Mount Albert Water Supply Upgrades Class Environmental Assessment

System Capacity Optimization Study

Final Draft

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Regional Municipality of York

Region of York

JACOBS

Mount Albert Water Supply Upgrades Class Environmental Assessment

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Contents

1. Introduction

The Mount Albert community, located within the Town of East Gwillimbury, is supplied with drinking water from groundwater wells owned and operated by the Regional Municipality of York (Region). The Region is also responsible for providing, maintaining and operating treatment and water storage facilities within this drinking water system. The Mount Albert Water Supply System has historically experienced aesthetic water quality issues related to iron and manganese as a result of the presence of these constituents in the source water. The Region has engaged Jacobs to undertake a Schedule 'B' Class Environmental Assessment (EA) to identify the best approach for resolving customer complaints with current water quality, meeting anticipated changes in manganese regulations and providing system redundancy and reliability (including optimization of supply and system storage).

The purpose of this Technical Memorandum (TM) is to describe the baseline conditions of the Mount Albert water supply system and based on the finding of the Hydraulic Analysis Study (March 2020) and other completed and on-going studies related to Mount Albert Water Supply System, identify opportunities for performance enhancement and optimization of existing infrastructure. The optimization includes addressing water supply and storage redundancy and strategies for operating the system with the Mount Albert North Elevated Tank offline for maintenance. The findings of this study will be carried forward to support the Needs Assessment and Justification Study. Documentation and additional information used in the development of this report are listed in Appendix A.

2. Baseline Conditions

2.1 System Description

The Mount Albert Water Supply System consists of three municipal supply wells, located at two treatment facilities and two elevated storage tanks that are owned and operated by the Region. The local distribution system is owned and operated by the Town of East Gwillimbury, as shown in Figure 2-1.

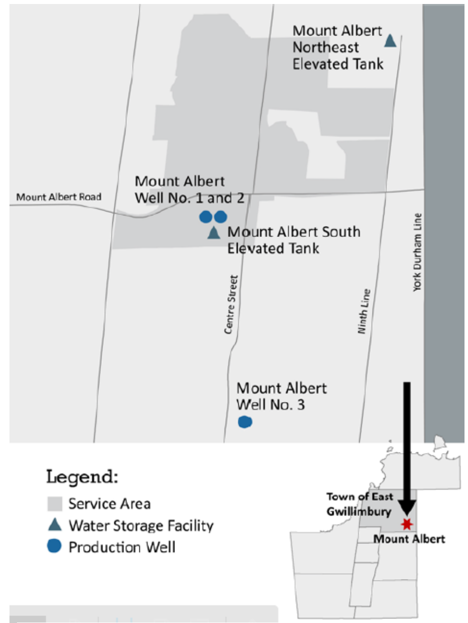


Figure 2-1: Location of Mount Albert Distribution System

The system is supplied solely by groundwater that contains elevated levels of iron and manganese. The well supplies are treated using sodium silicate for sequestration to minimize deposition in the distribution system and discoloured water issues. Chlorine is added to support sequestration, as well as to provide primary and secondary disinfection.

The Mount Albert Water Supply System is represented schematically in Figure 2-2. Table 2-1 provides an overview of the Mount Albert Water Supply System. Details of the major system components are provided in the subsequent sections.

Mount Albert Well 1 is currently not being used due to manganese concentrations in the raw water reaching the maximum acceptable concentration (MAC) for manganese of 0.12 mg/L, as identified by Health Canada.

Under normal operation, Mount Albert Well 3 operates as the duty well, with Mount Albert Well 2 started and stopped to meet system demand as measured by level setpoints in Mount Albert North Elevated Tank. The operation of the Mount Albert Water Supply System is monitored, controlled, and recorded through the Region’s central SCADA control system.

