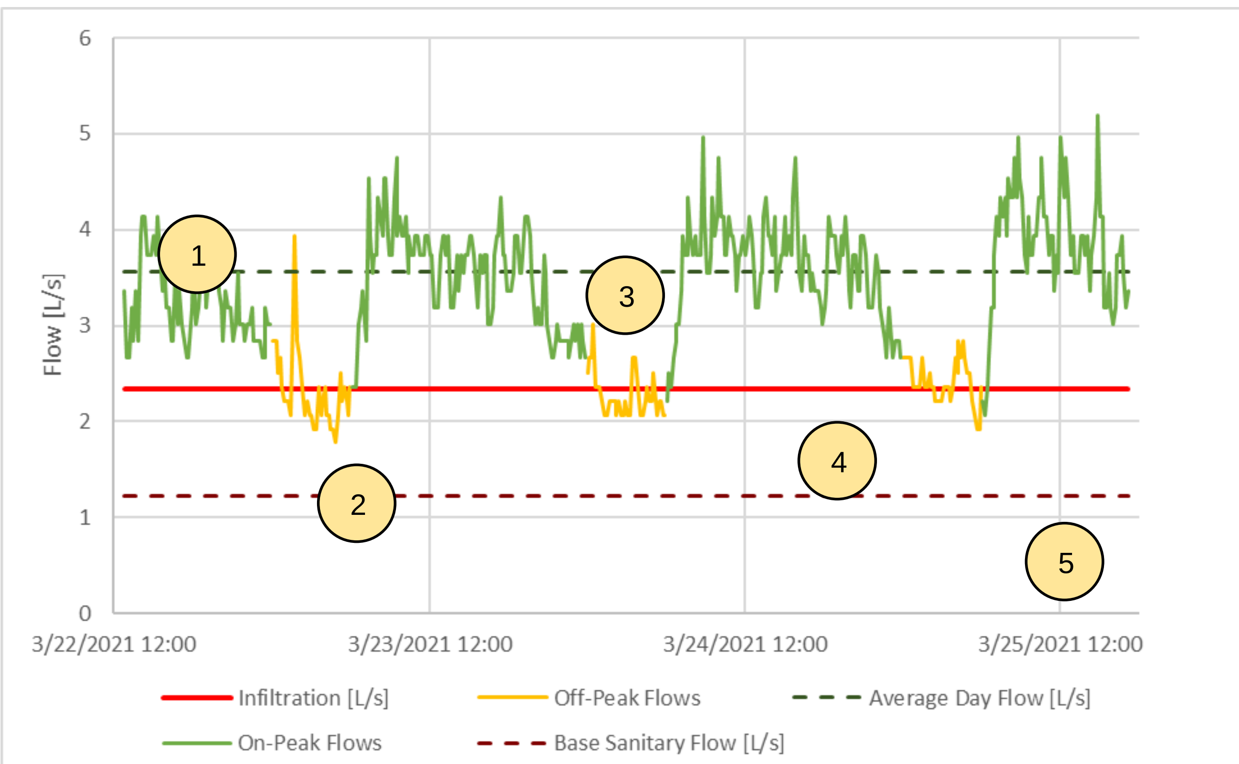

Figure 2 – Sample Figure for Dry Weather Period, Infiltration Analysis

1. **On-Peak Sanitary Flows:** Flow resulting from infiltration and from daily water use.
2. **Off-Peak Sanitary Flows:** Flow from infiltration and any 24-hr commercial water use
3. **Average Daytime Flow:** Average of sanitary flows during on-peak usage
4. **Infiltration Rate:** Average of sanitary flows during off-peak period
5. **Base Sanitary Flow:** Subtraction of the average infiltration rate from the average on-peak flow

Sanitary flows during the dry weather period are expected to follow the trends as shown in Figure 2, stable and predictable on-peak water demand during the day and with off-peak troughs well above zero, indicating that the system is experiencing some constant rate of infiltration.

With all other potential sources isolated, the assumption is that all off-peak flow during the dry weather period is infiltration. Taking an average of off-peak flows during the dry weather period produces an **average peak infiltration rate (Infiltration)**. Taking an average of on-peak flows during the dry weather period produces an average day flow rate (Average Day Flow). Subtracting the Infiltration rate from the Average Day Flow rate produces an average base sanitary flow rate (BSF) which represents the average rate of sanitary demand generation. Comparing infiltration to BSF for each flow monitor provides a measurement of the impact of infiltration on each sub-catchment of the sanitary system.

2.2.2 Estimating Infiltration from Daily Pumped Sewage Flows

Sewage pumping stations in Harriston record pumped flow data once daily. Data at this resolution cannot be used to identify a base sanitary flow rate or a peak average infiltration rate. Instead, conducting an aggregate analysis of one continuous year of data can provide an estimated level of concern for infiltration for each tributary area to a sanitary pumping station. Collecting precipitation and temperature data in parallel allows for the identification of trends in pumped flow data according to season, weather event, and groundwater condition. Figure 3 provides a visual reference for the comparison of pumped flow data to changes in

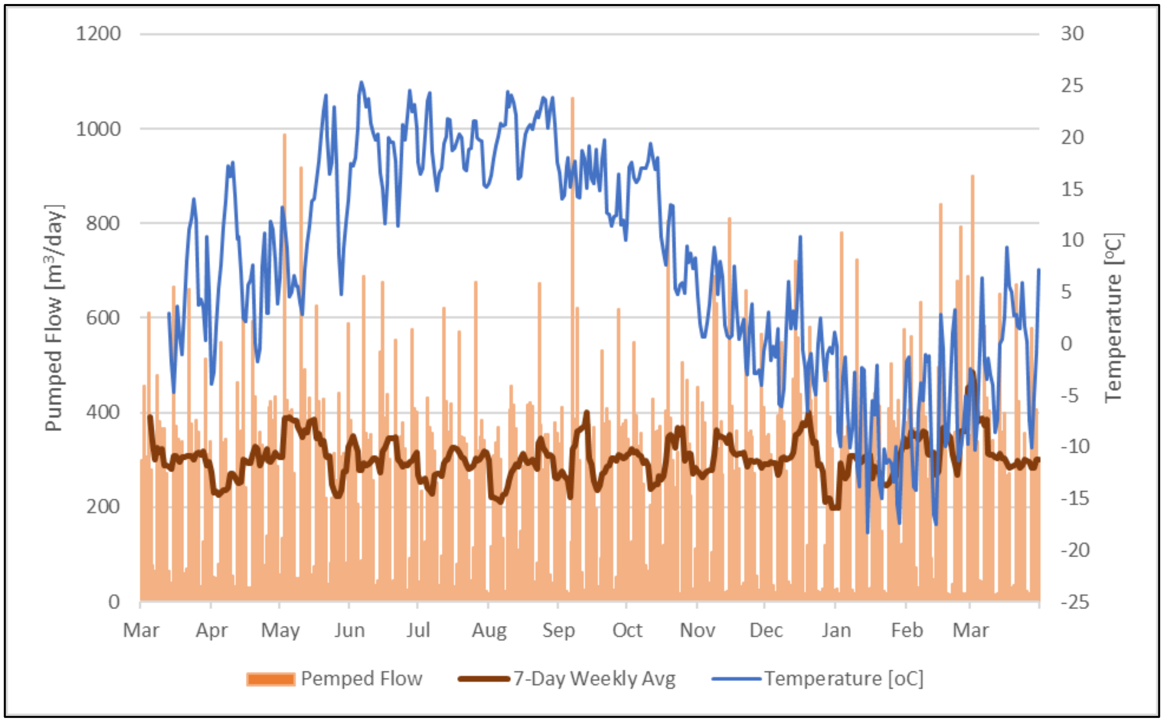

Figure 3 – Sample Figure for Infiltration Analysis, Pumping Station Data

A 7-day trailing weekly average for pumped flows provides a useful sense for changes in pumped flow independent of inflow sources. Analyzing 90th percentile peaks in weekly average flows against changes in temperature provides an estimate for the impact of snow melt and subsequent groundwater on sewage flows. In the sample figure, the highest 7-day weekly average flows occur most frequently in February and March, right has temperature tends to cross 0 degrees Celsius. This suggests that sewage flows can be increased by infiltration from snow melting and changes in groundwater conditions.

2.3 Inflow Analysis

Quantifying inflow requires the identification and isolation of extraneous flows during and immediately following an intense storm event. The following is a paragraph excerpted from the Guide (2014) which summarizes the inflow calculation process.

> *Inflow represents the influence of wet weather on the sewer system and is calculated by subtracting out the sanitary wastewater and infiltration flow during a time that the system has been influence by rain. Flow data during a significant storm event should be compared to the dry weather data immediately preceding the storm when groundwater conditions are similar. The rate and volume of inflow can be estimated by subtracting the base sanitary flow and infiltration flow data from the wet weather flow data.*

The Guide provides a starting point that can be modified to analyze inflow in Harriston.

2.3.1 Calculating Inflow from hourly Sewage Flows

An analysis of extraneous sanitary flows against temperature in a water treatment system can provide insights into when summer heat is likely to minimize infiltration. Collecting precipitation data in parallel allows for the identification of an intense, isolated storm event to avoid misinterpreting the impacts of successive storm or infiltration events. The intersection of these two analyses provides a wet weather analysis period that begins with dry weather, is interrupted by an intense rain event, and ends with dry weather. This wet weather period provides ideal conditions for calculating inflow characteristics.

Analyzing sewage flow at monitor locations before, during, and after the storm event allows for the elimination of as many variable sources of I/I as possible. Analyzing dry weather flows during pre-storm conditions enables the calculation of a pre-storm infiltration rate for the wet weather period. While the measured peak infiltration rate is less, it is almost impossible to eliminate infiltration from a System altogether. With the pre-storm infiltration calculated and the base sanitary flow rate from the prior infiltration analysis, their addition produces a nominal average flow rate that represents an expected average flow rate during the wet weather period absent the impact of any inflow.

Taking the nominal average flow rate as a threshold value for extraneous flow, all flow measured above the threshold can be defined as originating from sources of inflow. Therefore, all flow above the nominal threshold during the storm attributed to direct inflow and all flow above the threshold after the storm is delayed inflow. Figure 4 provides a visual reference for calculating inflow parameters for a sample flow monitor.

