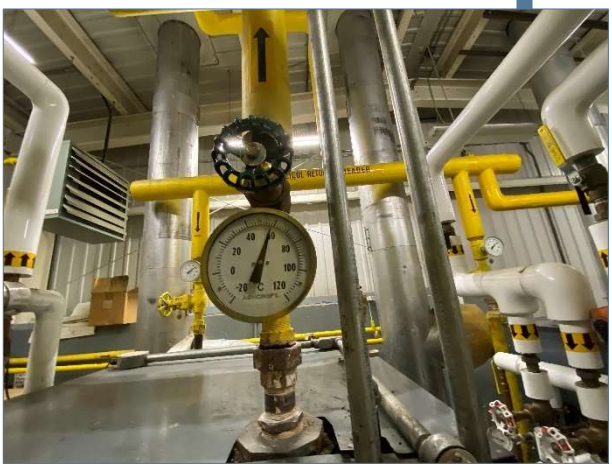
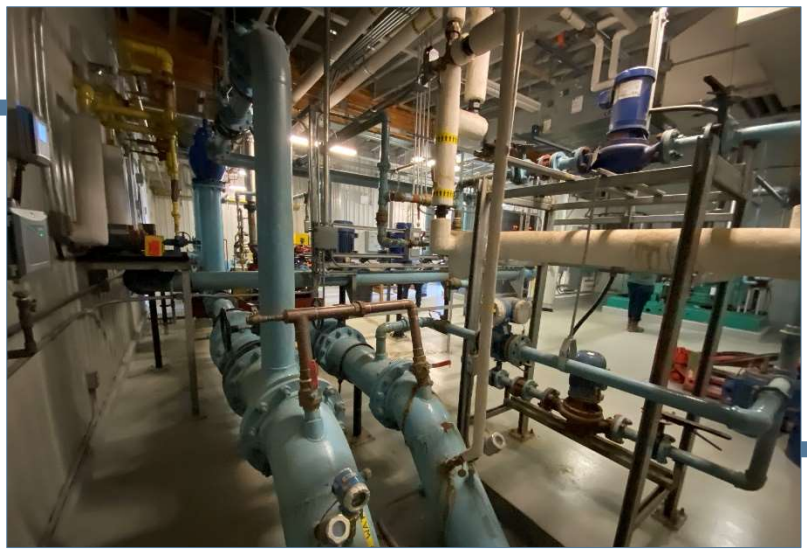
IQALUIT LONG-TERM WATER PROJECT

DISTRIBUTION SYSTEM DEFICIENCIES AND OPPORTUNITIES

DRAFT REPORT
PREPARED FOR CITY OF IQALUIT





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WSP PROJECT NO. CA0023312.3294

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DISTRIBUTION SYSTEM DEFICIENCIES AND OPPORTUNITIES

November 18, 2024

DRAFT REPORT

City of Iqaluit
1085 Mivvik Street,
P.O. Box 460,
Iqaluit Nunavut, X0A 0H0

Attention: **City of Iqaluit**

Subject: **Long-Term Water Project Owner's Engineer - Distribution System Deficiencies and Opportunities**

Dear Sir/Madam:

WSP Canada Inc. (WSP) is pleased to submit our attached Draft Water Distribution System Deficiencies List Report in partial satisfaction of the Phase 2 Scope of Work Packages portion of the Iqaluit Long-Term Water Project.

The purpose of this Project activity is to identify existing system deficiencies as they relate to the performance of the distribution system – namely with respect to non-revenue water loss – and opportunities for improving system resiliency and level of service standards.

The contents of this report follow the findings of WSP's site investigation conducted during the week of July 8th, 2024, interviews with City staff, and a review of other information provided throughout the course of the overall Project. The findings of this report will be used to inform the priority matrix – a latter Phase 2 deliverable – in accordance with the City's funding requirements through the Disaster Mitigation and Adaptation Fund.

We look forward to your response and incorporating the necessary changes and comments into the final version of this Report.

Yours sincerely,

_____

Ian Moran, B.Eng., PMP
Technical Project Manager, WSP Canada Inc.

_____

Neil Noble-Pattinson, B.Sc., B.A., P.Eng., PMP
Project Manager, WSP Canada Inc.

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November 18, 2024

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This limitations statement is considered an integral part of this report.

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EXECUTIVE SUMMARY

The City of Iqaluit is undergoing significant infrastructure improvements to ensure the long-term sustainability and resiliency of its water distribution system. This project, funded through the Disaster Mitigation and Adaptation Fund (DMAF), focuses on three main objectives: replacing and modernizing the existing piped infrastructure, developing a new long-term water source, and constructing a new raw water reservoir. WSP has been engaged by the City to provide consulting services with a focus on investigating system deficiencies and identifying improvement opportunities to enhance water management efficiency and resiliency.

Key findings from WSP's site investigation, conducted in July 2024, revealed several system deficiencies and potential improvements. The report identifies key issues such as malfunctioning flow meters, outdated bleeder lines, non-connected customers in piped districts, aging access vaults, and unmetered water usage at critical stations. These deficiencies contribute to non-revenue water losses, undermining the overall performance and sustainability of the distribution network.

To address these issues, the following recommendations are provided:

1. **Infrastructure Upgrades:** Install flow meters at key system locations, particularly at Booster Stations and Reheat Stations, and replace totalizing flow meters with instantaneous ones to improve measurement accuracy and enhance system resiliency by upgrading access vaults and water supply lines.
2. **Data Collection and Monitoring:** Improve centralized data storage by connecting flow meters and monitoring equipment to the Supervisory Control and Data Acquisition (SCADA) system. This will enable real-time monitoring and quicker response to leaks or breaks.
3. **Policy and Operational Improvements:** Implement regular preventative maintenance programs, such as valve exercising, hydrant flushing, and uni-directional watermain flushing. Update standard operating procedures (SOPs) for firefighting water usage, dust abatement, and hydrant testing to ensure that water use is tracked and optimized.
4. **Service Expansion:** Consider extending piped services to underserved areas like Apex and Tundra Ridge to reduce reliance on trucked services, thus increasing service resiliency.

These measures will not only address the current deficiencies but will also significantly reduce non-revenue water loss, improve system performance, and support the City in meeting its obligations under the DMAF funding agreement.

1 INTRODUCTION

1.1 COMMUNITY BACKGROUND

Iqaluit is the capital of the Nunavut Territory, located at the south end of Baffin Island near the end of Frobisher Bay (63°45'N latitude and 68°31'W longitude). Access to Iqaluit is provided year-round by regularly scheduled commercial aircraft, snowmobile trails from other Baffin Island communities in the winter, and sealift from the port of Montreal and Valleyfield in the summer.

1.1.1 GEOLOGY AND TERRAIN

Iqaluit's location is above the tree line and within the permafrost zone of Canada. The region generally consists of glacially scoured igneous/ metamorphic terrain. In some locations, a thin layer of organic material is found.

1.1.2 CLIMATE

Iqaluit has a tundra climate typical of the Arctic region, although it is well outside the Arctic Circle. The city experiences long, cold winters and brief, cool summers. Average monthly temperatures remain below freezing for eight months of the year. The city's climate is marked by an average January temperature of -21.5°C and an average July average temperature of 8°C. The annual precipitation consists of 19.2 cm of rainfall and 255.0 cm of snowfall, totaling 43.0 cm of precipitation. Prevailing winds blow from the northwest at an average speed of 16.7 km/h.

1.1.3 CITY GROWTH AND POPULATION

Iqaluit is the newest capital city in Canada, and as a result, has undergone a period of rapid development and growth. It serves as the seat of government for the Nunavut Territory and hosts many federal and territorial government departments. The City is also emerging as a regional center for the territory, with various northern businesses and Inuit organizations establishing their base of operations. According to 2021 Census, Iqaluit's population is estimated at approximately 7,500 people, with an average annual growth rate between three and four percent.

1.1.4 LAND OWNERSHIP SYSTEM

Iqaluit has a unique land ownership system. The major landowners in Iqaluit are the Commissioner of Nunavut, the City, and the regional Inuit associations. These entities in turn lease land to individuals, corporations, and other government departments. The City's land is administered through a land acquisition by-law and by a Territorial Statute. Generally, there is no private ownership of land.

1.2 PROJECT DESCRIPTION

1.2.1 PROJECT OBJECTIVES

Given the unreliable nature of annual precipitation for replenishing the city's sole reservoir, it is critical to establish a sustainable, long-term water source to mitigate the potential risk of future water shortages. In response, the City of Iqaluit has undertaken several projects in recent years to prepare for the further development of its raw water supply and is now seeking consulting services to advance this goal.

In line with the existing Infrastructure Canada funding agreement through the Disaster Mitigation and Adaptation Fund (DMAF), the three main goals of this Project are:

- Replace and Modernize the Existing Piped Infrastructure
- Develop a New Long-Term Water Source and Supporting Infrastructure
- Construct a New Raw Water Reservoir

WSP has been engaged by the City to provide Owner's Engineer consulting services for the *Replace and Modernize the Existing Piped Infrastructure* component of the Project. To achieve these objectives, this component is broken down into the following five phases:

1. Water Model Development
2. Scope of Work Packages
3. Water Model Maintenance
4. Resiliency Study
5. Specialized Services

The Distribution System Deficiencies and Opportunities Investigation is part of the *Phase 2 Scope of Work Packages*.