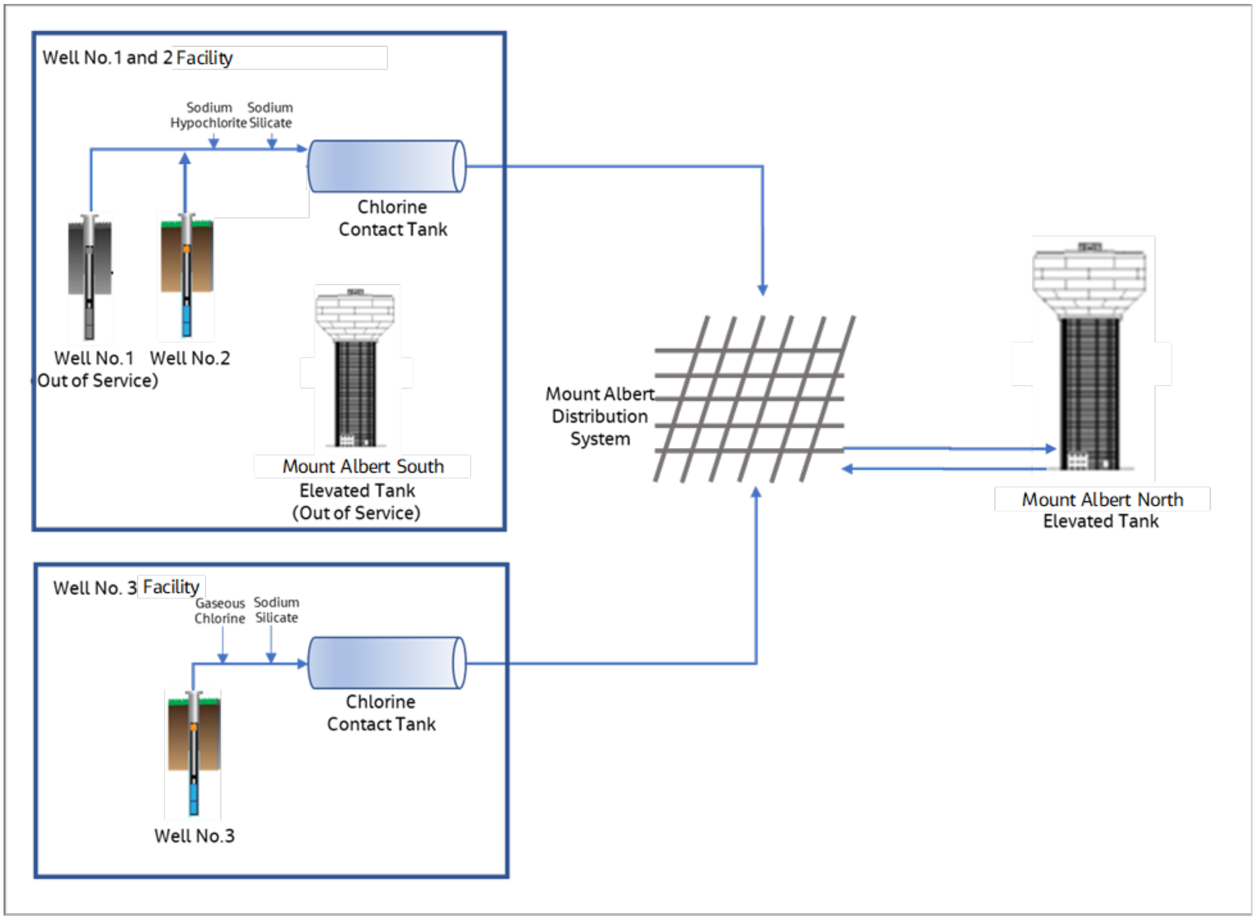


Figure 2-2. Overview of Mount Albert Water Supply System

Table 2-1. Mount Albert Water Supply System Overview

Item	Description
System Name	Mount Albert Water Supply System
MECP Drinking Water System Numbers:	Town of East Gwillimbury Mount Albert Drinking Water System: 260002265 Mount Albert Drinking Water Sub-System (York Region): 220006543
York Region Area	3
Municipality Serviced	Town of East Gwillimbury: Community of Mount Albert
Water Source(s)	Three groundwater wells owned and operated by the Region: • Mount Albert Well 1 (Currently not in operation due to high manganese concentration) • Mount Albert Well 2 • Mount Albert Well 3
Permit to Take Water	The permit to take water (PTTW) defines the maximum water taking allowed from the three wells in this system, as a combined daily taking from any combination of Wells 1 to 3 of 4,990 m^3/day (57.8 L/s) with a maximum taking per minute per well of 2,273 L/min (37.88 L/s) (PTTW 1312-AVKKZM dated February 13, 2018).

Item	Description
Treatment	Water from Wells 1 and 2 are combined and treated at the Mount Albert Wells 1 and 2 Pumphouse. Treatment consists of sequestration with sodium silicate and disinfection with sodium hypochlorite. Water from Wells 3 is treated at the Mount Albert Well 3 Pumphouse. Treatment consists of sequestration with sodium silicate and disinfection with chlorine gas.
System Description	The distribution system is comprised of a single pressure zone supplied from Wells 1, 2, and 3. There are two storage facilities: • Mount Albert North Elevated Tank (operational) • Mount Albert South Elevated Tank (out-of-service for approximately 15 years)
Service Area Elevation Range[(a)]	245 to 282 m, range of 37 m
Hydraulic Grade Line	304.79 to 313.94 m (Water Level Report dated June 5, 2017)
Fire Storage Requirement [(b)]	1,200 m^3
Associated Permits and Approvals	Production wells: • Permit to Take Water No. 1312-AVKKZM, dated February 13, 2018 to replace 0050-7FCMMY, dated June 9, 2008 Drinking water system: • Municipal Drinking Water Licence No. 013-103, dated January 27, 2015 • Drinking Water Works Permit No. 013-203, dated January 27, 2015 Distribution system: • Municipal Drinking Water Licence No. 117-101 • Drinking Water Works Permit No. 117-201
Distribution System Residual (Secondary Disinfectant)	Free chlorine
Wastewater Treatment Plant(s) and Receiving Water Body(ies)	The stand-alone Mount Albert Water Resource Recovery Facility (WRRF) supports wastewater collection in Mount Albert. The facility is a tertiary extended aeration treatment facility with chemical phosphorus removal, sand filtration, and UV disinfection, and has a capacity of 2.04 MLD. The facility discharges to Mount Albert Creek and Vivian Creek, water from both of which ultimately flows to Lake Simcoe.