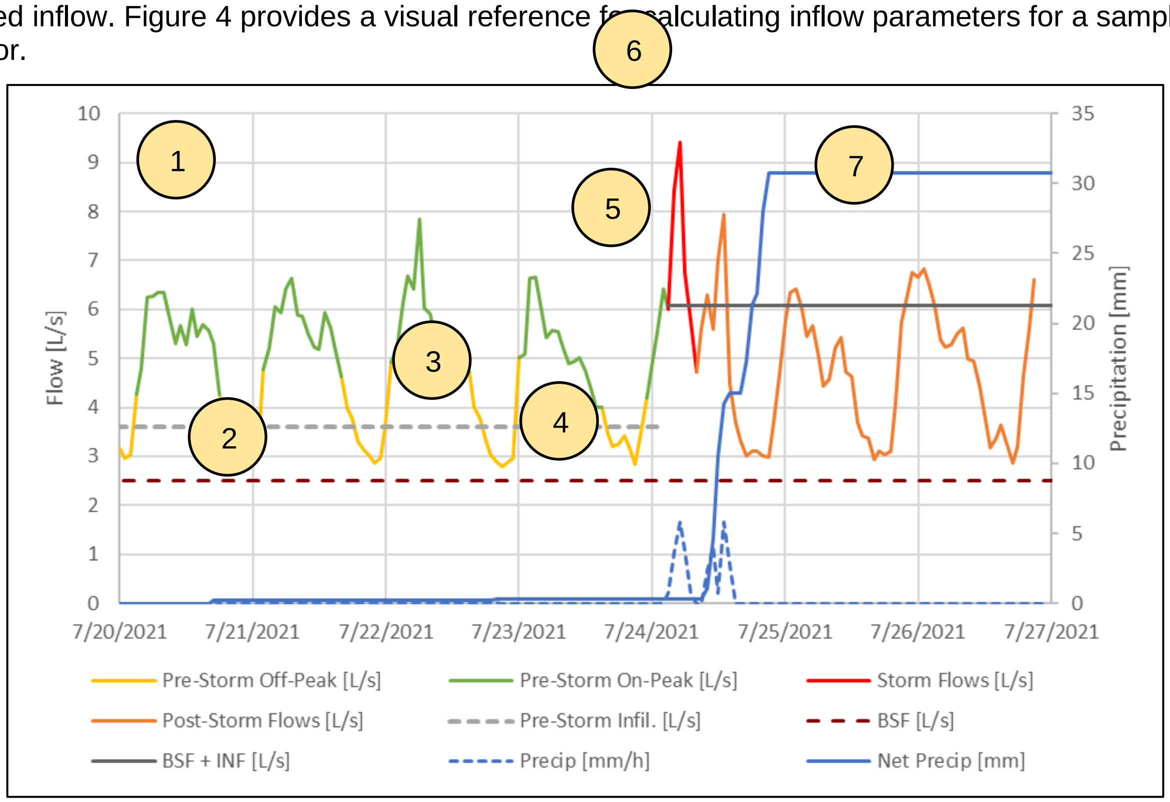

Figure 4 – Sample Figure for Wet Weather Period, Inflow Analysis

1. **On-Peak Pre-Storm Sanitary Flows:** Flows from infiltration and from daily water use
2. **Off-Peak Pre-Storm Sanitary Flows:** Flow from infiltration and any overnight water use.
3. **Pre-Storm Infiltration Rate:** Average of sanitary flows during off-peak use.
4. **Base Sanitary Flow:** Derived from prior dry weather analysis.
5. **Inflow Threshold:** Addition of BSF and pre-storm infiltration rates.
6. **Direct Inflow:** All flow above the nominal flow rate during the storm event.
7. **Indirect Inflow:** All flow above the nominal flow rate following the storm event.

Sanitary flows during the wet weather period are expected to follow the trends as shown in Figure 2: a dry period before the storm event to calculate pre-storm infiltration, a sharp spike in flow at the onset of precipitation indicating direct inflow, and decaying rises in on- and off-peak flows for several days following the event to indicate indirect inflow.

Inflow calculations require a BSF as calculated from a prior dry weather analysis to ensure that the impact of inflow from other storm events is minimized. However, a revised pre-storm infiltration rate is required as the wet weather period should have an infiltration rate much lower than the peak value as calculated during dry weather analysis.

With all other sanitary sources constrained and controlled, all flow above the nominal threshold for average use during and after the storm event is categorized as inflow.

2.3.2 Estimating Inflow from Daily Pumped Sewage Flows

Sewage pumping stations in Harriston record pumped flow data once daily. Data at this resolution cannot be used to identify pre-storm conditions or isolate inflow sources from a single rain event. Instead, an aggregate analysis of one continuous year of data can provide an estimated level of concern for inflow for each tributary area to a sanitary pumping station. Collecting precipitation and temperature data in parallel allows for the identification of trends in pumped flow data according to season, weather event, and groundwater condition. Figure 5 provides a visual reference for the comparison of pumped flow data to changes in

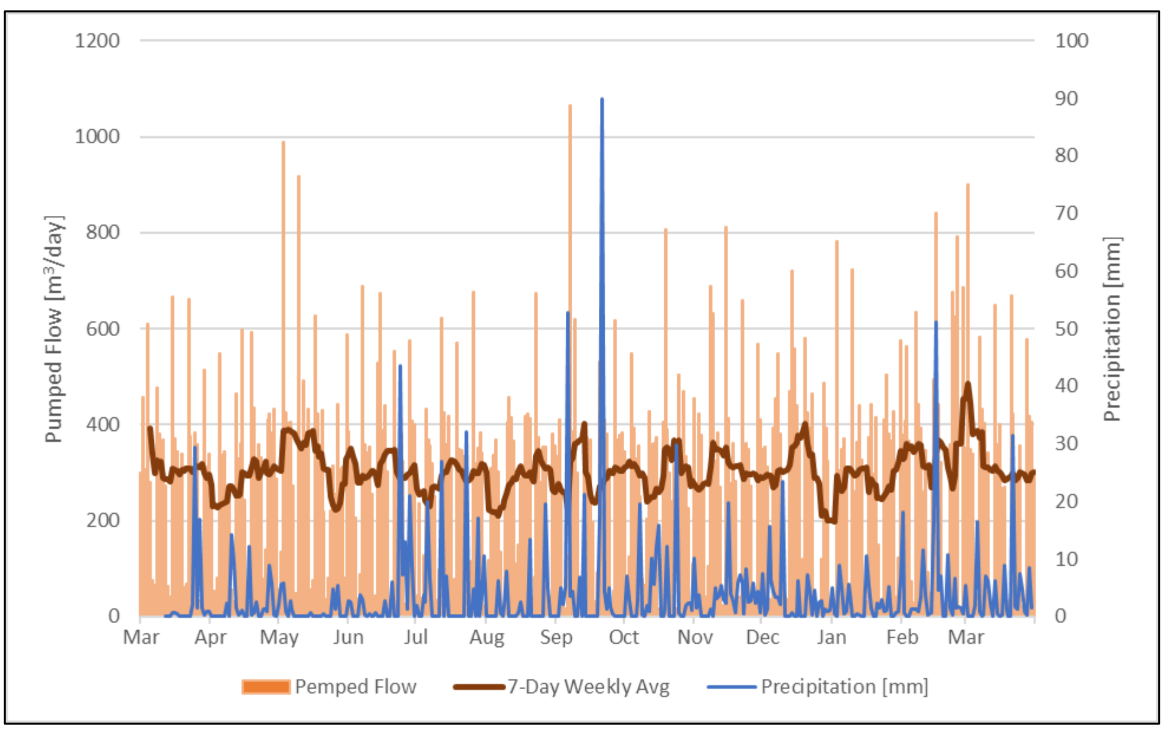

Figure 5 – Sample Figure for Inflow Analysis, Pumping Station Data

A 7-day trailing weekly average for pumped flows provides a useful sense for changes in pumped flow from infiltration sources, which can be excluded from inflow estimation. Analyzing 90th percentile peaks in daily pumped sewage flows against 90th percentile daily precipitation provides an estimation of inflow characteristics during significant storm events. A high peak daily pumped flow during or immediately following a day with high precipitation can indicate the presence of direct inflow. 90th percentile daily flows for several days following a significant rain event can indicate that indirect inflow is a concern.

In the above figure, peaks in daily precipitation are always paired with days of high pumped flow, indicating that direct inflow is likely a concern.

2.4 Expected I/I

Making conclusions and recommendations based on measured I/I results requires both an internal comparison of sanitary collection areas in Harriston and a general comparison to a comparable statistical area. The Ministry of Environment, Conservation, and Parks (MECP) provides a maximum recommended I/I rate of 1,400 L/cm/km/day for municipal sanitary collection systems. That is, a maximum of 1,400 L/day of I/I per pipe kilometer in the collection system, weighted by pipe diameter. This value is based on historical I/I data in Canada and follows the logic larger pipes provide more surface area for infiltration and that a larger collection system has greater opportunity for erroneous, inflow-causing connections. Comparing flow characteristics from collection area to expected values helps to direct further data collection efforts and/or planned remedial works for the sanitary system.

2.5 Data Collection

LINK Utility Technologies Inc. (LUTI) was retained by the Town to supply sanitary sewer monitoring equipment (SmartCover Real-time Sewer Monitor) and services to support the I/I Study. The monitors record the depth (mm) of flow in the sewer, sewage flow (L/s), ambient air temperature (ºC) and several monitor performance parameters. A rain gauge was installed on Elora Street in Harriston to record precipitation and ambient air temperature. Ambient air temperature data is used to understand periods of snow melting in fall, winter, and spring months, which can contribute to I/I flows in the sanitary sewage collection network.

Flow monitors were initially installed in three maintenance holes in Harriston on March 17, 2021. The maintenance holes, identified as H28, H90A, and H100, each capture the total sewage flows for a discrete Sanitary Contribution Area (SCA). The flow monitoring locations are provided both in Table 1 and in Figure 6 on the following page.

Table 1 – Summary of Flow Monitoring Locations

Sanitary Structure ID	Location Description	SCA	Land Use[1]
H28	Intersection of John Street and Brock Street	SCA 1	Residential, Industrial, Institutional and Main Street Mixed Use (Residential/Commercial)
H90A	Main Street and unopened ROW between Lorne Street and Henry Street	SCA 2	Industrial, Commercial, Residential and Mixed Use (Residential/Commercial)
H100	Victoria Street and Albert Street	SCA 3	Residential, Institutional and Commercial (Residential/Commercial)

Pumped sewage flow data was provided for each SPS in daily increments from the Town.