1.2.2 DISTRIBUTION SYSTEM DEFICIENCIES AND OPPORTUNITIES INVESTIGATION

The Distribution System Deficiencies and Opportunities Investigation aims to identify deficiencies in the City's water distribution system and explore opportunities for improvement. This includes both addressing the identified deficiencies and enhancing the overall resiliency of the distribution system.

A critical key performance indicator (KPI) for this investigation is the reduction of non-revenue water loss, as many of the identified system deficiencies contribute directly to this loss. Therefore, addressing these deficiencies will not only enhance system performance but also align with the City's goal of improving water management efficiency.

The findings of this investigation will directly inform the development of priority matrix, a key deliverable in Phase 2 of the project. This matrix will help prioritize actions based on their impact on non-revenue water

loss and system resiliency, ensuring alignment with the City's obligations under the DMAF funding agreement.

2 REVIEW OF EXISTING DATA AND DOCUMENTATION

2.1 EXISTING SYSTEM OVERVIEW

The City owns and operates the Iqaluit Public Water System (PWS) and Iqaluit Public Wastewater System (PWWS). The PWS is includes water treatment and treated water distribution systems. The major PWS components are as follows:

- Water Treatment System
  - Lake Geraldine (the City's raw water source)
  - Raw Water Intake
  - Water Treatment Plant (WTP)
- Treated Water Distribution System
  - Pipes, Valves, Appurtenances, and Access Vaults (AVs)
  - Booster Station #1
  - Booster Station #2
  - Reheat Station #1
  - Reheat Station #2 (also known as Reheat Station 222)

These major PWS components are shown graphically in **Figure 1**.

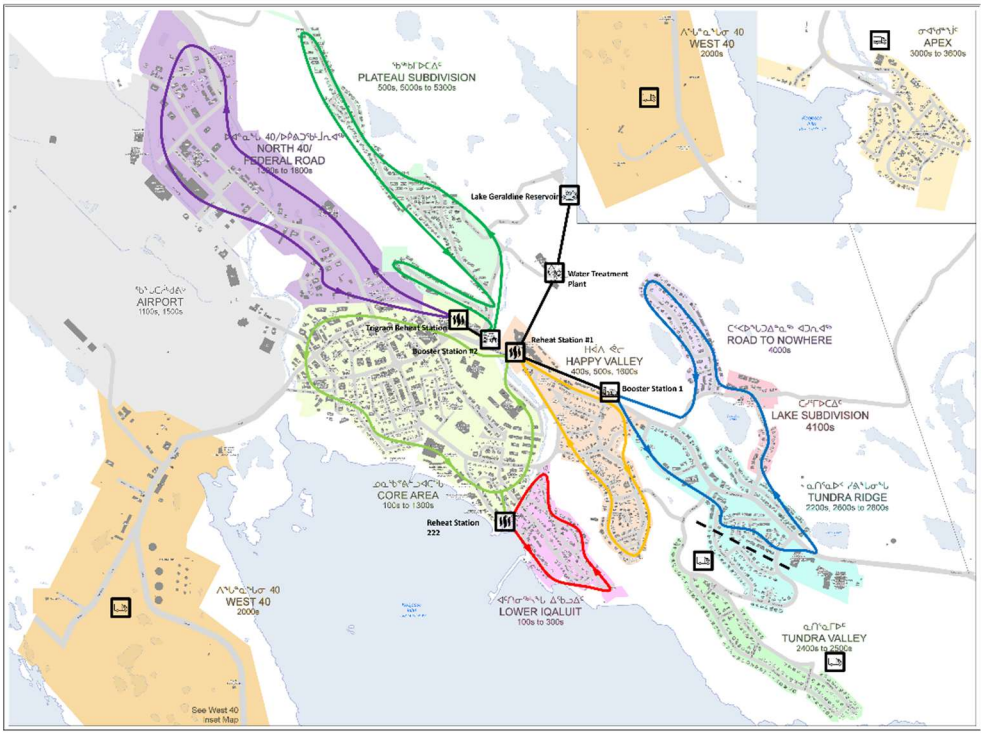

Figure 1: Major Iqaluit Public Water System components.

A review of the PWWS is not within the scope of this investigation, however, some of the PWWS components may be discussed as they relate to the performance and/or operability of the distribution system.

Most PWS and PWWS components are connected to the City's existing Supervisory Control and Data Acquisition (SCADA) system, which provides centralized monitoring and automated control over many electrical and mechanical equipment systems (i.e., pumps, automated valves, monitoring equipment). The SCADA also includes integrated alarms that, depending on the nature and severity of the situation, can issue text or phone-based notifications to key individuals assigned to respond to these situations. When operating normally, the SCADA system automates nearly all processes, minimizing the need for operator intervention.

2.2 DISTRIBUTION SYSTEM NETWORK

Treated water enters the distribution system from the City's treated water reservoir, located directly south of the Water Treatment Plant (WTP) at the top of Hospital Hill. The water flows by gravity down Hospital Hill and branches into three distinct pressure zones:

- **Gravity pressure zone**: This zone provides treated water to the North 40/Federal Road, Core Area, Lower Iqaluit, and Happy Valley districts. Water pressure is supplied solely by the elevation of the reservoir.
- **Road to Nowhere zone:** Pressurized water in this zone is supplied by Booster Station #1.
- **Plateau zone:** Pressurized water in this zone is provided by Booster Station #2.

Districts not connected to the piped distribution system receive treated water and wastewater services via truck deliveries. These districts, shown with a “Truck” icon in **Figure 1**, include:

- West 40
- The southern portion of Tundra Ridge
- Tundra Valley
- Apex

A subset customers in piped service districts are also not connected to the water distribution system. This non-connectivity can be due to variety of reasons, including lack of pressure and construction challenges. Extending services to these non-connected customers could improve operational efficiency by reducing reliance on trucked services.

A simplified flow diagram for the different pressure zones and service supply points is given in **Figure 2**.

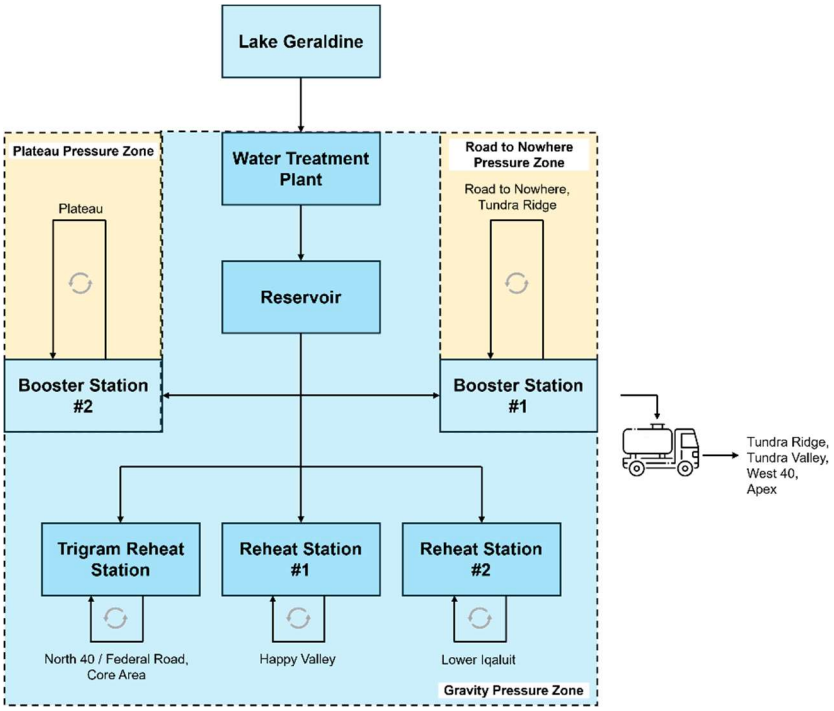

Figure 2: Simplified Iqaluit distribution system flow and district service diagram.

3 SITE INVESTIGATION FINDINGS

3.1 OVERVIEW

WSP conducted a site visit in Iqaluit during the week of July 8th, 2024 with the following objectives:

- Engage with the experienced staff responsible for the day-to-day management of the Public Water System (PWS).
- Identify existing system deficiencies and opportunities for addressing them.
- Explore opportunities to minimize non-revenue water loss.
- Address outstanding queries from other phases of the OE project.

During the site visit, WSP personnel met with the Director of Engineering, Public Works Superintendent, Water Treatment Plant (WTP) Operator, and the City's project management representative from Colliers Project Leaders (Colliers). Key locations visited included:

- Lake Geraldine
- Raw Water Intake
- WTP
- Booster Station #1
- Booster Station #2
- Reheat Station #1
- Reheat Station #2 (also known as Reheat Station 222)
- Lift Station #1
- Lift Station #2

This report does not discuss each site in detail but focuses on findings related to potential sources of non-revenue water loss.

3.2 EXISTING SYSTEM DEFICIENCIES

During the site investigation, several deficiencies were identified with the existing distribution system. Descriptions of the identified deficiencies are provided below. The term "deficiency" has been used to describe a lower-than-ideal service standard, rather than an item that is simply broken or non-functioning. Given the unobservable, below-grade nature of a majority of the distribution system, many of the noted deficiencies are accounts from City personnel.

3.2.1 FLOW METERS

Two existing flow meters in the system are not gathering data as intended.

1. The flow meter on the discharge side of Booster Station #1 is currently non-functional requires further investigation to determine the cause.
2. The flow meter on the supply side of Booster Station #2 is functional, however, it's location in the system limits its ability to gather appropriate data (**Figure 3**).