Notes:

a) Service area elevations as indicated on Pressure District Data table provided by the Region. The pressure district has an elevation range of 37 m which is 7 m more than the typical range for the Region pressure districts as defined in Section 16.7.2 of the Region Design Guidelines (2017).

b) Fire storage requirement is based on providing, in storage, the amount of water defined by the Region Design Guidelines for a small water system to satisfy a fire water demand of 10,000 L/min for a duration of 2 hours.

2.2 Well Facilities

2.2.1 Mount Albert Wells 1 and 2

2.2.1.1 Overview

Mount Albert Wells 1 and 2 are housed at the Wells 1&2 Treatment Facility, where treatment is provided for these two wells. Well 1 is located inside the pumphouse, and Well 2 is located outside on the property, approximately 50 m southwest of the facility. Well 1 was constructed in 1977 and Well 2 was constructed in 1993. An overview of the wells is provided below in Table 2-2, with historical raw and treated water quality summarized in Table 2-3 and Table 2-6, respectively. Well 1 was removed from service in June 2017 due to the high manganese concentration in this well water.

Table 2-2. Overview of Mount Albert Wells 1 and 2

Item	Well 1 (MTA PW 1)	Well 2 (MTA PW 2)	Comment
Source Aquifer	Thorncliffe aquifer (deep aquifer system)	Thorncliffe aquifer (deep aquifer system)	
Well Pump Capacity	2,265 L/min (37.8 L/s) at 100 m TDH (VFD)	2,265 L/min (37.8 L/s) at 100 m TDH (VFD)	Total available pumping capacity: 6,524 m^3/d (75.5 L/s)
Well Pump Type	Vertical turbine pump	Submersed pump	
Permitted Capacity	3,273 m^3/d (37.88 L/s)	3,273 m^3/d (37.88 L/s)	PTTW maximum taking is 4,990 m^3/d (57.75 L/s) from any combination of the 3 wells in the system.
Date Well Drilled	October 24, 1977	November 1, 1993 (rehabilitated in 2011 and 2012)	
Well Depth	64 metre	64 metres	

2.2.1.2 Raw Water Quality

The raw water quality of Wells 1 and 2 is summarized in Table 2-3, based on 5 years of historical data (2014 to 2018). In some cases, as noted in Table 2-3, data limitations either due to minimal sampling events or variations in reported method detection limit (MDL) have been addressed by expanding the analysis to consider datasets from previous years.

The applicable limits as identified in O. Reg. 169/03: Ontario Drinking Water Quality Standards (ODWQS), the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines and relevant guidance from Health Canada are presented for comparison purposes, where applicable. It should be noted that the only water quality parameters that are enforceable are those stated in O.Reg. 169/03. Any parameter identified as an aesthetic objective or operational guideline provided by the Ministry of Environment, Conservation and Parks (MECP) are provided for comparative reference, and guidance published by Health Canada are provided as context for potential future regulatory changes. The parameters selected were those which can potentially have a water quality impact on the treatment process or distribution system water quality or residual maintenance.

Table 2-3. Raw Water Quality for Mount Albert Wells 1 and 2

Parameter	Drinking Water Standards or Guidelines [1]	Well 1			Well 2		
		Minimum	Average[2]	Maximum	Minimum	Average[2]	Maximum
Dissolved Organic Carbon, mg/L	5 (AO)	0.48	0.78	1.18	0.46	0.72	1.16
pH	6.5-8.5 (OG)	7.8	7.94	8.1	7.8	8.02	8.2
Alkalinity, mg/L as $CaCO_3$	30-500 (OG)	233	242	254	225	229	235
Hardness, mg/L as $CaCO_3$	80-100 (OG)	192	292	345	162	259	299
Ammonium and Ammonia, mg/L as N[3]	0.1[4]	0.09	0.28	0.38	<0.05	0.17	0.25
Nitrate, mg/L as N[5]	10 (MAC)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrite, mg/L as N[6]	1 (MAC)	<0.008	0.038	<0.25	<0.008	0.038	<0.25
Methane[7], L/m^3	3 (AO)	0.01	0.015	0.026	0.011	0.018	0.052
Sulfide, mg/L as H_2S[5,8]	0.05 (AO)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Iron, total, mg/L	0.3 (AO)	0.67	0.89	1.11	0.44	0.60	0.89
Manganese, total, mg/L	0.05 (AO) HC: 0.12 (MAC)[9], 0.02 (AO)[10]	0.081	0.104	0.120	0.048	0.059	0.068
Sodium, mg/L	200 (AO)[11]	5.8	8.1	10.1	3.8	4.4	6.0
Calcium, mg/L		57.0	84.8	100.0	46.4	73.5	85.0
Magnesium, mg/L		11.9	19.1	22.9	11.1	18.3	21.1
Chloride, mg/L	250 (AO)	20.6	29.3	41.2	8.2	13.8	21.5
Sulfate, mg/L	500 (AO)	23.4	39.9	61.6	19.8	30.7	36.1
Phosphate, mg/L[6, 12]		<0.005	0.028	0.090	<0.01	0.026	0.060

Notes:

1. Ontario Drinking Water Standards (ODWS) O.Reg. 169/03 – Maximum Acceptable Concentration (MAC); Aesthetic Objectives (AO) and Operational Guidelines (OG) as presented in the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (MOE, 2006).
2. Where some of the measured values were reported as less than the Method Detection Limit (MDL), the average was calculated by assigning half the MDL to those values. If all measured values were less than MDL or if the average was less than the MDL, the average is indicated as being less than the MDL.
3. The data reported for ammonia for 2016 to 2018 for Wells 1 and 2 had a single value of 0.2 mg/L to a Reportable Detection Limit (RDL) of <1.25 mg/L. This unusually high RDL of < 1.25 mg/L would skew the results if used as described in Note 2, and therefore, the historical values for 2010 to 2015 are presented for this parameter.