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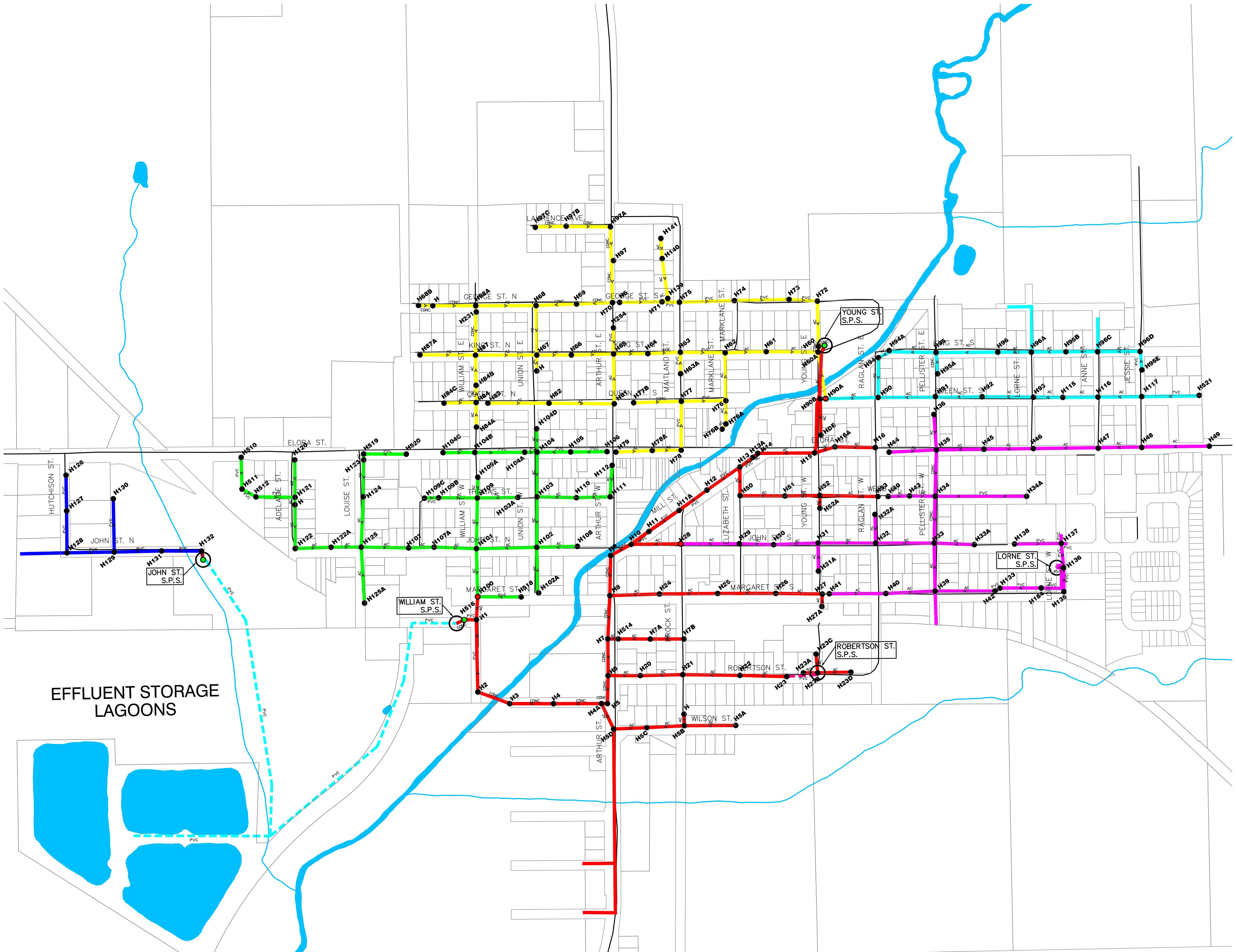

NOTES:
THIS IS A SCHEMATIC REPRESENTATION OF THE SANITARY SYSTEM. THIS MAPPING SHOULD BE USED FOR GENERAL PURPOSES ONLY.

LEGEND

- DIRECTION OF FLOW
- P120 MAINTENANCE HOLE ID
- MAINTENANCE HOLE WITH FLOW MONITOR
- EXISTING FLOW MONITOR
- SEWAGE PUMPING STATION

FLOW MONITORING LOCATIONS AND CONTRIBUTING SANITARY SEWERS

H28 = SCA 1
H90A = SCA 2
H100 = SCA 3
YOUNG ST SPS = H90A +
JOHN ST SPS =
WILLIAM ST SPS = H100 + H28 + YOUNG ST SPS +

FIGURE 6 FLOW MONITORING LOCATIONS

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3.0 Extraneous Flow Analysis

Understanding where and when a system treats wastewater that is unaccounted for in water billing is essential to capturing the full scope of impact of I/I on the System. Any emergent patterns in unaccounted demand can assist in the development and guidance of analysis efforts to calculate I/I.

Moreover, 14 years have elapsed between the commission of this I/I study and the previous 2007 monitoring program. The System has continued to degrade during this time, except where rehabilitation or replacement activities have been completed. Change in unaccounted water demand can assist in forecasting changes in I/I characteristics as the System continues to age.

To both ends, a comparison of daily sewage flows and water demand/consumption from 2016 through 2020 was completed to understand unaccounted flows in higher resolution. This calculation, when compared across several years, can indicate time periods of interest for inflow and infiltration, respectively. A ratio of sewage flow to water consumption above 1.0 indicates extraneous flows entering the system.

Table 2 – Monthly Influent Sewage at WWTP vs. Total Water Demand (SCADA) in Harriston, 2016-2020

	Year					
Month	2016	2017	2018	2019	2020	Monthly Average
January	2.30	**3.38**	2.23	2.07	2.93	2.58
February	3.29	2.92	2.63	2.09	1.74	2.53
March	**3.83**	2.29	1.89	**2.81**	**2.99**	**2.76**
April	3.04	2.58	**3.25**	2.23	1.94	2.61
May	1.56	2.52	1.78	2.26	1.94	2.01
June	1.17	2.31	1.31	1.54	1.46	1.56
July	*1.02*	1.64	*1.12*	1.16	*1.12*	1.21
August	1.11	*1.28*	1.29	*0.77*	1.39	*1.17*
September	1.11	1.42	1.32	1.11	1.39	1.27
October	1.06	1.55	1.19	1.19	1.29	1.26
November	1.18	2.24	1.91	1.86	1.93	1.83
December	1.68	1.73	2.36	1.96	2.13	1.97
Annual Average	1.86	2.16	1.86	1.75	1.85	1.90

The annual average ratio was almost always greater than 1.0 and only the month of August experienced less monthly treated flow than was billed in all analysis years. This indicates that extraneous flows have been a consistent hindrance to the performance of the STW. Extraneous flows tended to peak in March and April and trough in September, consistent with seasonal changes in groundwater. This suggests that infiltration is a large source of I/I in Harriston.

Comparing precipitation, water demand, and monthly sewage flows can provide insights into the specific impact of inflow on the system. This information is summarized in Figure 7.

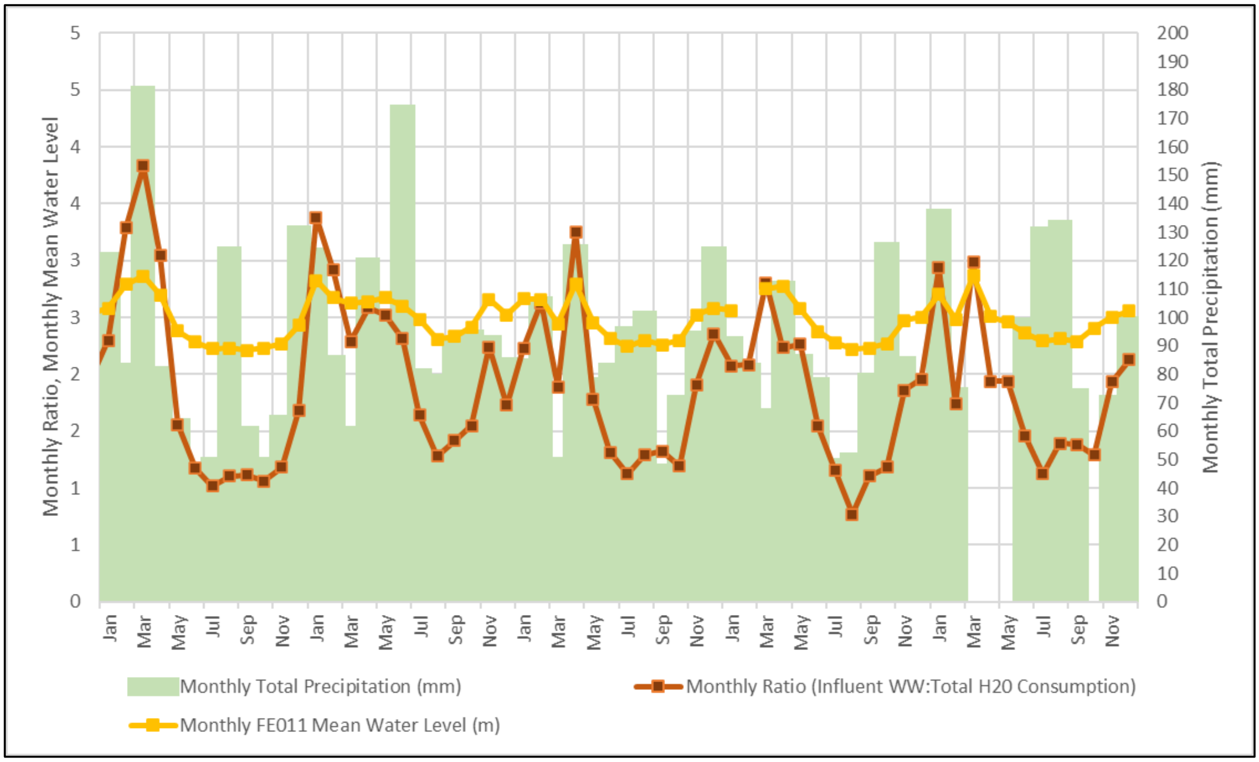

Figure 7 – Comparison of Precipitation, Maitland River Height, and Ratio of Billed to Consumed Water

Per Figure 7, there is a trend between the monthly ratio of billed to consumed water and the monthly mean water level in the Maitland River. The water level in the Maitland River also tends to rise and fall with precipitation; however, precipitation appears to have less of an impact on the water levels in the river during typical dry weather periods (June through October). Given these observed trends, it appears that the groundwater levels in Harriston have a direct impact on the river water level and flow within the sewage collection network (i.e., from infiltration).

4.0 Data Collection and Processing

The system was discretized into several contribution areas for analysis as shown in Table 1 and Figure 5. The following Table 3 summarizes the collection characteristics for each sanitary contribution area (SCA) as required to estimate expected I/I.

Table 4 – Expected I/I, 2021 Analysis Year

MH	SCA	$L_{upstream}$ [km]	Ø [cm] X L [km]	Expected I/I [m^3/day]	Expected I/I [L/s]
H28	1	2.8	57.9	81.1	0.9
H90A	2	1.5	29.3	41.1	0.5
H100	3	2.8	57.9	81.1	0.9

While it is possible to produce expected I/I characteristics for the tributary areas of each SPS, limitations in data resolution make producing exact value impossible, rendering such values unnecessary.

Figure 8 summarizes data collection for sewage flows and precipitation.