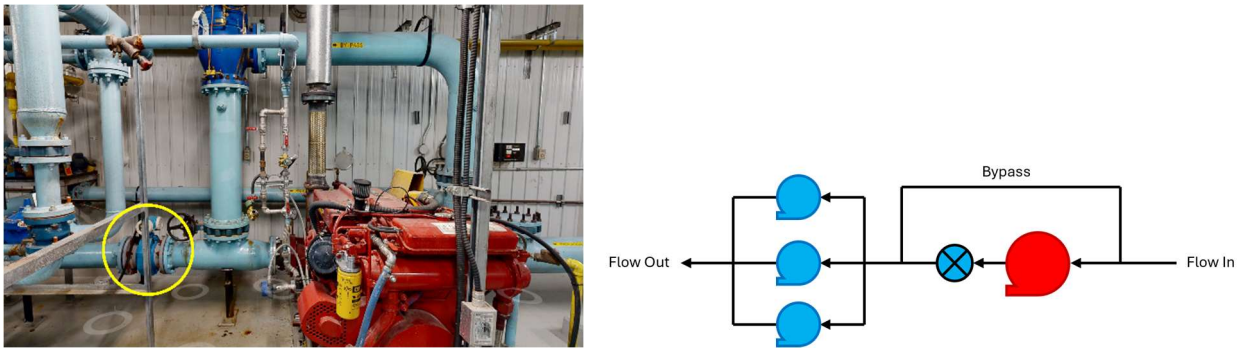

Figure 3: Booster Station #2 supply-side flow meter location (left) and corresponding process flow diagram (right).

Current operating practice utilizes the fire pump bypass and thus no water flows through the flow meter. Further, flow meters require a certain spacing before and after pumps, valves, and other piping appurtenances (tees, elbows, etc.) in order to minimize the impact of turbulence and maximize accuracy. The most common spacing requirement is ten (10) pipe diameters before the meter and five (5) pipe diameters after the meter. The existing location of the flow meter falls well short of these typical minimum requirements, particularly on the supply side. In light of this, it is recommended that the City should consider relocating the flow meter at Booster Station #2 to a more suitable location, ensuring proper spacing (10 pipe diameters before and 5 after) to improve measurement accuracy.

3.2.2 BLEEDER LINES

Bleeder lines are installed for purposes such as preventing water stagnation, air removal, temperature control, system flushing and pressure regulation. There are currently 11 known bleeder lines in the City, with locations summarized in

Table 1 and shown in **Figure 4**.

Table 1: Locations of bleeder lines and their attributes.

Access Vault	District	Metered?	Purpose
TAC 04	Happy Valley	Metered	To keep the sewer flowing at the airport
MH 89	Happy Valley	Unmetered	To keep the end of water main from freezing
AV 213	Federal Road / North 40	Unmetered	To keep from freezing the water main
AV 227	Happy Valley	Unmetered	To keep the loop from freezing
AV 229	Happy Valley	Unmetered	To keep the loop from freezing
AV 235	Happy Valley	Metered	End of sewer and water main
AV 239	Happy Valley	Metered	End of sewer line and water main
AV 240	Happy Valley	Metered	End of sewer line and water main
AV 271	Federal Road / North 40	Unknown	To prevent freezing water main
AV 523	Tundra Ridge	Metered	For sewer main to prevent freezing
AV 629	Plateau	Metered	End of sewer Main to prevent freezing

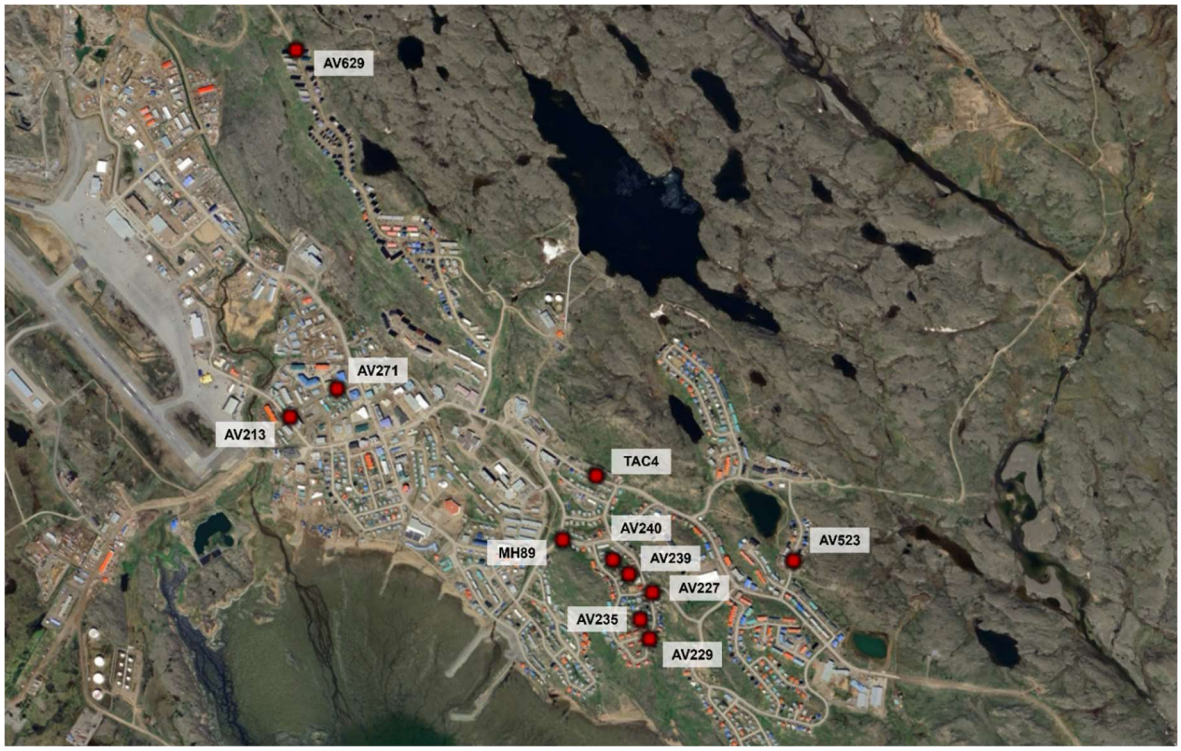

Figure 4: Locations of existing bleeder lines in Iqaluit.

Many of these bleeder lines serve a necessary purpose, such as AV629 at the end of the Plateau Loop to mitigate sewer main freezing. However, there are several bleeder lines that serve a temporary or interim purpose, such as those in cul-de-sacs or dead ends in Happy Valley (namely AV229, AV235, AV239, and AV240). According to Public Work personnel, the return lines for the small cul-de-sac loops may be undersized and have, historically, posed a higher risk of leaks and breaks. In response to this, the City installed bleeder lines to mitigate the perceived risk.

It is recommended that the City should investigate alternatives to eliminate or reduce the reliance on bleeder lines, particularly in areas where system improvements can address the underlying issues.

3.2.3 NON-CONNECTED CUSTOMERS IN PREDOMINANTLY PIPED DISTRICTS

As noted in **Section 2.2**, some customers in districts serviced by piped distribution system remain on trucked services. While this is not a deficiency per se, the City could consider, on a connection-by-connection basis, the feasibility of extending the service supply to the dispersed customers currently on trucked services.

3.2.4 OLD ACCESS VAULTS AND MANHOLES

Particularly in older City district, namely Lower Iqaluit, there are older access vaults (AVs) and manholes that were constructed using outdated or obsoleted materials and methods. While these components are not necessarily in poor current condition, their age and non-conformance with modern design guidelines can lead to an increased risk of failure or other safety concerns.

WSP is aware of, but has not reviewed in detail, an AV condition assessment report prepared by another consultant. It is recommended that all AVs, particularly the older AVs, are reviewed for deficiencies and a subsequent priority matrix is prepared to address high risk AVs.

3.2.5 COMBINED WATER AND SEWER PIPING IN EXISTING AVS

Many of the City's existing AVs convey both treated water and municipal wastewater as shown in **Figure 5**, in accordance with an outdated version of the City's Municipal Design Guidelines. In the figure below, showing AV239, the treated water pipe, equipped with a metered bleeder line, is located toward the bottom of the image, while the open-channel wastewater collection pipe is located near the top of the image. It is important to note that the plate covers for the wastewater collection pipe are typically closed but remain open for AV239 to facilitate the flow of the bleed water.

Figure 5: Treated water and wastewater collection piping in AV239.

The conveyance of treated water in the same vault as wastewater does not meet current industry best practices. This arrangement poses a significantly higher risk of contaminating the treated water supply, compared to installation in separate AVs. The consequence of a leak or break in a water line within an AV flooded with wastewater can lead to severe consequences, including disruption of customer service, loss of water revenue, and diminished consumer confidence.

Although the treated water piping is generally installed at a higher elevation than the sewer piping, the water level in many AVs is known to rise and submerge, or partially submerge, the treated water pipes. AV326, located in front of Booster Station #1, is one such AV where the water level frequently rises above the treated water pipe. Public Works personnel are well aware of this troublesome AV.

WSP acknowledges the significant cost and labour implications of rerouting piping and replacing one AV, let alone the cost of updating all of AVs with mixed piping in the City. Such a project is infeasible in the short-term and may remain so in the long-term.