4. Health Canada's Drinking Water Guidelines recommend limiting excess free ammonia to below 0.1 mg/L-N to help prevent nitrification; however, there is no aesthetic objective or maximum acceptable concentration noted.
5. Measurements from all sampling events were lower than the MDL or RDL.
6. Different MDLs or RDLs reported for different sampling dates. The minimum is reported as the minimum measured value or as the lowest MDL/RDL noted, whichever was lower. The calculated average, as described in Note 2, was compared to the highest MDL/RDL and, where it was lower than this value, is reported as such here. The maximum is reported as the maximum measured value or, where all values were lower than MDL/RDL, as the highest MDL/RDL noted.
7. Methane results from two sampling events conducted between 2002 and 2018.
8. Sulfide results from six sampling events conducted between 2001 and 2019.
9. Maximum Acceptable Concentration [MAC] under Health Canada's Drinking Water Guidelines.
10. Aesthetic Objective (AO) under Health Canada's Drinking Water Guidelines.
11. MOE (2006) notes that "The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L, so that this information may be passed on to local physicians".
12. The data reported for phosphate for 2016 to 2018 for Wells 1, 2 and 3 from the MDL of <0.01 to RDL of <2.5 mg/L. The unusually high RDL of <2.5 mg/L would skew the results if used as described in Note 2, and therefore, the historical values for 2010 to 2015 are presented for this parameter using the method described in Note 2 for values reported as less than the MDL for this time period.

The following are noted from the review of raw water quality data:

- Manganese concentrations appear to be relatively stable over the past five years with no consistent increase or decrease observed with respect to time in either well. Manganese concentrations range from 0.081 - 0.120 mg/L for Well 1 and 0.048 - 0.068 mg/L for Well 2, with results exceeding the aesthetic objective of 0.05 mg/L. While concentrations approach the Health Canada MAC of 0.12 mg/L, the (AO) of 0.02 mg/L is exceeded. In addition, results also exceed the treated water operational goal of ≤0.015 mg/L that Health Canada recommends for removal treatment plants to minimize the accumulation of manganese in the distribution system and the associated potential release of manganese or other contaminants in the distributed water. At present, no changes have been proposed to implement a MAC for manganese under the Ontario Drinking Water Quality Standards; however, this information is presented for consideration of potential future regulatory changes.

- Iron concentrations in both wells are above the Ontario AO of 0.3 mg/L with averages at or above double the AO. Concentrations have been variable with no defined trend with respect to time; however, it is noted that the concentrations in Well 1 are significantly higher than those measured in Well 2.

- No consistent increase or decrease in ammonia concentration with respect to time was identified.

- No consistent increase or decrease in sodium or chloride concentrations with respect to time was observed from this data for either Wells 1 or 2.

- Methane concentrations are low and do not require any specific treatment.

- Hardness is high in both wells at greater than two times the upper operational guideline.

2.2.1.3 Treatment Process

The treatment provided at this facility includes the addition of sodium hypochlorite and sodium silicate to the water in order to sequester the iron and manganese. The addition of sodium hypochlorite provides for the disinfection of the water supply. The chemicals are added to the raw water at the individual well discharge headers (one from each well). These headers combine to a single pipe that then flows through an in-ground, pressurized, chlorine contact tank that provides the required chlorine contact time for primary disinfection. The treated water then enters the distribution system via a single watermain.

A rehabilitation contract is underway at the facility to install new chemical feed systems and monitoring as well as a standby generator. The work is scheduled for completion in March 2020.

Well Pump 1 was equipped with a direct drive diesel engine for standby power supply, which was recently removed. The new 150 kW diesel generator and automatic transfer switch will provide sufficient capacity to power the entire facility.

The two well pumps discharge and combine into a common header where duty and standby sodium hypochlorite and sodium silicate injection points are located. The chemical feed systems for sodium hypochlorite and sodium silicate were upgraded in the rehabilitation contract. Each system now consists of duty and standby chemical feed pump, piping, valves, controls and a common calibration column. A tempered water flushing system has been provided to allow cleaning of the calibration column and injection lines.

The equipment list and facility components are summarized in Table 2-4, and the process-related instrumentation list is presented in Table 2-5.