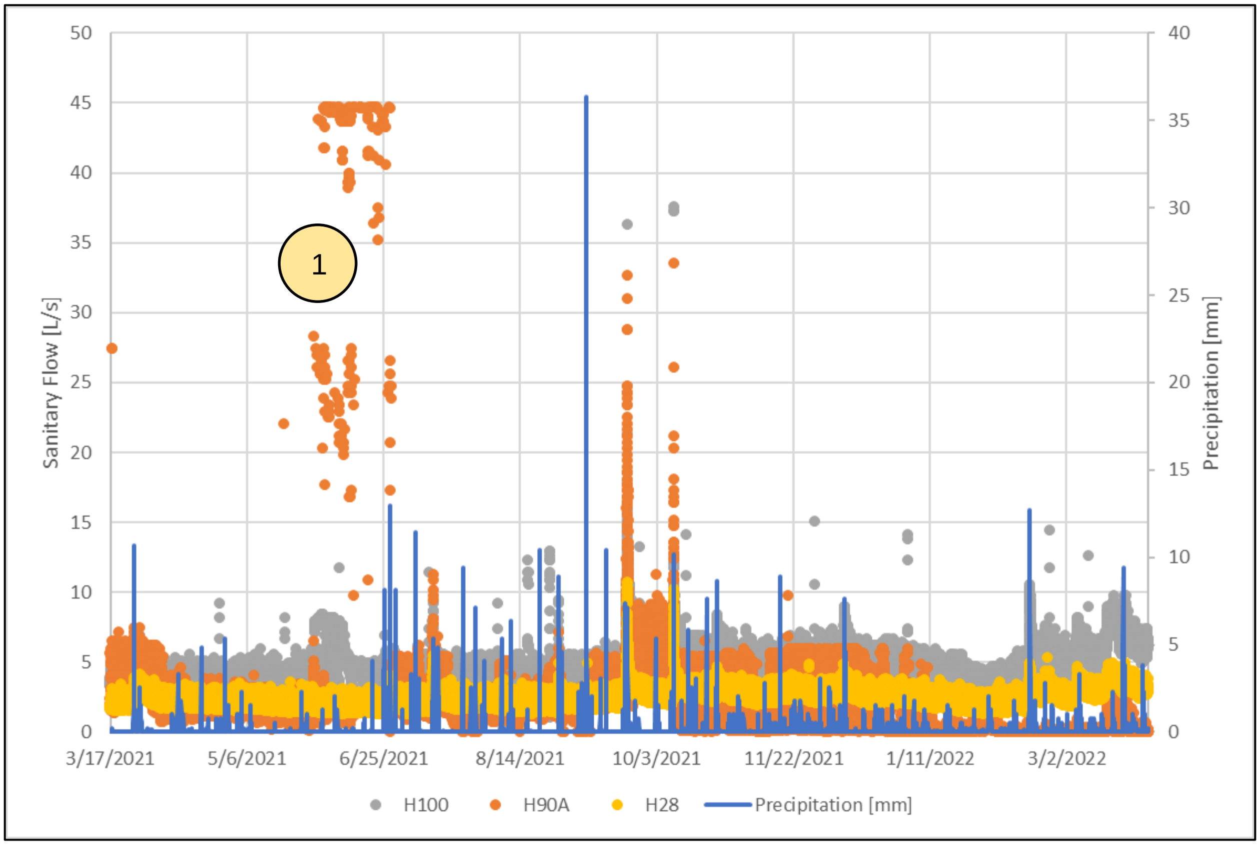

Figure 8 – Aggregated Flow Data, Flowmeters

Flows recorded at each location generally followed the expected form for sanitary flows, peaking daily between 6AM and 9AM and troughing between midnight and 6AM. Large spikes can be seen coincidentally with storm events, indicating approximately that direct inflow is likely a concern in Harriston. Higher peak, trough and mean daily flows can be seen at the start of data collection and then again in February 2022, consistent with the beginning of snow melt in each year. This suggests approximately that groundwater infiltration is a factor in I/I in Harriston.

Per results from the extraneous flow assessment (Section 3) and collected precipitation data, a primary dry weather period was selected between March 19-25, 2021. While not the longest period of dry weather recorded, in 2021, it was the longest period of consistent dry weather occurring during in proximity to annual peak times extraneous flows at the WWTP as recorded in Table 2. A secondary dry weather period between April 4-7, to ensure data fidelity as needed for effective analysis.

The wet weather period chosen for analysis occurred from August 24 through September 2, 2021, centered on a storm event on August 27. No secondary wet weather period was required.

Only one substantial subset of flow data displayed erratic or unexplainable non-periodic activity during analysis periods. H90A recorded flows above feasible values occasionally from May 25 to June 28, 2021. This period was outside the scope of data necessary for this analysis.

<u>5.0 Analysis</u>

Analysis is split according to data source and methodology. It is provided first for flow meters, then for sanitary pumping stations. Section 5.3 provides an aggregation of both types of analysis.

5.1 Flow Monitor Analysis

5.1.1 SCA 1 – H28

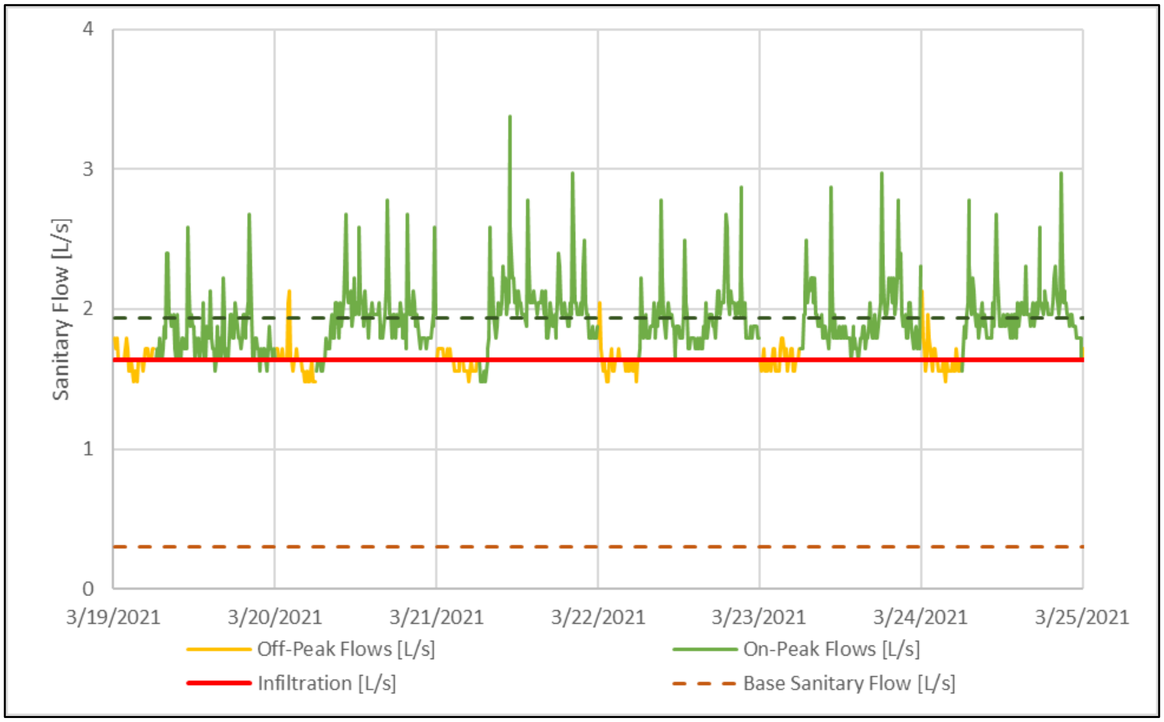

Figure 9 – Dry Weather Analysis, H28

Dry weather analysis yielded a peak average infiltration rate of 1.6 L/s and a base sanitary flow rate of 0.3 L/s. This indicates considerable extraneous flow from infiltration in SCA 1.

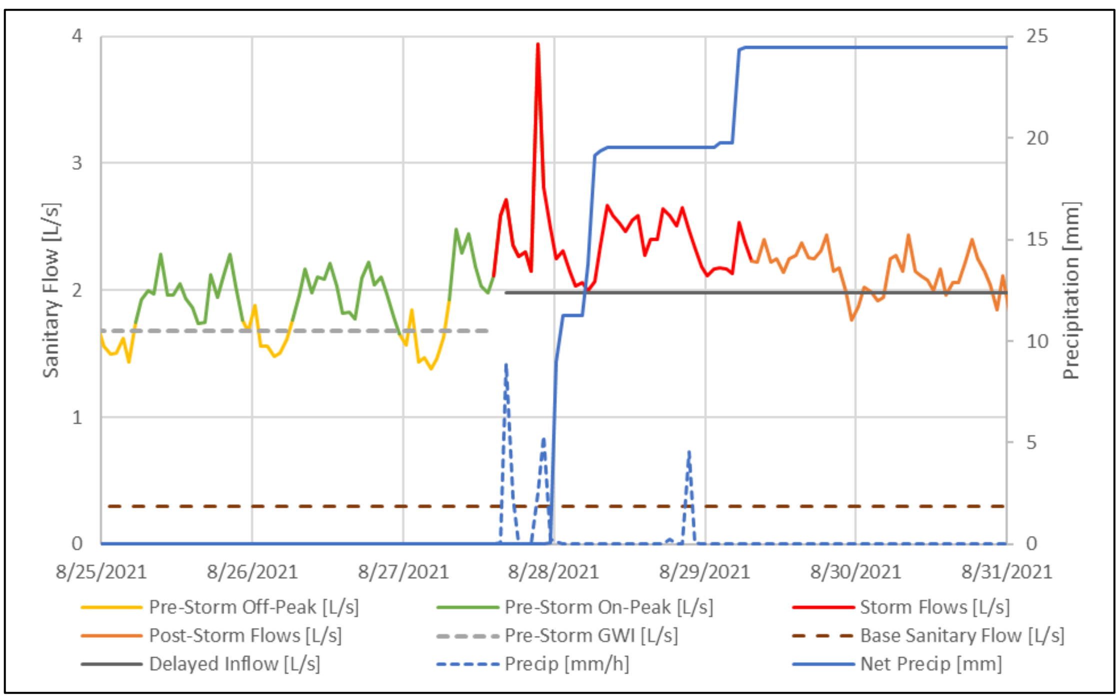

Figure 10 – Wet Weather Analysis, H28

Wet weather analysis produced direct and indirect inflow rates of 0.41 L/s and 0.14 L/s, respectively. A pre-storm infiltration rate of 1.6 L/s indicates that seasonal changes in groundwater do not result in a lower infiltration rate.

The occurrence of the highest peak flow during the second peak in rainfall intensity indicates improper connection to the system from sump pumps responding to an increase in groundwater. Sustained indirect inflow indicates that stormwater stored as groundwater contributes to extraneous sewage flows.