In accordance with the findings of the 2024 AV condition assessment report (prepared by others), WSP recommends developing a priority matrix to identify critical AVs in need of replacement. The priority matrix should consider the age, condition, history of issues, and system criticality of each AV (i.e., does it supply half of the City's treated water supply or half a dozen customers?).

3.2.6 ACCESS VAULT 305

AV305 is known to have a history of issues and serves as a critical access vault, providing treated water to approximately half of the City. The City is aware of the issues and has engaged with another party to address them.

WSP has no further recommendations for AV305 at this time.

3.2.7 REHEAT STATION #2 TRUCK FILL ARM

The truck fill arm at Reheat Station #2 does not currently meet occupational health & safety (OHS) requirements (**Figure 6**). Key deficiencies include a lack of access stairways and protective barriers. Further consultation with the local OHS officer may be required to determine the full scope of requirements before the station can be reinstated for use.

Figure 6: Truck fill arm at Reheat Station #2.

The City has indicated no current interest in reinstating the truck fill arm for municipal purposes, as trucked services currently source water from the Booster Station #1, or as a backup, from the WTP truck fill station.

A potential adaptive re-use of the truck fill arm is a pay-per-use filling station for third-party use. This potential upgrade would enhance the City's metering capabilities and provide an additional source of revenue source for bulk water. If pursued, the City would need to consider the necessary upgrades to meet OHS requirements.

3.2.8 FUEL CONTAMINATION IN 700S (CORE AREA)

The City is aware of fuel contamination in the 700s in the Core Area (west of Northmart). A water leak or break in this area could increase the risk of treated water contamination, potentially affecting customers in the North 40 / Federal Road district loop and the Lower Iqaluit sub-loop.

The extent of the contamination and its impact on the treated water supply is currently unknown to WSP. It is recommended that the City review existing data and documentation related to the contamination and take appropriate action to mitigate or eliminate its risk to the treated water supply.

3.2.9 LACK OF PREVENTIVE MAINTENANCE PROGRAMMING

According to Public Works personnel, there is a lack of formalized or regularly executed preventative maintenance program for the water distribution and wastewater collection systems. Key activities that are currently lacking include:

- Uni-Directional Sewer Flushing
- Valve Exercising
- Hydrant Flushing

Public Works personnel indicated that formal programs for these activities will be developed or updated in 2024, with plans to execute them annually.

3.3 OPPORTUNITIES

3.3.1 INSTALLATION OF PRESSURE AND FLOW METERS

WSP recommends the installation of pressure and flow meters on the inlet and outlets all major water infrastructure buildings. This combination would significantly improve the visibility of system performance and reduce response times during leaks or breaks.

While not directly related to the scope of this report, installing flow meters at the inlets and outlets of all wastewater stations (lift stations and WWTP) could provide better insight into treated water use beyond its primary points of consumption.

A simplified diagram of all meter locations is provided in **Figure 7**.

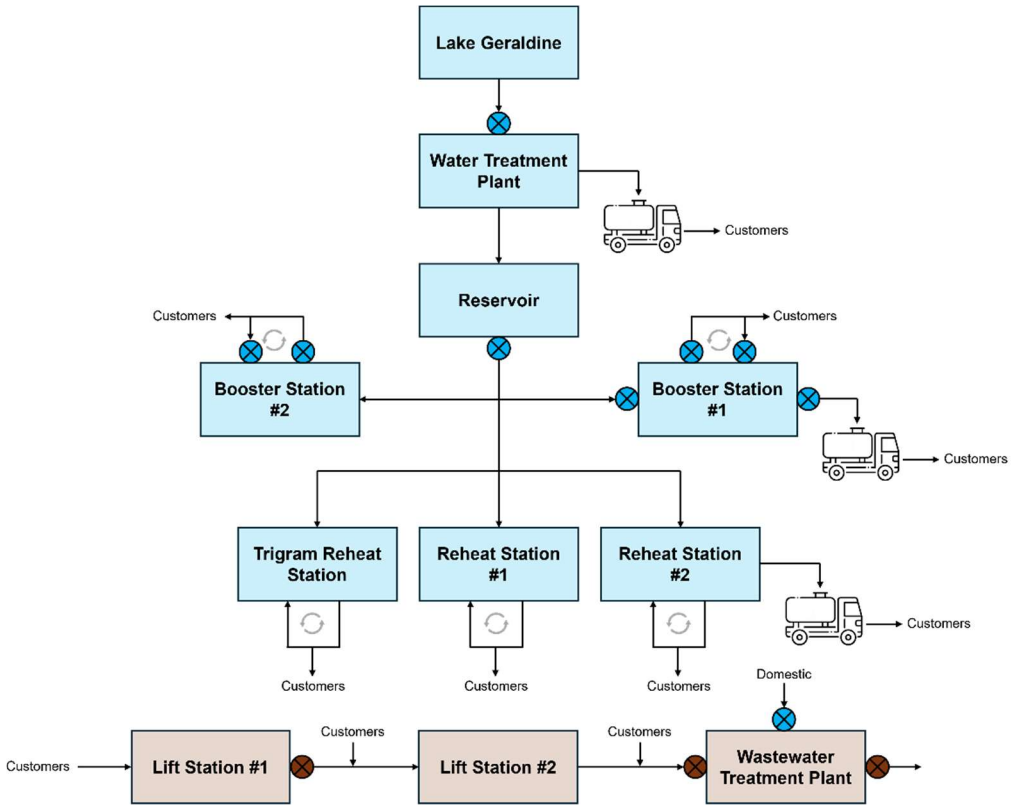

Figure 7: Existing flow monitoring devices in the Iqaluit Public Water System and Public Wastewater System.

It is recommended that the City should install pressure and flow monitoring devices at the following locations:

- WTP Truck Fill Station
- WTP Discharge to Reservoir
- Booster Station #2 Supply (or reconfigure existing flow meter to be ahead of fire pump)
- Trigram Reheat Station Supply
- Trigram Reheat Station Return
- Reheat Station #1 Supply
- Reheat Station #1 Return
- Reheat Station #2 Supply
- Reheat Station #2 Return
- Reheat Station #2 Truck Fill Station
- Lift Station #1 Supply (flow only)
- Lift Station #2 Supply (flow only)
- Lift Station #2 Discharge (flow only)

3.3.2 EXTENSION OF SERVICE SUPPLY TO TUNDRA RIDGE AND/OR TUNDRA VALLEY

The existing piped distribution via the Booster Station #1 pressure zone serves the Road to Nowhere and the northern half of the Tundra Ridge districts (**Figure 1**). The piped service to Tundra Ridge includes the 2100s, 2200s, 2700s, 2800s, and select customers in the 2600s including 2602, 2604, 2621, 2623, 2692, 2694, and 2696. The remaining approximately 66 customers in Tundra Ridge are on trucked services (**Figure 8**).

Figure 8: Piped and trucked services supply cutoff for Tundra Ridge.

According to the elevation markers in the existing distribution system model, all of Tundra Ridge is within the Booster Station #1 pressure zone and all but apparently two customers are in Tundra Valley are in the Gravity Pressure Zone (**Figure 9**).

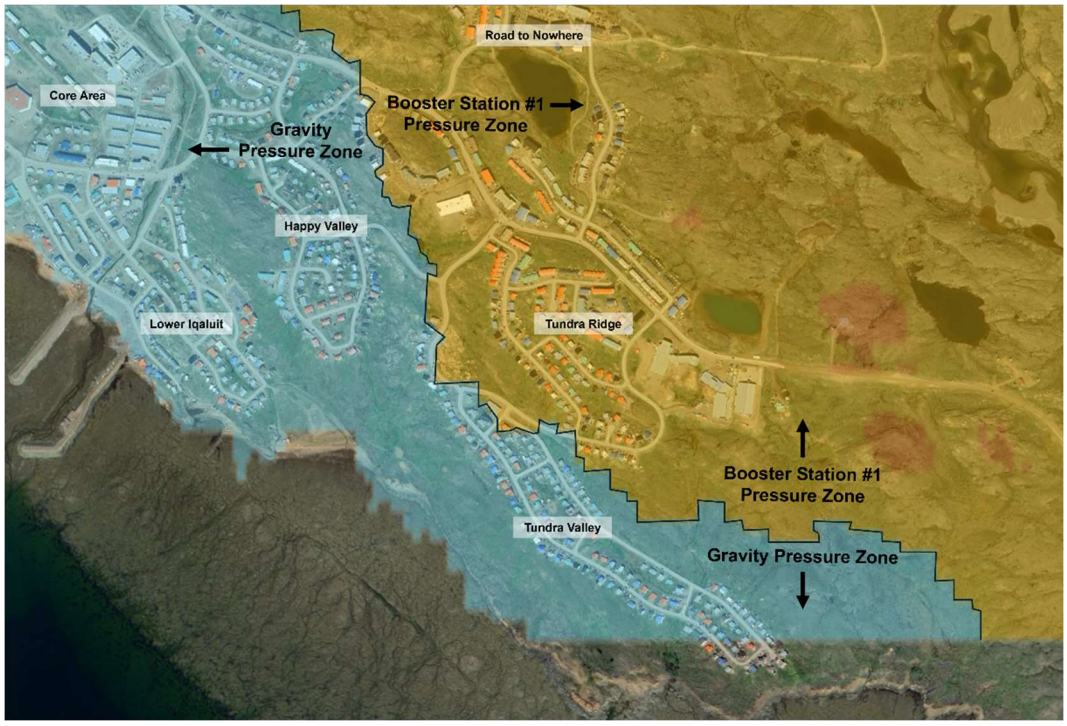

Figure 9: Pressure zones by elevation in eastern residential districts in Iqaluit.