Table 2-4. Chemical Feed System Components for Mt. Albert Wells 1 and 2 Treatment Facility

Item	Equipment/Facility Component
Sodium Hypochlorite	Two (2) sodium hypochlorite metering pumps (Prominent Gamma X, diaphragm), each rated at 12.9 L/h rated at 703 kPa TDH, Two (2) sodium hypochlorite tanks (680 L each)
Sodium Silicate	Two (2) sodium silicate metering pumps (Grundfos DDA, diaphragm), each rated for 17 L/h at 703 kPa TDH One (1) inground sodium silicate storage tank (5,400 L) with mixer
Chlorine Contact Tank	One (1) in-ground chlorine contact tank Dimensions: 2.1 m diameter (ID) × 26.0 m length; total volume of 90.05 m^3 Baffle factor: 0.7 Hydraulic retention time (at PTTW Maximum of 57.75 L/s): 25.99 min Effective contact time (at PTTW of 57.75 L/s): 18.19 min

Table 2-5. Instrumentation List for Mt. Albert Wells No. 1 and 2 and Treatment Facility

Category	Type/Description	Location
Flow Control and Measurement	Well pump 1 discharge header flow meter, 100 mm dia.	Wellhouse, Pump Room
	Well pump 2 discharge header flow meter, 100 mm dia.	Wellhouse, Silicate Room
Level Measurement	Sodium silicate storage tank level transmitter	Wellhouse, Silicate Room
	Sodium hypochlorite storage tank 1 level transmitter	Wellhouse, Chlorine Room
	Sodium hypochlorite storage tank 2 level transmitter	Wellhouse, Chlorine Room
Chlorine Measurement	Pre-chlorine contact tank free chlorine analyzer (process)	Wellhouse, Silicate Room
	Post-chlorine contact tank free chlorine analyzer (regulatory)	Wellhouse, Silicate Room
Others	Turbidity analyzer	Wellhouse, Pump Room

The duty sodium hypochlorite and silicate feed pumps are flow paced to the raw water flow signal of the duty well pump. The duty chemical feed pump starts and stops based on the open/close status of the limit switch of the check valve of the duty well pump. The chemical dosages are operator-adjustable through SCADA, or locally by adjusting the operating speed of the metering pump. The sodium hypochlorite pumps are also residual feed-back controlled within a target range as measured upstream of the chlorine contact tank.

The sodium hypochlorite feed system dosage is adjusted to target a free chlorine residual of 1.5 mg/L after the chlorine contact tank, and the silicate feed system is set to supply a dosage of 26 mg/L silicate which is the maximum dosage for the Region groundwater facilities practicing iron and manganese sequestration, in line with 10 State Standards (2018) recommendations.

During a site visit conducted with operations staff in 2016 though the on-going Region Groundwater Treatment Strategy (GWTS) project, it was noted that there are challenges achieving the silicate target dosage as feed pump adjustments were being made based on a calculated dosage using the well pump flow rate and level differential in the bulk storage tank. Due to the large volume of the bulk storage tank, a small variance in the tank level could result in a significant variance in the “calculated” chemical dosage, triggering inaccurate adjustments to the feed pumps. It was also noted that frequent adjustment of the dosage should not be required, as the raw water quality does not generally fluctuate on a day to day, week to week basis. The challenge with dosing sodium silicate was also noted during a site visit conducted with operations staff in 2019 as part of this study, during the iron and manganese sampling program and subsequently verified through Region analysis of silicate levels in the treated water supply which showed levels as Na_2SiO_3 more than 50% higher than the SCADA set-point.

Sodium silicate can have a shelf life of 18 months provided that storage conditions are optimized, such as having cone-shaped or sloped bottoms where particulate can settle and providing mixing to avoid silicate dehydration (20 minutes every 24 hours) and regular cleaning of the storage tanks (as recommended by the manufacturer, National Silicates). At design flows of 38 L/s (24 hours per day) and a dosage of 26 mg/L, the plant would use the sodium silicate volume stored on-site in 25 days. At the current plant flow of 23 L/s, the tank capacity would be consumed in about 6 months. However, it should be noted that the sodium silicate delivered to the Mount Albert facilities originates from the bulk storage tanks located at the Aurora Wells 1-4 Treatment Facility, which would add to the chemical age depending on the rate of usage in the Region. Aged or improperly stored sodium silicate can result in:

- A loss in product performance
- Formation of precipitates that can clog chemical injection systems
- Product stratification that can result in under or overdosing

These issues may be improved through the use of smaller storage tanks that can be easily cleaned and through automation or scheduled daily operation for the tank mixer.

2.2.1.4 Treated Water Quality

The treated water quality for this facility is summarized in Table 2-6, based on five (5) years of historical data (2014-2018, unless otherwise noted). The applicable limits as identified in O. Reg. 169/03: Ontario Drinking Water Quality Standards and the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines are presented for comparison purposes.