5.1.2 SCA 2 – H90A

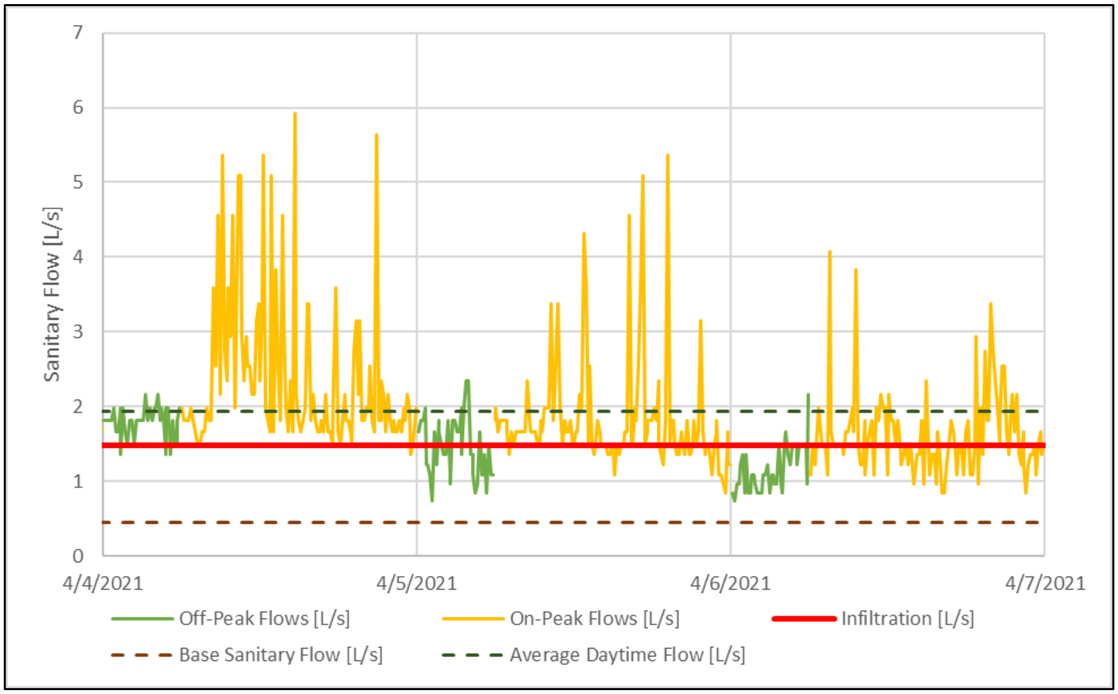

Figure 11 – Wet Weather Analysis, H90A

Dry weather analysis yielded a peak average infiltration rate of 1.5 L/s and a base sanitary flow rate of 0.46 L/s. This indicates considerable extraneous flow from infiltration in SCA 2.

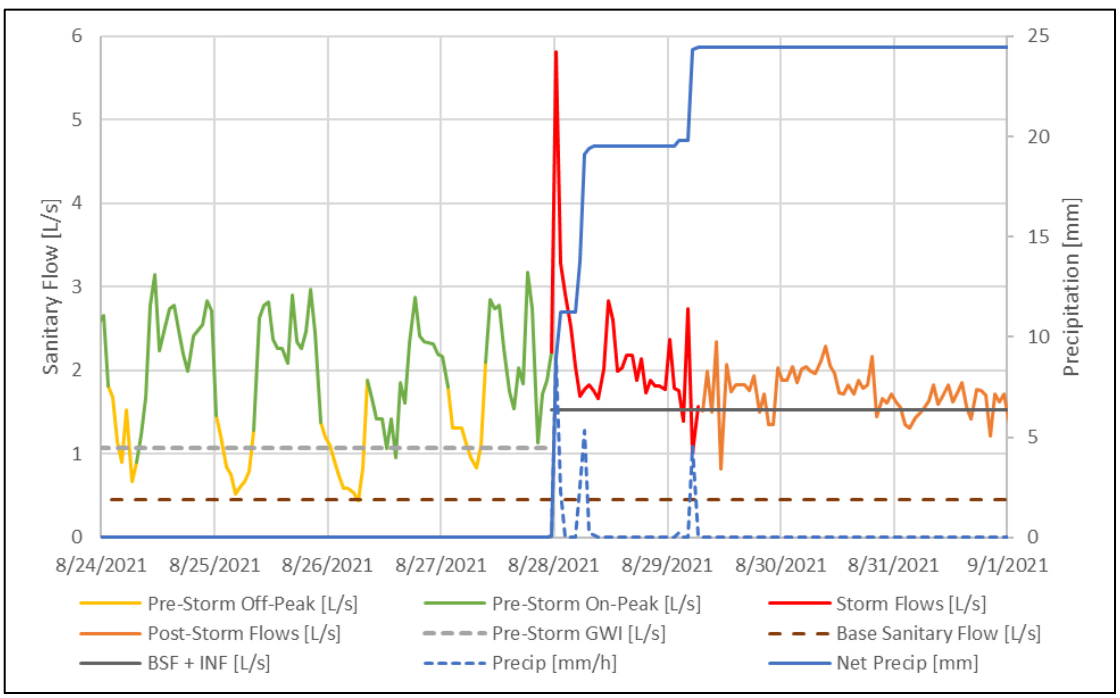

Figure 12 – Wet Weather Analysis, H90A Uncorrected

Initial wet weather analysis produced high direct and indirect inflow despite visual reductions in flow following the storm event. The base sanitary flow calculated during dry weather analysis does not accurately describe the differences in on- and off-peak flows during the dry weather period.

This indicates that SCA 2 has considerable seasonal differences in sanitary demand. Analyzing pre-storm conditions shows a base sanitary flow rate of 1.1 L/s and an infiltration rate of 1.1 L/s.

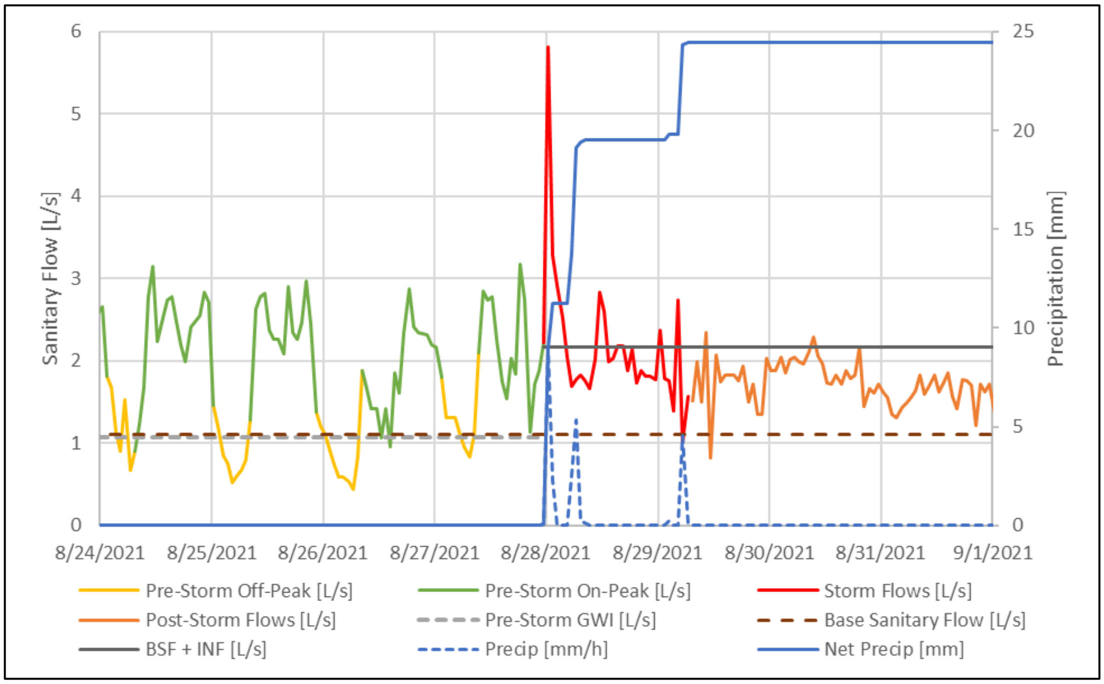

Figure 13 – Wet Weather Analysis, H90A Corrected

Revised wet weather analysis produced a direct flow rate of 0.24 L/s and did not indicate any indirect inflow. A large peak at the onset of the storm event indicates several downspout connections close to the monitoring site for SCA 2. Higher off-peak flows following the storm event imply the presence of indirect inflow, but its impact on flows is insignificant compared to the impact of the storm event on users generating sewage flows.

5.1.2 SCA 3 – H100

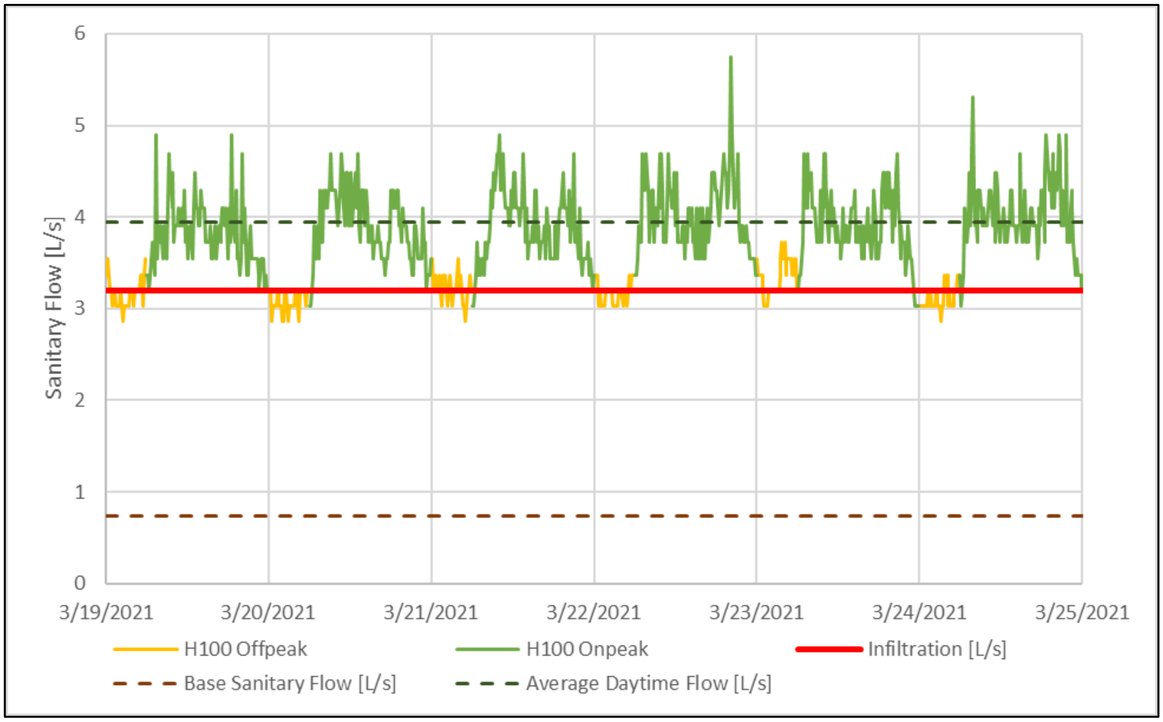

Figure 14 – Dry Weather Analysis, H100

Dry weather analysis yielded a peak average infiltration rate of 3.2 L/s and a base sanitary flow rate of 0.74 L/s. This indicates considerable extraneous flow from infiltration in SCA 2.