The following information can be inferred from **Figure 9** regarding the feasibility of a distribution system expansion:

- A watermain extension to the 66 truck-service customers in Tundra Ridge could be achieved via Booster Station #1 supply.
- A watermain extension to Tundra Valley could be supplied via Happy Valley.

Corresponding piped sewer connections could be achieved via the construction of a new lift station at the southeastern extents of Tundra Valley. A simplified potential service extension diagram to both Tundra Ridge and Tundra Valley is given in **Figure 10**.

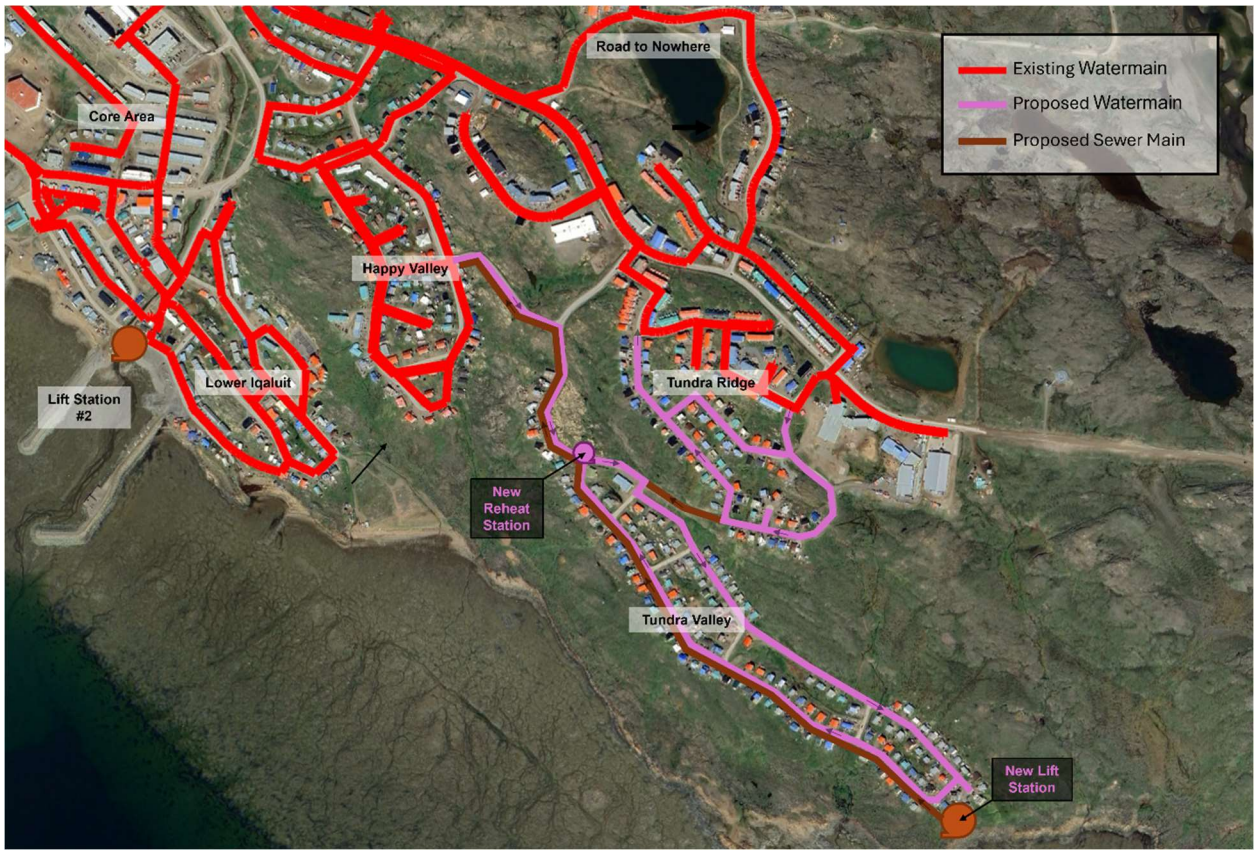

Figure 10: Simplified potential piped water and wastewater service connection extension to Tundra Ridge and Tundra Valley.

Should the City be interested in some or all of the watermain extensions shown in **Figure 10**, further information would need to be gathered to assess feasibility including the capacity of the existing pumps to supply a higher volume of water, the size of the existing watermain, and terrain & elevation limitations, among others. A water modeling exercise would be necessary to confirm most of these proposed system characteristics.

3.3.3 SERVICE SUPPLY TO APEX

Historically, Apex was the place where most Inuit lived when Iqaluit was a military site and was off-limits to anyone not working at the base. Although officially and functionally part of the City of Iqaluit, some Apex residents tend to reject affiliation with "Frobisher Bay" on account of its historical context. In light of this, there may be socio-political motivations toward increasing the level of municipal service.

At present, all customers in Apex are serviced by trucked services for their water and wastewater use. Residents of Apex have expressed concerns to the City regarding trucked services to make it over the hill, particularly during adverse weather conditions. In such a case, customers may be at an increased

risk of running out of water and be unable to effectively deal with a fire event. Further, residents have also requested a separate water treatment facility for Apex.

Potential treated water supply upgrades to Apex and brief descriptions of each are provided below.

DEVELOPMENT OF A NEW RAW WATER SOURCE AND LOCALIZED WATER TREATMENT FACILITY

A raw water source study would need to be conducted for this upgrade. Such study would assess the viability of several potential raw water sources and their feasibility for development into a treatment system. It is possible that the study will not identify a viable raw water source or that the most feasible source comes with significant cost or treatment requirements.

This development and associated infrastructure (raw water intake, wastewater outfall, etc.) involves significant capital allocation. This new facility would incur additional O&M costs and labour requirements. Depending on the type of treatment technologies within the facility, it may require additional operators, or operators with a higher skill requirement.

CONSTRUCTION OF A NEW WATERMAIN CONNECTED TO THE EXISTING DISTRIBUTION SYSTEM

A new watermain could be constructed along the road connecting Apex to the greater Iqaluit area. A possible tie-in point to the existing system would be the eastern extents of Tundra Ridge near the Arctic Winter Games Arena (AWG). The capacity of Booster Station #1 and the existing watermains in the Road to Nowhere and Tundra Ridge loops would need to be considered against the increase in piped water demand. The need for additional pumping, reheating, recirculation, and chlorine top-up should also be reviewed. It should be noted that the elevation of Apex is approximately 20 m above sea level, which is similar to Lower Iqaluit. As such, boosting of the water may only need to overcome the peak elevation of the hill between Apex and the greater Iqaluit.

ERECTION OF A NEW TREATED WATER RESERVOIR

The construction of a new treated water reservoir would significantly improve the resiliency of the service supply to Apex. The reservoir could serve as a supply point for fire trucks and mitigate the need for trucked services to haul water over the hill during a fire event. A truck fill station could be installed on the new reservoir and be used as a backup station in the event of downtime at Booster Station #1. The truck fill station could also be used as a regular supply point for trucked service delivery to Apex customers and reduce labour and fuel requirements compared to filling at Booster Station #1. The reservoir could also include a metered customer supply point for residential and commercial purposes.

A new reservoir does not necessarily require a supply pipeline. Consideration could be given for a large tank kept full by trucked services, which could be used for fire fighting purposes.

INSTALLATION OF A PIPED DISTRIBUTION SYSTEM

The installation of a piped distribution network in Apex would increase the level of service for customers and would, by the nature of the upgrade, also include the installation of hydrants throughout the system. This would be a substantial capital undertaking.

RECOMMENDATIONS

If the City is interested in enhancing the level of service to Apex, WSP recommends the following upgrades, in the following suggested priority order:

1. Erection of a new treated water reservoir with an optional truck and/or customer fill station.
2. Construction of a new water supply line from the greater Iqaluit area.
3. Installation of a piped distribution system.

The development of a new raw water source and treatment facility is not recommended at this time due to the increased skilled labour requirements, environmental & regulatory risks, as the existing water treatment system is capable of meeting water quality and demand requirements.

The City has conveyed historical socio-political factors regarding the Apex district, which could justify upgrades to the existing service supply system. The City has relayed Apex resident's concerns about trucked services being able to get over the hill during adverse weather conditions.

In light of this, the City is open to upgrades which improve the redundancy and resiliency of the service supply to Apex. One option could be a satellite reservoir supplied by a new pipeline with standpipe connections for fire fighting, a truck fill station to reduce staffing/water delivery demand, a chlorine top-up system, and infrastructure for anticipated future upgrades.

Residents of Apex also expressed interest in having their own separate water treatment system.

To better assess, account for, and address potential risks of non-revenue water loss associated with bleeder lines, the following is recommended:

- Install meters on the bleeder lines not currently equipped with meters.
- Review existing SOPs to identify opportunities to limit bleeder line usage (i.e., seasonal/temperature thresholds).
- Identify and take advantage of opportunities to eliminate bleeder lines. Upgrading the return piping in the Happy Valley cul-de-sacs may be one of such opportunities.
- Review and update protocols for meter reading and centralized recording practices.