Table 2-6. Treated Water Quality for Mt. Albert Wells 1 and 2

Parameter	Drinking Water Standards or Guideline [1]	Wells 1 and 2		
		Minimum	Average[2]	Maximum
Dissolved Organic Carbon, mg/L	5 (AO)	0.5	0.9	1.3
pH	6.5-8.5 (OG)	7.9	8.1	8.3
Alkalinity, mg/L as $CaCO_3$	30-500 (OG)	233	244	253
Hardness, mg/L as $CaCO_3$	80-100 (OG)	180	265	309
Ammonium and Ammonia, mg/L as N[3, 4]	0.1[5]	<0.005	<0.10	0.04
Nitrate, mg/L as N[3,6]	10 (MAC)	<0.001	0.098	<0.5
Nitrite, mg/L as N[3]	1 (MAC)	<0.003	0.019	<0.25
Methane, L/m^3	3 (AO)	0.028	0.050	0.084
Iron, total, mg/L	0.3 (AO)	0.411	0.610	0.924
Manganese, total, mg/L	0.05 (AO) HC: 0.12 (MAC)[7], 0.02 (AO)[8]	0.049	0.066	0.089
Sodium, mg/L	200 (AO)[9]	8.5	11.4	16.0
Calcium, mg/L		52.8	76.3	90.6
Magnesium, mg/L		11.6	18.2	20.0
Chloride, mg/L	250 (AO)	16.0	26.7	42.0
Sulfate, mg/L	500 (AO)	22.5	35.3	41.5
Phosphate, mg/L[10]		<0.01	0.03	0.05
Chlorine Residual, mg/L	0.05 (minimum)[11] 4.0 mg/L (maximum)[11]	See Figure 2-3	See Figure 2-3	See Figure 2-3
N-Nitrosodimethylamine, ng/L[12]	9.0 (MAC)	<0.9	<0.9	<0.9
Nitrilotriacetic Acid (NTA), mg/L[13]	0.4 (MAC)	<0.05	<0.05	<0.05

Notes:

1. Ontario Drinking Water Standards (ODWS) O.Reg. 169/03 – Maximum Acceptable Concentration (MAC); Aesthetic Objectives (AO) and Operational Guidelines (OG) as presented in the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (MOE, 2006)
2. Where some of the measured values were reported as less than the MDL, the average was calculated by assigning half the MDL to those values. If all measured values were less than MDL or the calculated average was less than the MDL, the average is indicated as being less than the MDL.
3. Different MDLs or RDLs reported for different sampling dates. The minimum is reported as the minimum measured value or as the lowest MDL/RDL noted, whichever was lower. The calculated average, as described in Note 2, was compared to the

highest MDL/RDL and, where it was lower than this value, is reported as such here. The maximum is reported as the maximum measured value or, where all values were lower than MDL/RDL, as the highest MDL/RDL noted.

4. The data reported for ammonia for 2016 to 2018 for Wells 1 and 2 ranged from a MDL of <0.1 to a RDL of <1.25 mg/L. This unusually high RDL of <1.25 mg/L would skew the results if used as described in Note 2, and therefore, the historical values for 2010 to 2015 are presented for this parameter.
5. Health Canada's Drinking Water Guidelines recommend limiting excess free ammonia to below 0.1 mg/L-N to help prevent nitrification; however, there is no aesthetic objective or maximum acceptable concentration noted.
6. Nitrate data for April 13, 2017 reported as a RDL of <2.5 mg/L was excluded from the analysis as half the MDL was higher than historical values and would have significantly skewed the results.
7. Maximum Acceptable Concentration [MAC] under Health Canada's Drinking Water Guidelines.
8. Aesthetic Objective (AO) under Health Canada's Drinking Water Guidelines.
9. MOE (2006) notes that "The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L, so that this information may be passed on to local physicians" Ontario Drinking Water Standard under O.Reg. 169/03.
10. The values presented are for the period from 2010 to 2015. The data from 2016 to 2018 for Wells 1 and 2 Facility, 3 of the 12 data points were actual reported values ranging from 0.03 to 0.05 mg/L, while the remaining values were reported as either less than the MDL of <0.01 or <0.05 mg/L or less than the RDL of <2.5 mg/L. For Well 3 Facility, all values reported were less than the MDL or RDL. Using the values reported for 2016 to 2018 in the manner described in Note 2 would skew the results, and therefore, the data from 2010 to 2015 are used.
11. Procedure for Disinfection of Drinking water in Ontario (MECP, 2018). Minimum and maximum free chlorine residuals when using chlorine as a secondary disinfectant at a pH of 8.5 or lower. The maximum value of 4.0 mg/L for free chlorine is a recommended high and does not result in an adverse result if exceeded. Data shown is from 2012 to 2016.
12. No values were reported for 2014 or 2015. The three values reported from 2016 to 2018 were the MDL of <0.9 ng/L.
13. The values presented are for the period from 2010 to 2013, as there was no data available for NTA from 2014 to 2018. The values reported from 2010 to 2013 were all lower than the MDL.

The free chlorine residuals entering the distribution system from the Well 1&2 Treatment Facility (as measured downstream of the chlorine contact tank, where disinfection contact time is achieved) for the historical period from January 2016 through to December 2018 (excluding March and April 2016, as data was missing for this time period) are presented in Figure 2-3.

Between January 2016 to early 2017, the daily average chlorine residual leaving the facility was 1.51 mg/L with maximum variability of 1.7 mg/L day to day (minimum average day to maximum average day, where 90% of the values fell within 0.88 mg/L of each other). The data shows that the treated water free chlorine residual has been maintained within a tighter band since the Region completed upgrades to the control system at the facility in late November 2016 to incorporate the residual feedback control on the chlorine dose as measured upstream of the chlorine contact tank. From May 2017 to December 2018, the average chlorine was 1.46 mg/L with a maximum variability of 1.1 mg/L day to day (minimum average day to maximum average day, where 90% of the values fell within 0.44 mg/L of each other).