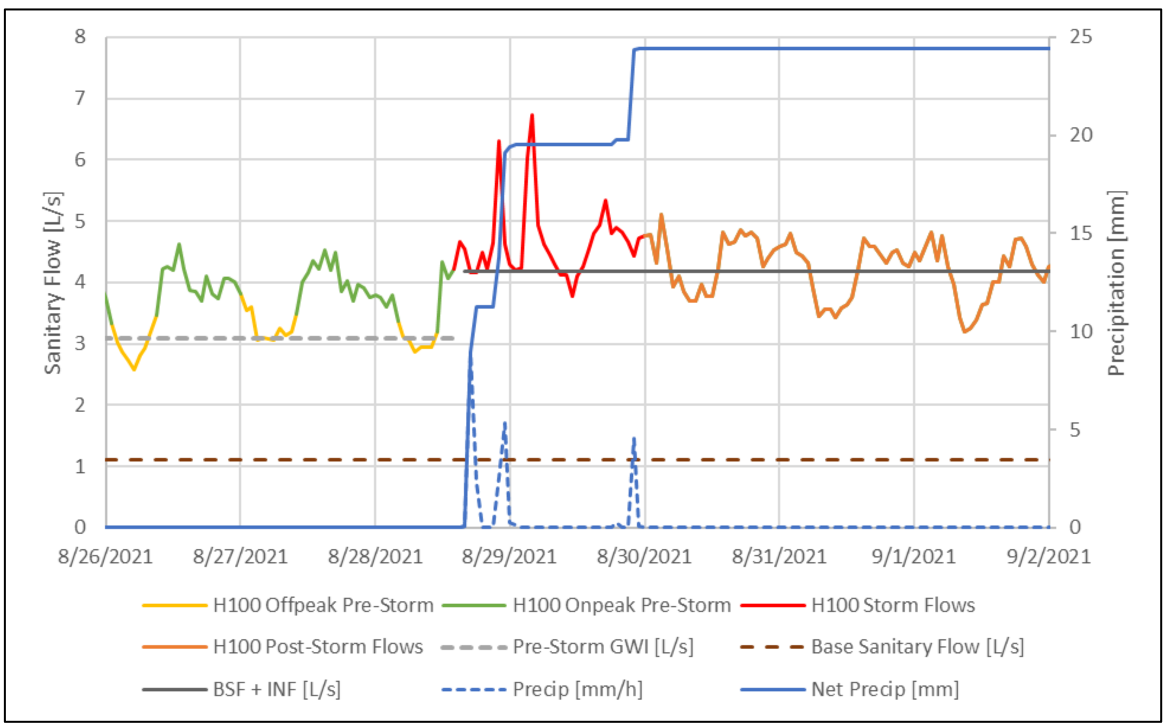

Figure 15 – Dry Weather Analysis, H100

Wet weather analysis yielded direct and indirect flow rates of 0.49 and 0.19 L/s, respectively. The analysis used a revised base sanitary flow rate of 1.1 L/s based on pre-storm conditions. Peak flows during the storm event coincided with peaks in rainfall intensity, indicating inflow from downspout runoff.

Sustained higher flows in on- and off-peak flows indicate indirect inflow from groundwater sources.

5.1.4 Aggregated Flowmeter Analysis

Tables 5, 6, and 7 provide an aggregated summary of I/I performance for the system relative to both BSF and expected values for data recorded from flowmeters.

Table 5 - Infiltration Assessment, Flowmeters

MH	SCA	BSF [L/s]	Peak Infiltration [L/s]	Infil. / BSF Ratio	Ranking
H28	1	0.3	1.6	5.3	1
H90A	2	0.46	1.5	3.3	3
H100	3	0.74	3.2	4.3	2

Infiltration is of highest concern in SCA 1, though it affects all areas in Harriston measured by flowmeters. All measured areas experienced fluctuations in infiltration according to expected changes in groundwater, indicating a system sensitivity to groundwater dynamics that is likely to worsen over time.

Table 6 - Inflow Assessment, Flowmeters

MH	SCA	Direct Inflow [L/s]	Indirect Inflow [L/s]	Σ Inflow [L/s]	Infl. / BSF Ratio	Ranking
H28	1	0.41	0.14	0.55	1.8	1
H90A	2	0.24	0.0	0.24	0.22	3
H100	3	0.49	0.19	0.68	0.62	2

Inflow is of lower concern in Harriston than infiltration. The only area of concern as measured by BSF is SCA 1. All monitors recorded peaks in flow coinciding with storm events, indicating direct inflow improper downspout connections to the sanitary system. Indirect inflow is generally of much lower concern.

Table 7 - Expected I/I Assessment, Flowmeters

MH	SCA	Expected I/I [L/s]	Measured I/I[1] [L/s]	Meas. / Exp. Ratio	Ranking
H28	1	0.9	2.15	2.4	3
H90A	2	0.5	1.74	3.5	2
H100	3	0.9	3.88	4.3	1

1: Addition of infiltration and inflow

All areas studied in produced I/I results higher than expected values for a system operating in ideal condition. SCA 3 recorded the highest ratio of measured to expected I/I, governed by its high peak infiltration rate.

5.2 Sanitary Pumping Station Analysis

5.2.1 John Street SPS

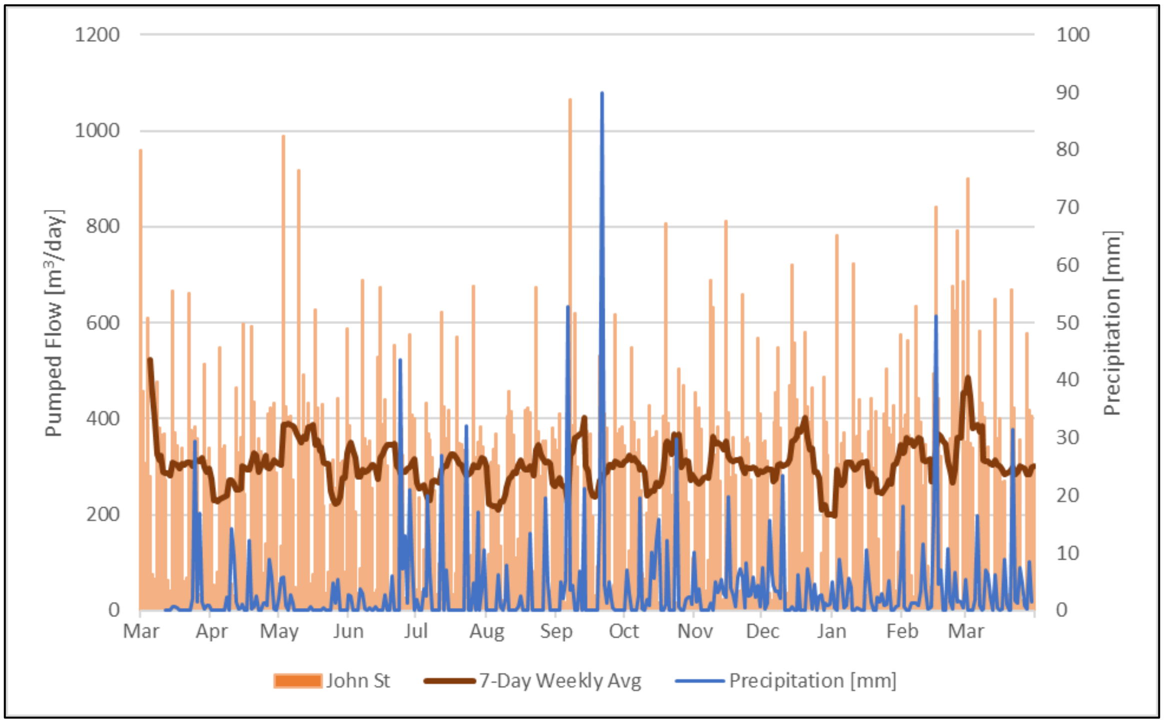

Figure 16 – Inflow Analysis, John Street SPS

Inflow analysis for the John Street pumping station shows that stormwater originating from its upstream area generates extraneous pumped flows for the system. 90th percentile peaks in daily precipitation always resulted in statistically significant increases in daily pumped flow and all 95th percentile flows always occurred within one week of a substantial rain event.

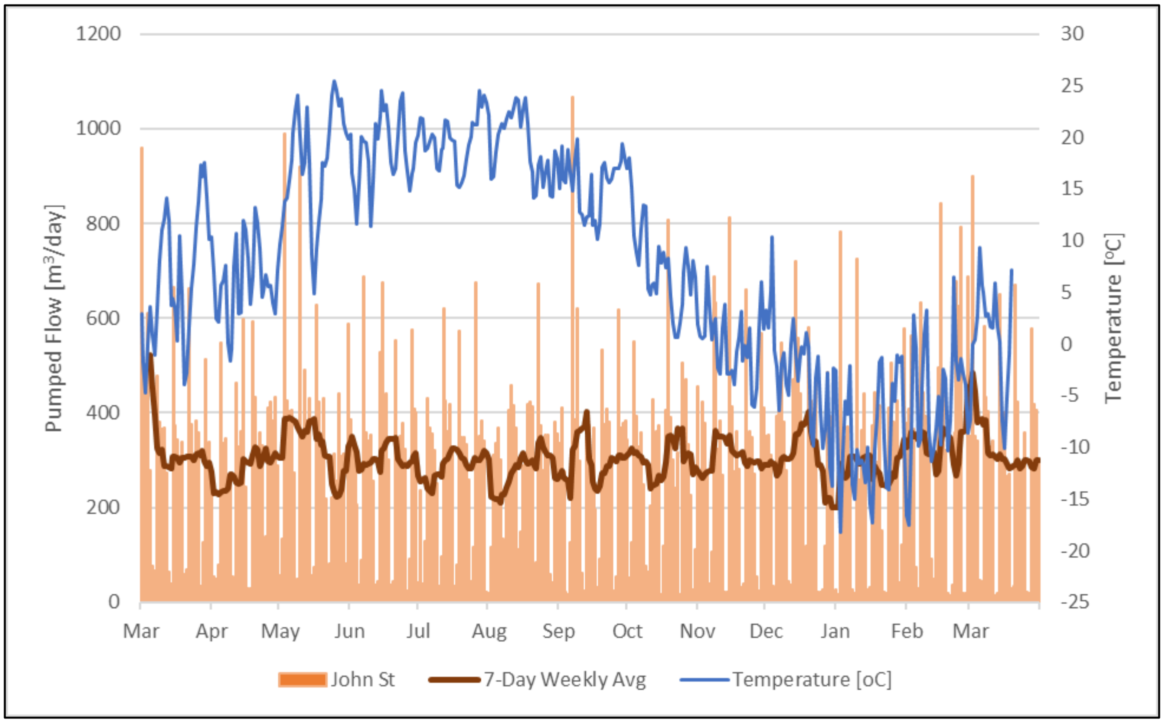

Figure 17 – Infiltration Analysis, John Street SPS

Infiltration analysis John Street SPS shows that seasonal highs in groundwater cause pumped sewage flows. While single-day peak flows are not governed by fluctuations in temperature, the station pumped 80th percentile average weekly flows continuously for three weeks following the last day with a recorded average temperature above 5 degrees Celsius. This means that spring thaw and the resultant increase in groundwater led to a consistent annual high in sewage flows at the John Street SPS.