3.3.4 DUST ABATEMENT

The City uses water to mitigate dust on dirt and gravel roads, which causes the particles to stick together. Depending on weather conditions, a single watering may be effective for hours or for days. Industry best practice for water-based approaches to dust abatement suggest that regular, light watering is better than less frequent, heavy watering.

WSP recommends the following for dust abatement:

- Review SOPs to identify opportunities to reduce water usage (i.e., prevent over-application).
- Update protocols for meter reading and centralized data recording practices.

3.3.5 FIRE FIGHTING

According to the City, approximately 5-7 fires occur per month in Iqaluit. Depending on the location of the fire event, water is either drawn from a nearby hydrant (typical of communities on piped service) or deliver by water trucks (typical of communities on truck services).

According to Public Works personnel, the fire trucks are equipped with flow monitoring equipment, however the amount of water drawn for fire fighting purposes is not recorded. For the supply of water from trucked services for a fire event, it is not understood to be recorded by Public Works personnel. Although this water is indirectly 'recorded' by the Booster Station #1 truck fill meter, it may be difficult to accurately differentiate between customer usage and other municipal purposes.

Beyond responses to fire fighting events, it is not known how much non-revenue water is used by the Fire Department for training purposes.

In light of this, it is recommended that the City should:

- Review and update protocols for meter reading and centralized data recording for the Fire Department (including training) and trucked services.
- Explore opportunities to extend hydrant coverage, such as extending the piped distribution system to customers currently supplied via trucked services).

3.3.6 HYDRANT FLUSHING AND TESTING

Hydrant flushing and testing has historically been an informal program performed on an irregular basis. In light of this, it is unclear whether SOPs exist and, if so, include descriptions for documenting and recording data for non-revenue water usage. According to Public Works personnel, a formal hydrant flushing and testing program is planned to commence in 2024 and be formalized as an annual activity. Considering this, it recommended that:

- Newly created or updated SOPs include descriptions for documenting and recording water usage during hydrant flushing and testing.

- Opportunities for optimizing water usage during hydrant flushing and testing are investigated and implemented.

3.3.7 LEAKS AND BREAKS

Leaks and breaks can be a highly variable and major contributor to non-revenue water loss. The amount of non-revenue water loss is a function of the severity of the leak or break and the time required to respond to it. Major breaks can release a significant amount of water in short period of time and are likely to be responded more quickly. However, small leaks can remain undetected for extended periods, and in the long run, can be just as impactful as major breaks. Further to this, prolonged system downtime limits the ability to generate revenue from the supply of water to customers.

Public Works personnel noted that majority of the leaks and breaks occur in the older parts of the City, with pipes made from obsoleted materials (e.g. ductile iron, asbestos cement) or high age. Many of these events occur on pipe saddles near the access vaults and are attributed with ground shifting.

With respect to leaks and breaks, WSP recommends to the City the following:

- Install pressure and flow monitoring equipment at strategic locations throughout the City to identify leaks or breaks during pressure loss events.
- Replace obsoleted and aged piping with modern piped infrastructure to mitigate the risk and severity of leaks and breaks. The City could also consider installing flexible couplings to better accommodate ground shifting.
- Review existing leak and break response protocols to identify opportunities for reducing response times.

3.3.8 METER BYPASSES

Meter bypasses are understood to be installed in every customer connection. The purpose of the meter bypass is to be able to service the meter in the event of downtime, while still maintaining the (unmetered) flow of water to the customer during the servicing. However, they are not tagged or equipped with other tamper-resistant countermeasures. While it is possible to identify customers that operate their bypasses at the administrative/customer account level (i.e., comparing historical water usage to sudden drops in water usage), it is possible that there are several customers that operate, or partially operate, their bypassed without detection for prolonged periods of time. Furthermore, there is no current City bylaw or administrative penalty for consumers.

To address this, WSP recommends to the City the following:

- Create and execute a program to assess the frequency and severity of customer meter bypass usage.

- Retrofit tags and/or tamper-resistant equipment on existing meter bypasses and install new meters with equivalent equipment.
- Enact a City bylaw and corresponding administrative penalty for customers that illegally operate their meter bypass.

3.3.9 QEC FIRE PUMP STATION

Qulliq Energy Corporation (QEC) owns and operates a fire pump house next to the reservoir (**Figure 11**). Accounts from previous City personnel suggest that QEC's construction of the pump house in the early 2010s was in response to the absence of fire protection, which was removed from the WTP in approximately 1995.

Figure 11: Qulliq Energy Corporation fire pump house adjacent to Iqaluit Water Treatment Plant detached treated water reservoir

In reviewing historical photos of the fire pump house and its connection to the City's treated water supply, it is suspected that this connection is unmetered. It is important to note that the connection point to the City's infrastructure is located downstream of the reservoir, but before the meter (**Figure 12**). In light of this, QEC's treated water usage through the fire pump house would not be compared to distribution system non-revenue water loss (which compares water at and after the reservoir meter), but rather the efficiency of the WTP to convert raw water to treated water.

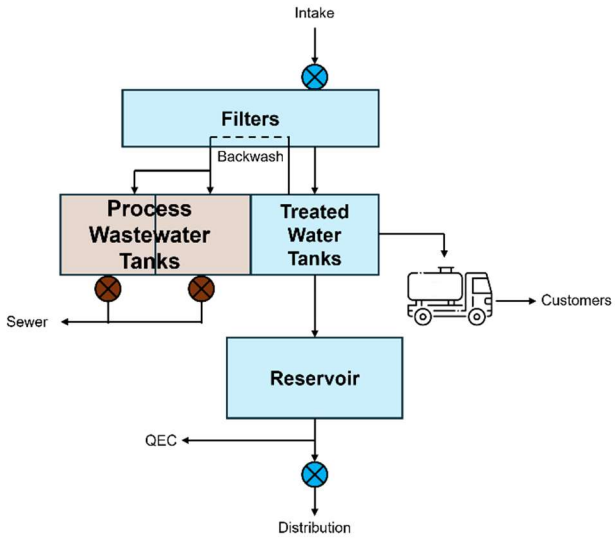

Figure 12: Water Treatment Plant process flow and metering diagram.

In light of the above, it is recommended that the City:

- Request further information from QEC regarding potential metering infrastructure and usage records. Actionable follow-ups are dependent on this information, or its availability thereof.

3.3.10 REHEAT STATION #2 UNMETERED HEATED WATER SUPPLY

Historically, contractors had keyed access to an unmetered heated water supply at Reheat Station #2 (**Figure 13**). In its earliest stages of contractor usage, the 'honour system' was implemented where contractors were encouraged to log their estimated water draw on a clipboard form available next to the water supply. However, contractors did not use this clipboard form as intended, which led to indeterminate non-revenue water loss associated with its use, prompting Public Works to restrict access to Reheat Station #2. This prompted several assumed break-ins for access to the unmetered heated water supply.

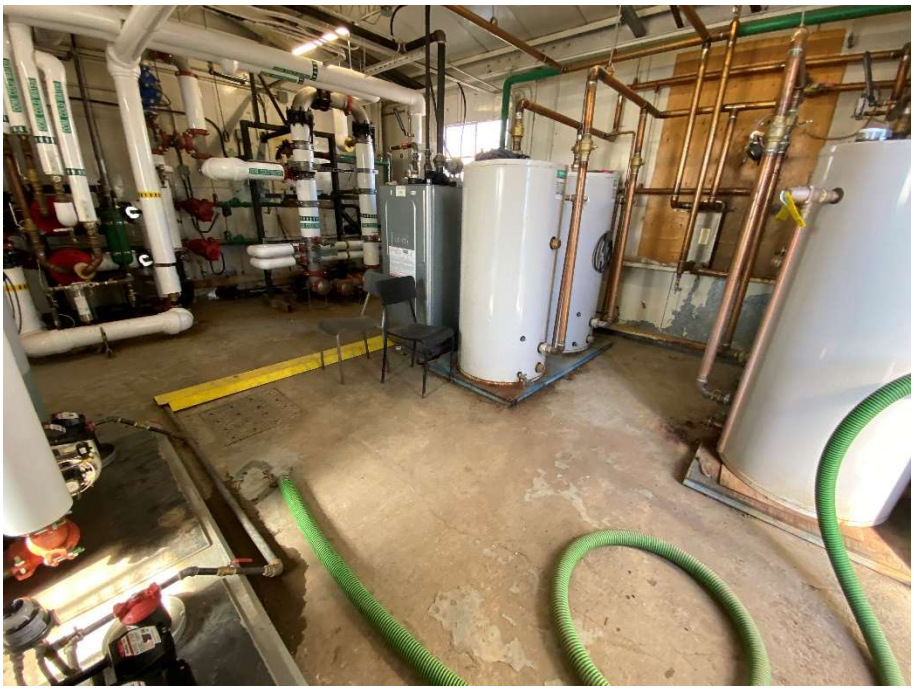

Figure 13: Unmetered heated water supply in Reheat Station #2.

The City has expressed their discontent with further allowing third parties (contractors or otherwise) to utilize the unmetered heated water supply in Reheat Station #2 without prior consent and expressed interest in a metered pay-per-use system.

In light of the above, WSP recommends to the City the following:

- Effectively communicating with third parties the City's interest in no longer providing unrestricted access to the heated water supply and upgrading site security measures accordingly.
- Install water meters at supply point(s).
- Consider installing a metered pay-per-use system at the preferred supply point. It is recommended that the supply point be the currently unused truck fill arm and contractors are to operate it at their own risk.