The target residual of 1.5 mg/L is based on maintaining a free chlorine residual above the regulatory minimum of 0.05 mg/L and above the minimum operating target of 0.4 mg/L throughout the distribution system. The target residual for the secondary disinfectant residual is based on experience in the system to maintain the residual throughout the distribution system above the regulatory minimum at the ends of the distribution system after allowing for chlorine decay due to water age, to suppress the potential for regrowth in the drinking water system and provide disinfection should contaminants enter the distribution system.

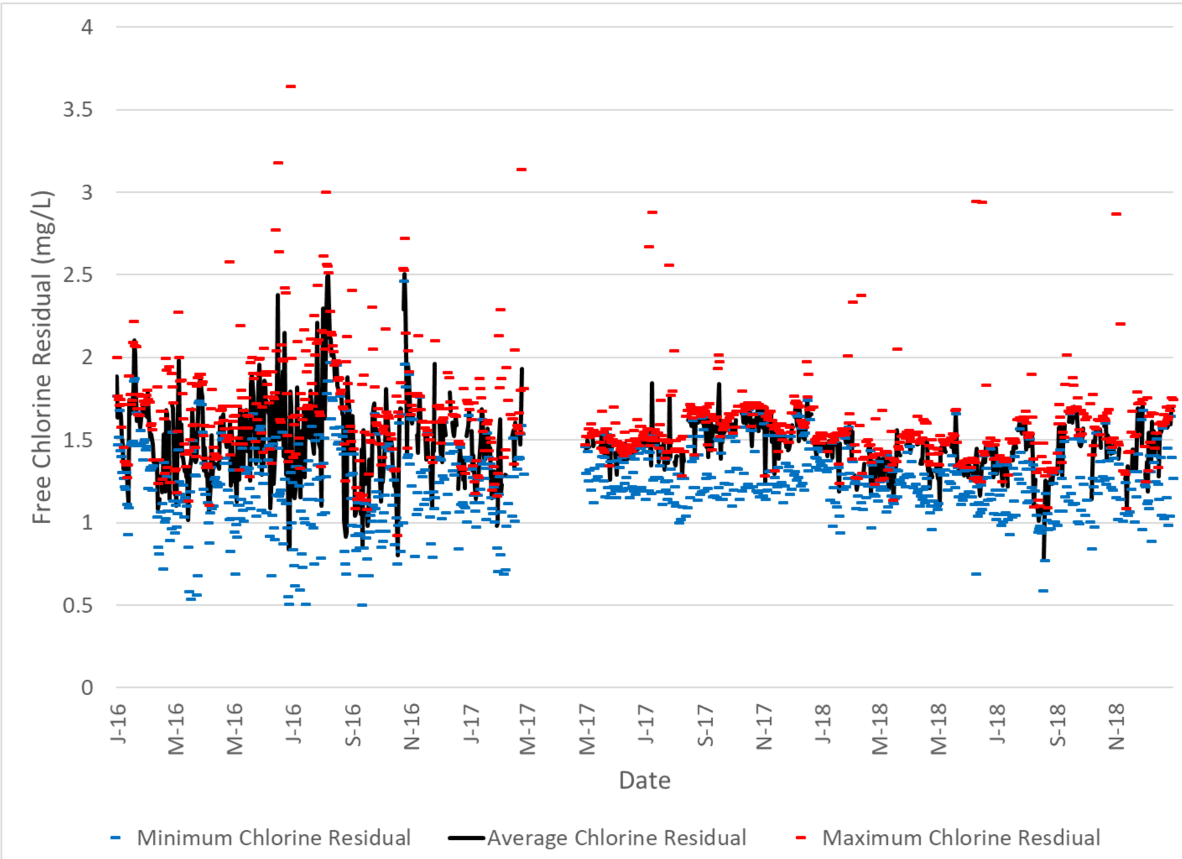


Figure 2-3. Free Chlorine Residual – Chlorine Contact Tank Effluent – Wells 1&2 Treatment Facility

The following observations are made with respect to treated water quality at Wells 1 and 2:

- Chlorine: The free chlorine residual entering the distribution system is maintained on average at 1.5 mg/L.
- Manganese: Manganese concentrations typically exceed the aesthetic objective of 0.05 mg/L but are less than the Health Canada MAC guideline of 0.12 mg/L. With Well 1 in operation, the treated manganese concentrations would be higher with the contribution of the higher raw water manganese concentrations in Well 1 water. The removal of Well 1 from operation reduced the overall average manganese concentration entering the distribution system from this facility.
- Iron: Iron concentrations are double the aesthetic objective of 0.3 mg/L for iron. The treated water iron concentrations from 2016 to 2018 range from 0.43 to 0.92 mg/L.
- Ammonia: Ammonia concentrations are much lower than in the raw water due to the use of breakpoint chlorination to achieve a free chlorine residual.
- Sodium: Sodium concentrations are higher than in the raw water due to the addition of sodium hypochlorite and sodium silicate for disinfection and sequestration, but concentrations are still well below the 20 mg/L level that requires that the Medical Officer of Health be notified.

2.2.1.5 Primary Disinfection

Primary disinfection is achieved in the Mount Albert Water Supply System with the use of a free chlorine residual.