5.2.2 Lorne Street SPS

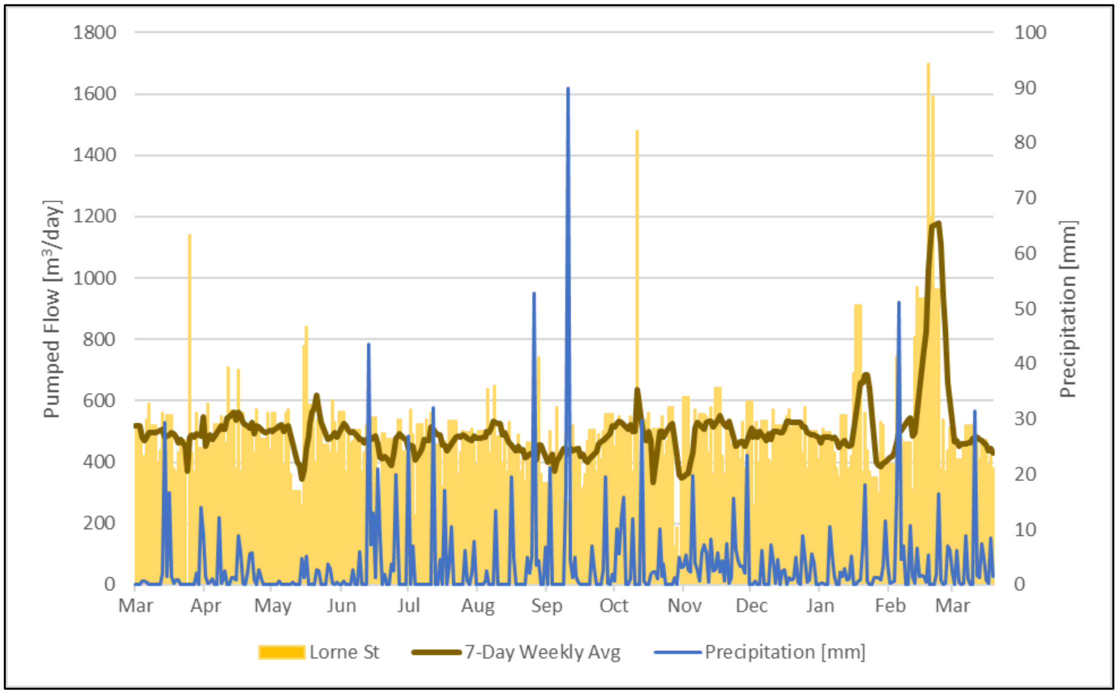

Figure 18 – Inflow Analysis, Lorne Street SPS

Inflow analysis for the Lorne Street SPS shows that precipitation is a driving force for peaks in pumped sewage flow. Peaks in daily and weekly average flows tend to follow 1-3 days after storm events.

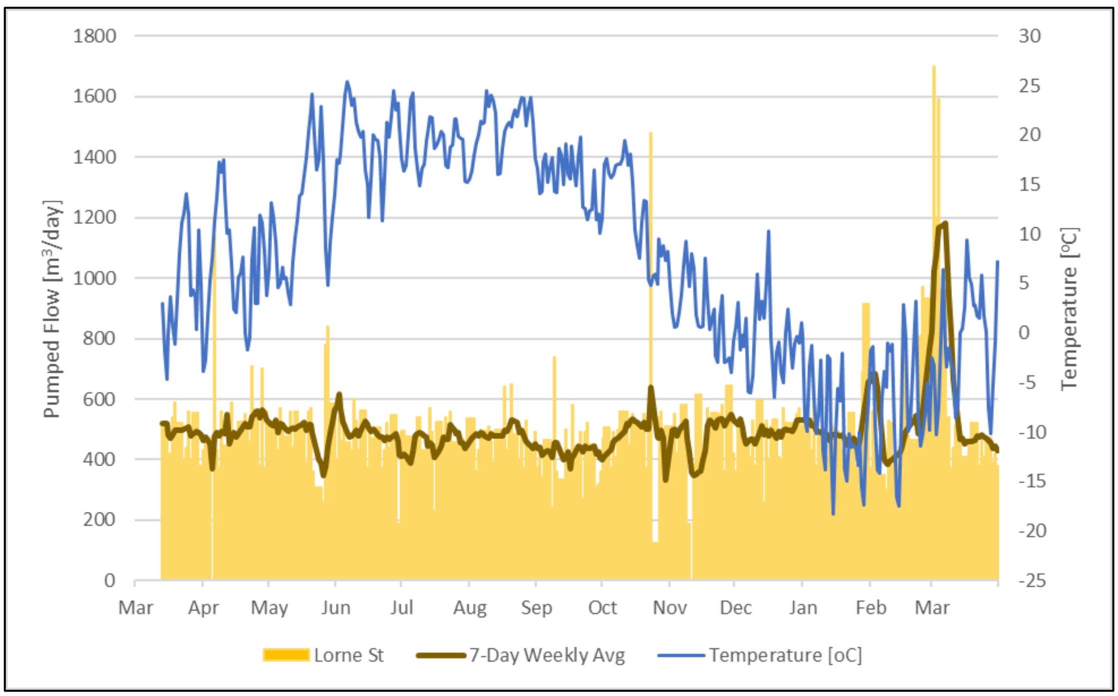

Figure 19 – Infiltration Analysis, John Street SPS

Infiltration analysis for the Lorne Street SPS shows that spring that and fluctuating groundwater do not impact pumped sewage flows. 90th percentile daily sewage flows occur during spring thaw, but only in the days immediately following a storm event.

5.2.3 Robertson Street SPS

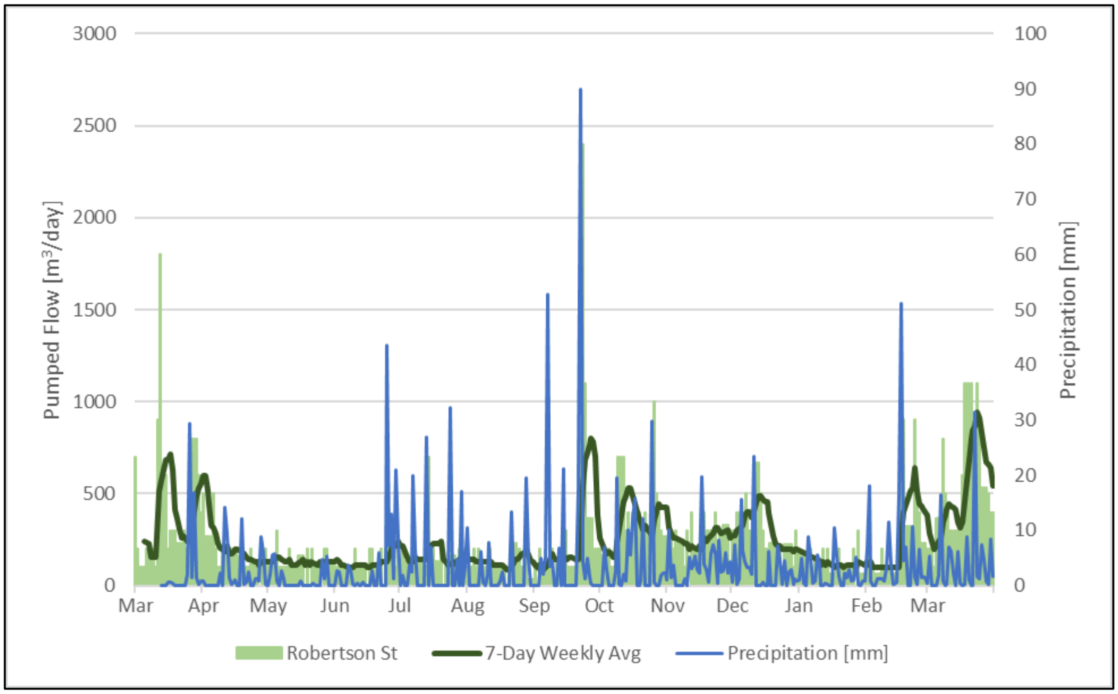

Figure 20 – Inflow Analysis, Robertson Street SPS

Inflow analysis for the Robertson Street SPS shows that precipitation contributes to increases in pumped sewage flow. Significant storm events tended to cause peaks in flow 2-3 times higher than average for 2-4 consecutive days.

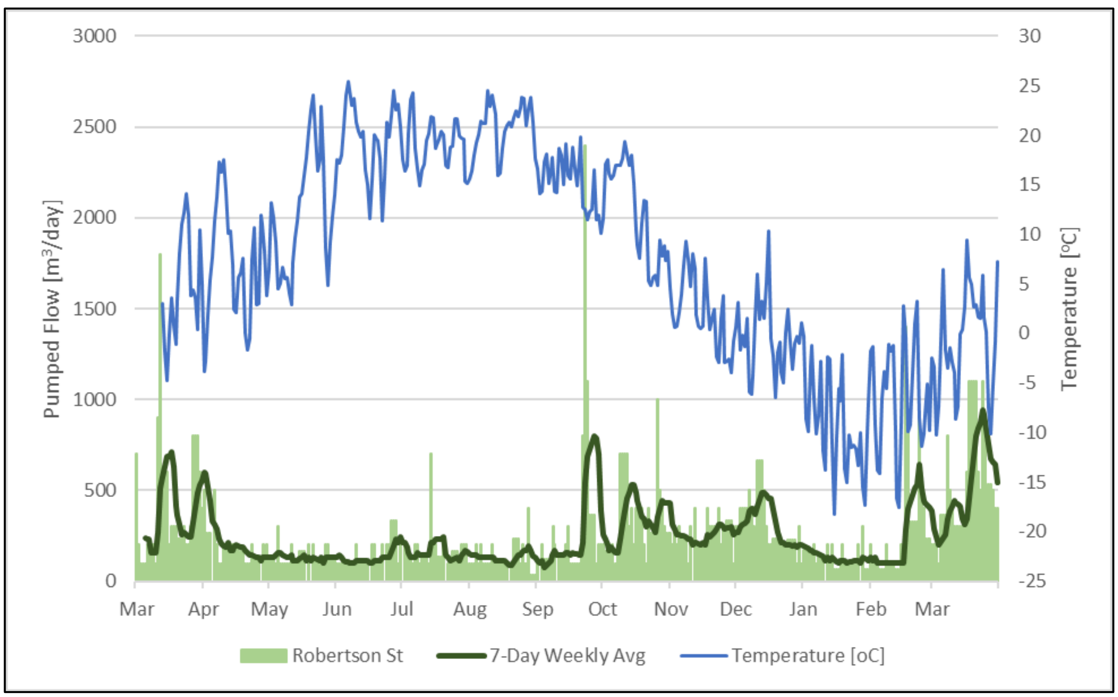

Figure 21 – Infiltration Analysis, Robertson Street SPS

Infiltration analysis for the Robertson Street SPS shows that infiltration contributes to increases in pumped sewage flow. Recorded weekly average sewage flows reach consistent 90th percentile peaks during the first weeks of the year with average temperatures above 0 degrees Celsius. Rising temperature drives snow to melt, causing a rise in groundwater and a spike in pumped sewage flows.