3.3.11 UNI-DIRECTIONAL WATERMAIN & SEWER FLUSHING

As it is understood, uni-directional watermain and sewer flushing has been an informal program performed on an irregular historical basis. In light of this, it is unclear whether SOPs exist and, if so, include descriptions for documenting and recording non-revenue water usage data. According to Public Works personnel, formal uni-directional watermain and sewer flushing programs is to commence this year (2024) and be formalized as an annual activity. In light of this, it recommended that:

- Newly created or updated SOPs include descriptions for documenting and recording water usage.

- Opportunities for optimizing water usage for uni-directional watermain and sewer flushing are investigated and implemented.

3.3.12 WTP IN-PLANT AND OTHER NEEDS

The WTP utilizes treated water for several in-plant processes. The process that consumes the highest volume of treated water is the backwashing operation for the filters, which includes both backwash and filter-to-waste sequences. During the backwash sequence, high volumes of treated water are pushed backwards through the filters to fluidize the filter media and remove particulate matter. The backwash water is discharged to the Backwash Waste Tank and subsequently to the City sewer system.

Following the backwash, a filter-to-waste sequence is operated, in which raw water is moved forward through the filter to rinse the filter media before it is returned to service. The filter-to-waste water is stored in the Filter-to-Waste Tank (also known as the Surge Tank) before being discharged to the City sewer. Both the Backwash Waste Tank and Filter-to-Waste Tank discharge outlets have orifice plates that restrict flow to the sewer to prevent surging, and both outlets are metered, however those flow rates are instantaneous and thus the same recommendation of replacing the flow meters to provide instantaneous, pulse and fieldbus communication (**Figure 12**).

The WTP also uses treated water for various domestic purposes, including toilets, sinks, faucets, and hoses. Additionally, some of the water monitoring equipment operates with a flow-through cell that draws and discharges small volumes of water on a continuous basis. The treated water supply line for QEC is connected to the domestic water supply line to the WTP. Although the QEC water supply line is metered, it is unclear whether the meter data is regularly recorded. It is recommended that both the WTP domestic water and the QEC Water flow meters be replaced and connected to the PLC.

There are several different connection points for the supply of treated water to the WTP and QEC for their various purposes, and understanding the locations of these connection points is important for assessing non-revenue water loss. These connection points are shown in **Figure 14**.

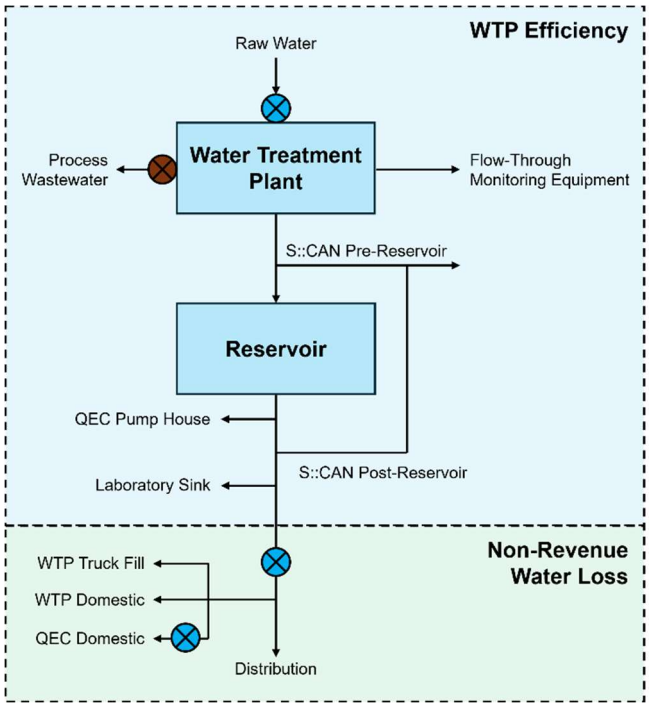

Figure 14: Connection points for treated water at the Water Treatment Plant and Reservoir.

As outlined in **Section 3.3.9**, two key performance indicators (KPIs) are essential when assessing water loss.

- The efficiency of the WTP in converting raw water into treated water (upstream of the post-reservoir flow meter).
- The non-revenue water loss (downstream of the post-reservoir flow meter), which is the primary focus of this investigation.

Although only the non-revenue water loss KPI is within the scope of this investigation, both of these KPIs are equally important in identifying opportunities to reduce the raw water draw from Lake Geraldine – an indirect driver for the overall Project.

The truck fill at the WTP, installed in 2022 as a backup for the truck fill station at Booster Station #1, is not metered and could potentially contribute to non-revenue water loss, as shown in **Figure 14**, However, Public Works staff indicated that the truck fill at the WTP has not yet been used, so it has not contributed to historical non-revenue water loss.

WSP recommends the following to the City regarding WTP in-plant and other needs:

- Consider installing a meter on the domestic supply header to the WTP/QEC to provide visibility on non-revenue water losses from these sources.

3.3.13 WWTP IN-PLANT NEEDS

Similarly, the WWTP uses treated water for in-plant needs including washing, cleaning, flushing, and other domestic purposes. A detailed review of all uses at the WWTP is beyond the scope of this investigation.

A meter is installed on the supply line to the WWTP, but it is unclear whether meter readings are collected in a manner consistent with those for typical customer connections. In light of this, WSP recommends the following:

- Confirm meter reading procedures at the WWTP and ensure centralized data storage for the readings.

3.4 SITE INVESTIGATION SUMMARY

Several potential sources of water loss were identified. This includes both:

- Non-revenue water loss, which compares metered water usage to water entering the distribution system (the scope of the investigation), and
- WTP efficiency, which accounts for the net efficiency of the WTP to convert raw water to treated water (outside the scope of this investigation).

A visual summary of all potential sources of water loss is given in **Figure 15**.

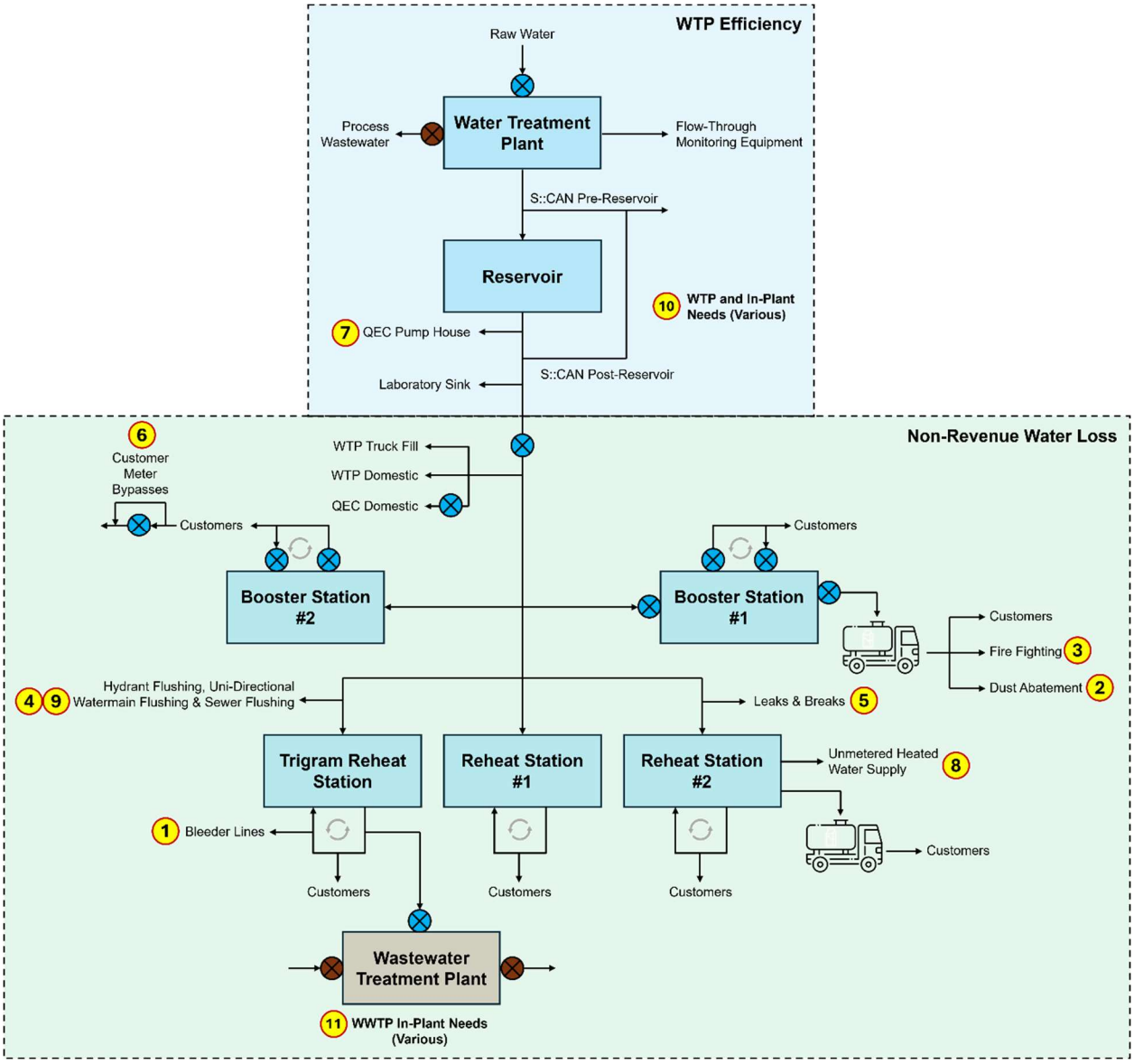

Figure 15: Simplified process flow diagram showing potential sources of non-revenue water loss.

4 ASSESSMENT AND RECOMMENDATIONS

Based on the site investigations and evaluation of the distribution system, following recommendations and strategies can contribute to improved system performance, reduced response times during system failures and enhance data collection.

4.1 FLOW METER LOCATIONS

Industry best practices recommend installing pressure and flow monitoring equipment on the supply, discharge, and return lines of all major water and wastewater infrastructure. Therefore, it is recommended that the City install pressure and flow monitoring devices at the following locations:

- WTP Truck Fill Station
- WTP Discharge to Reservoir
- Booster Station #2 Supply (or reconfigure existing flow meter to be ahead of fire pump)
- Trigram Reheat Station Supply (this is being moved to BS2)
- Trigram Reheat Station Return (this is being moved to BS2)
- Reheat Station #1 Supply (not connection to SCADA)
- Reheat Station #1 Return (not connection to SCADA)
- Reheat Station #2 Supply (not connection to SCADA)
- Reheat Station #2 Return (not connection to SCADA)
- Reheat Station #2 Truck Fill Station (not connection to SCADA)
- Lift Station #1 Supply (flow only)
- Lift Station #2 Supply (flow only)
- Lift Station #2 Discharge (flow only)

The combination of pressure and flow monitoring equipment at each station would significantly improve visibility of system performance and reduce response times for a leak or break. For example – at present, a break occurring in Lower Iqaluit (serviced through Reheat Station #2) would appear to operations staff as a break occurring in the Plateau, Federal Road, Core Area, Lower Iqaluit, or Happy Valley district with no system information on which district. Functional pressure and flow monitoring equipment installed at the recommended locations would narrow the search to the subject district, better inform the approach to dealing with the break, and assist with response times.

4.1.1 FLOW MEASUREMENTS

The existing flow meters provides an instantaneous flow value via a 4-20mA signal to the PLC. The PLC calculates the totalized volume by calculating the volume over 1 sec and adding it to a total. The estimated flow rate within this interval is estimated as follows:

$$\text{Estimated Flow Rate} = \Delta(\text{Totalized Flow}) / \Delta(\text{Time})$$

Calculating volume using flow rate no matter how little the interval will create error over time and introduces a higher degree of error against the onboard totalizer. To capture flow rates more accurately, it is recommended that the City replace its existing flow meters with flow meters that provide instantaneous flow rates using 4-20 mA, pulse rate using a dry contact and a fieldbus connection (using Ethernet/IP or Modbus TCP). It is also recommended that the City utilizes the same type of flow meter so that the operators are familiar with how each one works.

4.2 DATA ACQUISITION AND CENTRALIZED STORAGE

Some of the existing flow meters are not connected to the City's SCADA system. Consequently, collating and comparing flow rates across the City is time-consuming and requires manual data collection. Furthermore, the absence of active data upload to the SCADA system prevents real-time performance comparisons between City infrastructures. The lack of active monitoring can lead to longer response times in the event of leaks, breaks, or pressure loss events. Therefore, it is recommended that the City upgrade its flow meters to be able to connect to the local PLC's using Ethernet/IP communication protocol. In addition, the personal water meter program can likely export a file that could be imported into the SCADA providing up to date water usage.

Similarly, it is recommended that future flow meters be equipped with proper Ethernet/IP communications protocol so the PLC can gather the totalized value directly from the flow meter (see Flow Meter Locations discussion above).

Pending further investigations or information, the estimated relative degree of each of the potential sources of non-revenue water loss, or a range thereof (where a lack of supporting information is available), and their summarized recommendations are given in

Table 2.

Table 2: Relative estimated degree of potential sources of non-revenue water loss.

NO.	POTENTIAL SOURCE	RELATIVE ESTIMATED DEGREE	RECOMMENDATIONS
1	Bleeder Lines	Moderate	➢ Install meters on the bleeder lines not currently equipped with meters. ➢ Review existing SOPs to identify opportunities to limit bleeder line usage (i.e., seasonal/temperature thresholds). ➢ Identify and take advantage of opportunities to eliminate bleeder lines. Upgrading the return piping in the Happy Valley cul-de-sacs may be one of such opportunities. ➢ Review and update protocols for meter reading and centralized recording practices.
2	Dust Abatement	Low	➢ Review SOPs to identify opportunities to reduce water usage (i.e., preventing over-application). ➢ Review and update protocols for meter reading and centralized recording practices.
3	Fire Fighting	Medium to High	➢ Review and update protocols for meter reading and centralized recording practices for the Fire Department (including training) and trucked services. ➢ Explore opportunities to increase hydrant coverage, including expanding the piped distribution system to customers who are currently dependant on trucked services for water.
4	Hydrant Flushing and Testing	Low	➢ Newly created or updated SOPs include descriptions for documenting and recording water usage. ➢ Opportunities for optimizing water usage during hydrant flushing and testing are investigated and implemented.
5	Leaks and Breaks	Moderate to High	➢ Install pressure and flow monitoring equipment at strategic locations throughout the City to better inform the location of a leak or break during a pressure loss event. ➢ Replace obsoleted pipe material and aged piping with modern piped infrastructure to mitigate the risk and severity of leaks and breaks (addressed, in part, by the Long-Term Water Project). The City could also consider installing flex couplings to better account for ground shifting. ➢ Review existing leak and break response protocols to identify opportunities for reducing response times.
6	Meter Bypasses	Low to High	➢ Create and execute a program to assess (directly or indirectly) the frequency and severity of customer meter bypass usage. ➢ Retrofit tags and/or tamper resistant equipment on existing meter bypasses and install new meters with equivalent equipment. ➢ Enact a City bylaw and corresponding administrative penalty for customers that illegally operate their meter bypass.

NO.	POTENTIAL SOURCE	RELATIVE ESTIMATED DEGREE	RECOMMENDATIONS
7	QEC Fire Pump Station	Unknown	➢ Request further information from QEC regarding potential metering infrastructure and usage records. Actionable follow-ups are dependent on this information, or its availability thereof.
8	Reheat Station #2 Unmetered Heated Water Supply	Low to Moderate	➢ Effectively communicating with third parties the City's interest in no longer providing unrestricted access to the heated water supply and upgrading site security measures accordingly. ➢ Install water meters at supply point(s). ➢ Consider installing a metered pay-per-use system at the preferred supply point. It is recommended that the supply point be the currently unused truck fill arm and contractors are to operate it at their own risk.
9	Uni-Directional Watermain and Sewer Flushing	Low to Moderate	➢ Newly created or updated SOPs include descriptions for documenting and recording water usage. ➢ Opportunities for optimizing water usage for uni-directional watermain and sewer flushing are investigated and implemented.
10	WTP In-Plant and Other Needs	Low	➢ Consider installing a meter on the domestic supply header to the WTP/QEC to provide visibility on non-revenue water losses from these sources.
11	WWTP In-Plant Needs	Moderate	➢ Confirm meter reading procedures at the WWTP and corresponding centralized data storage.

4.3 PRIORITY RECOMMENDATIONS

Priority recommendations for approaching and/or addressing non-revenue water loss are summarized below.

4.3.1 INFORMATION AND DATA GATHERING

Knowledge gaps exist for a majority of potential sources of non-revenue water losses. Priority knowledge gaps to be addressed are:

1. Annual quantity of water discharged for bleeder lines.
2. Average/annual quantity of water used for firefighting purposes.
3. Customer meter bypass usage.
4. QEC fire pump house metering infrastructure and water usage.
5. Reheat Station #2 estimated third-party heated water usage.

4.3.2 POLICIES AND STANDARD OPERATING PROCEDURES

Several policies or SOPs can hinder data collection or increase ongoing risk of non-revenue water loss. Priority recommendations for these include:

1. Review SOPs for dust abatement, hydrant flushing & testing, and uni-directional watermain & sewer flushing to identify opportunities to reduce water usage. Review and update protocols for accounting for the respective water usages and centralized recording practices.
2. Review and update protocols for centralized recording practices of water used for firefighting purposes.
3. Update bylaws and administrative penalties for customers that operate their meter bypasses.

4.3.3 INFRASTRUCTURE UPGRADES

Priority recommended infrastructure upgrades are targeted at providing better visibility of system performance and understanding and how water moves through the system. These upgrades include:

1. Install flow meters on all existing and future bleeder lines.
2. Install flow and pressure monitoring equipment at industry best practice locations.
3. Fix faulty and calibrate existing flow meters. In the case of the flow meter at Booster Station #2 – either move the existing supply flow meter or modify system operation to gather the intended flow data.
4. Replace existing totalizing flow meters with instantaneous flow meters.
5. Upgrade ethernet and ICPs to improve the centralized storage of flow meter data.
6. Install flow meter at Reheat Station #2. Consider pay-per-use system for future third-party use.
7. Install tags or tamper-resistant infrastructure on customer meter bypass lines.

In conclusion, the recommended upgrades and strategies outlined are crucial for improving the City's water infrastructure. By installing the pressure and flow monitoring equipment, upgrading to instantaneous flow meters, and enhancing data acquisition and storage through centralized systems, the City will benefit from greater visibility into system performance and faster response times in the event of leaks or breaks.