5.2.4 Young Street SPS

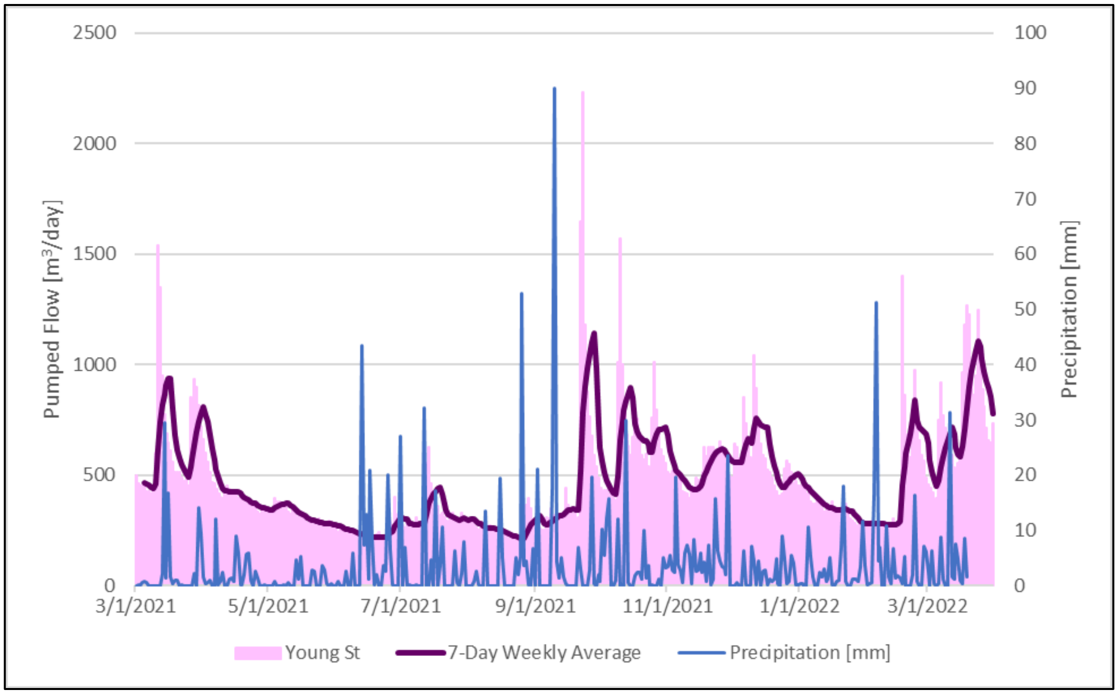

Figure 22 – Inflow Analysis, Young Street SPS

Inflow analysis for the Young Street SPS shows that stormwater has a significant impact on peaks in daily pumped sewage flows. Large rain events tended to cause 90th percentile sewage flows at the station for 2-3 consecutive days.

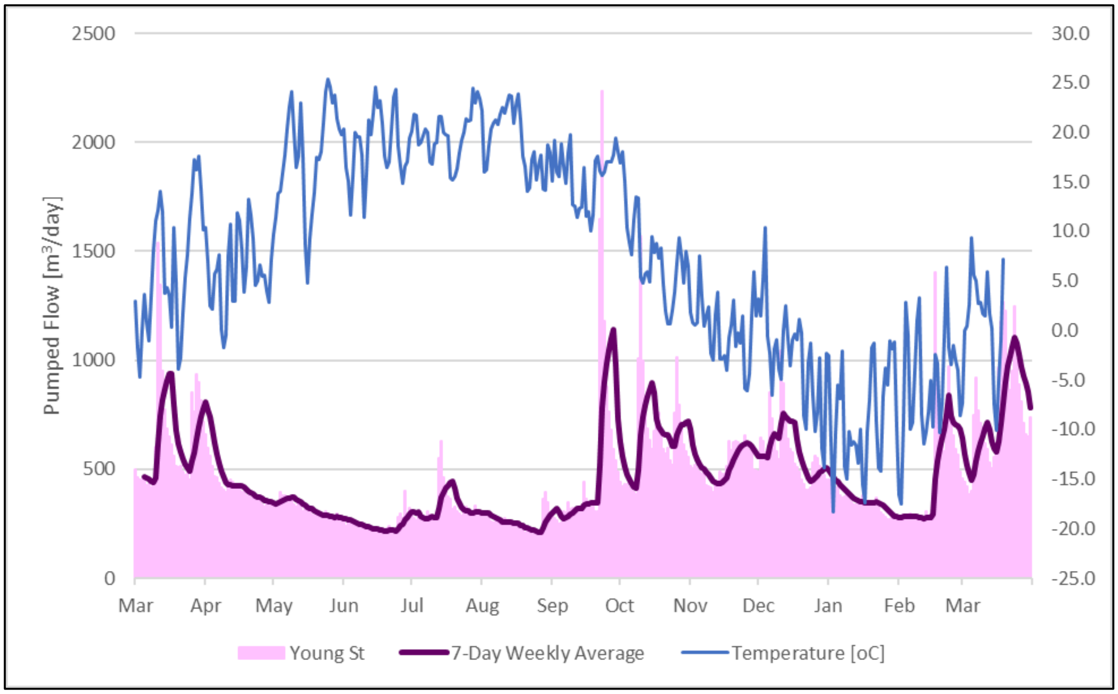

Figure 23 – Infiltration Analysis, Young Street SPS

Infiltration analysis for the Young Street SPS shows that spring thaw and seasonal high groundwater have a considerable impact on the system. 90th percentile weekly average flows occurred for two uninterrupted weeks following the first week with average temperature above 0 degrees Celsius in 2022.

5.2.5 Aggregated Pumping Station Analysis

Table 8 and 9 provide an aggregated summary of estimated I/I performance in the tributary area for each sanitary pumping station in Harriston. The aggregated analysis is largely qualitative due to the limited resolution of data for pumping stations.

Table 8 - Infiltration Assessment, Pumping Stations

SPS	D_{90}[1] During Spring Thaw [-]	Peak Spring Flow [m^3/d]	Infiltration Concern	Ranking
John St	12	901	Low	4
Lorne St	15	1700	Medium	1
Robertson St	17	1100	Medium	3
Young St	16	1269	Medium	2

1 – D90 refers to the number of days spent at 90th percentile weekly average pumped sewage flow during spring thaw

No area in Harriston measured by pumping stations is of high concern for infiltration. Weekly average sewage flows do reach the 90th percentile during spring thaw, but peaks flows are not excessive.

Table 9 - Infiltration Assessment, Pumping Stations

SPS	Peak Storm Flow [m^3/d]	Direct Inflow Concern	D_{90}[1] Following Storm Event	Indirect Inflow Concern	Ranking
John St	1066	Low	1.1	Low	4
Lorne St	1700	Low	1.6	Low	3
Robertson St	2400	Medium	2.4	Medium	2
Young St	2235	Medium	2.8	Medium	1

1 – D90 refers to the number of days spent at 90th percentile daily average pumped sewage flow following a significant storm event

No area in Harriston measured by pumping stations alone is of high concern for inflow. Concerns exist from annual peak flows coinciding with high daily precipitation and from elevated flows for several days after storm events in for Robertson Street and Young Street SPSs. However, it is estimated that these impacts are of lower priority than those recorded by flowmeters.

Data about sewage flows recorded in higher resolution than once per day is required for more accurate analysis.

6.0 Conclusions and Recommendations

Infiltration has a moderate impact on sewage flows in Harriston. Areas of highest concern showed infiltration somewhat beyond MECP conditions during seasonally high and low groundwater conditions.

Inflow has a lower impact on sewage flows in Harriston than infiltration. All measured areas experience increases in flow during significant storm events, but those impacts are much closer to expected values than other areas in the Town of Minto.

Harriston sanitary infrastructure is not the highest area of concern for I/I in the town of Minto.

6.1 Areas of Concern

Listed in descending order of priority.

1. H28 – SCA 1

Sanitary infrastructure in SCA 1 is of medium concern due to both infiltration and inflow. High peak infiltration in H28 and downstream Lorne Stret SPS indicate moderate sensitivity to groundwater. Peaks in sewage flows coincide with precipitation, indicating possible direct downspout connections to the system. It is recommended that the Town consider smoke testing and property surveys beginning from the bottom of the contribution area to find precise sources of inflow in the area. Follow-up CCTV inspections of pipes and structures should identify opportunities for waterproofing or rehabilitation as appropriate.

2. H100 – SCA 3

Sanitary infrastructure in SCA 1 is of moderate concern due to both infiltration and inflow sources. High infiltration measured in and outside of high groundwater season indicates that sanitary infrastructure in SCA 3 may be in relatively poor condition relative to other areas. It is recommended that the Town consider smoke testing and property surveys, concentrating efforts close to the measurement site due to the especially pronounced peaks in flow noted during wet weather analysis. Following up with visual inspections of pipes and structures of interest should identify opportunities for waterproofing or rehabilitation as appropriate.

3. Tributary Area to Young Street SPS – SCA 4

Sanitary infrastructure upstream from the Young Street SPS is of interest for further flowmeter analysis using existing town assets. Infiltration analysis yielded medium concern due to persistent 90th percentile peaks in pumped sewage flow coinciding with the onset of snow melt. Inflow analysis also showed medium concern due to peak flows as high as 4.8 times higher than average during storm events. However, these conclusions are limited by the resolution of the available sanitary flow data. It is recommended that the Town consider installing flowmeters at sanitary maintenance holes H72, H76, and H67 to capture high-resolution flow data at key junctions in SCA 4.

6.2 Next Steps

Specific remedial works can be recommended only when specific I/I sources are found. The following strategy is recommended to determine exact locations of I/I sources:

- Visually examine sewer flows in each maintenance hole starting downstream. Follow sources of higher flow in each upstream maintenance hole until the source of higher flow can be isolated. This process will need to consider the upstream service area as this will affect the flow rate.

  This process should be completed following a significant rainfall event and/or during high groundwater conditions to estimate inflow or infiltration, respectively.
- Inflow detection testing should be completed for the identified high I/I areas using sewer dye testing, smoke testing, etc. Then, conducting CCTV inspections during a wet period can provide the exact location of the inflow. A list of findings is to be prepared.
- Sanitary contribution areas only covered by SPS data should be subdivided using Town flowmeters to gather data in higher resolution. Consider sanitary maintenance holes H72, H76, and H67 to capture high-resolution flow data at key junctions in SCA 4.
- Prepare a work plan to address any identified deficiencies.

General remedial works in typical sanitary systems include the following:

- Complete per-house inspections of foundation drain and sump pump connections for connections to the sanitary network. If so, these connections should be disconnected and rerouted to a storm service or surface discharge location as appropriate.
- Ensure that new homes include the installation of storm sewer services and that sump pumps are connected to this service as per the Town's Municipal Servicing Standards.
- Ensure storm sewers are installed for the entire length of roads during new builds or reconstructions. The Town will need to weigh the costs and benefits of accommodating private storm services, foundation drains, or sump pump connections on an as-needed basis.
- Provide and maintain adequate drainage features to ensure storm blockages do not cause additional inflow during rainfall events.
- Install inserts in maintenance holes which may be susceptible to surface flooding.
- Repair all sewer and maintenance holes with identified deficiencies. This may include parging structure cracks, replacing brick/moduloc works, and grouting or lining leaking sewers and tees.

Once the Town has had a chance to review this information, we suggest a meeting to consider a course of action for further work.

Respectfully submitted,

Zach von Massow, EIT

Dustin Lyttle, P.Eng

Triton Engineering Services Limited

References

Triton Engineering Services Ltd. (2022). *Town of Minto Asset Management Plan.*

United States Environmental Protection Agency. (2014). *Guide for Estiamting Inflow and Infiltration.*