For primary disinfection, to achieve 2-log virus inactivation, a CT of 4 min*mg/L is required under conditions of pH of 6 to 9 and temperature at 5ºC. In order to achieve this in the existing chlorine contact tank at the Wells 1&2 Treatment Facility at the maximum permitted daily flow of 57.75 L/s, a minimum chlorine residual at the chlorine contact tank effluent of 0.22 mg/L is required to be maintained, well below the current residual target and recorded values.

The current guidance from Health Canada for enteric viruses (which is understood to be in consideration for implementation by MECP) recommends achieving a 4-log virus inactivation or a CT of at least 8 min*mg/L for groundwater. At the maximum permitted daily flow, a minimum free chlorine residual at the chlorine contact tank effluent of 0.44 mg/L would be required. This represents a conservative estimation as the wells do not currently operate at the permitted maximum capacity, nor is Well 1 currently in service.

2.2.1.6 Well Performance Assessment

The Region reports on well performance on an annual basis based on the results of well efficiency calculations. When the calculations reveal a decline of well performance greater than 20%, in-field well performance test are recommended to further assess potential performance issues.

The 2018 Performance Evaluation for the Region Production Wells (March 26, 2019) reported large improvements in well performance for Well 2; however, noted that the improvement was likely related to shifting supply to Well 3, due to its improved water quality, and not necessarily an indicator of improved efficiency. Well 1 was off-line through the period of assessment. The calculations indicated that performance testing was not indicated at this time.

Well 1 was step-tested in May 2017 and the Step Test report (May 30, 2017) noted minimal decrease in specific capacity from the previous test conducted in 2012 (2.8% decrease). No requirement for rehabilitation of this well was indicated in the short term, nor indication of well replacement and/or major well modifications required from a long-term assessment management perspective.

Well 2 was last step-tested in November 2016 and the Step Test report (November 7, 2016) noted minimal decrease in specific capacity from the original 1993 condition the well (1.63% decrease). Well 2 was last rehabilitated in 2012 and no further rehabilitation of this well was indicated in the short term. Well replacement and/or major well modifications were not required from a long-term assessment management perspective.

Well 2 pump was cleaned and inspected in March 2017 and found to be in good condition, and a video inspection showed the casing and screen to be in satisfactory condition.

2.2.1.7 Condition Assessment

A 2014 condition assessment of the treatment facility (Groundwater Facility Condition Assessment Report, May 2014)) summarized the condition of the assets on the site and gave recommendations for necessary interventions. Of the 136 assets on the site, the majority (117 of 136 assets) were assessed as needing no intervention or only routine maintenance (Table 2-7). As of the 2014 condition assessment, 9% of the assets required repair and 4% required replacement. Much of the work identified is cosmetic, consisting mainly of sandblasting and repainting of equipment.

The condition assessment report listed the following items that required replacement or a more extensive repair, and all are included in an upgrade contract currently underway and nearing completion. Reference to well and well pump condition has not been included as it has been superseded with the information referenced above.

- Diesel motor requires an automatic transfer switch and repair of starter motor or possible complete replacement of diesel motor for better automation
- Replacement of rusted pipe supports in pump room
- Repair of surface coatings, especially chemical containment areas
- Repair of access hatch for sodium silicate storage tank

Table 2-7. Condition Assessment Summary

Intervention Rating	Intervention Description	Number of Occurrences
1	No intervention required – Do Nothing	100
2	Specialist Assessment	1
3	Routine Maintenance (CLAIR)	17
4	Repair	12
5	Replacement	6
Total		**136**

The most immediate recommendations to keep the facility in a state of good repair are being addressed in the upgrade contract ongoing.

Additional maintenance may be required to keep the facility in good working order. It is possible that iron and manganese oxides have settled out in the contact tank during periods when silicate dosing was blocked, and sequestration was not occurring. These deposits could reduce the effective volume of the contact tank and increase the risk of particulate iron and manganese being re-entrained in the treated water. Inspection and cleaning of the contact tank should be conducted to identify and remove any iron and manganese deposits or silicate deposits and assess the condition of the tank.

2.2.2 Mount Albert Well 3

2.2.2.1 Overview

Mount Albert Well 3 is housed at the Well 3 Treatment Facility, where treatment is provided for this well. Well 3 was constructed in 2005. An overview of the well is provided in Table 2-8, with historical raw and treated water quality summarized in Table 2-9 and Table 2-12, respectively.

Table 2-8. Overview of Mount Albert Well 3

Item	Description
Source Aquifer	Thorncliffe aquifer (deep aquifer system)
Well Name	**Well 3 (MTA PW 3)**
Well Pump Capacity	2,280 L/min (38 L/s) at 79 m TDH (VFD)
Well Pump Type	Vertical turbine pump
Facility Rated Capacity	3,273 m^3/d (37.88 L/s) PTTW maximum taking is 4,990 m^3/d (57.75 L/s) from any combination of the 3 wells in the system.
Date Well Drilled	October 25, 2005
Well Depth	85.5 m

2.2.2.2 Raw Water Quality

The raw water quality of Well 3 is summarized in Table 2-9, based on five (5) years of historical data (2014-2018). In some cases, as noted in the table below, data limitations either due to minimal sampling events or variations in reported method detection limit (MDL) have been addressed by expanding the analysis to consider datasets from previous years.

The applicable limits as identified in O. Reg. 169/03: Ontario Drinking Water Quality Standards, the Technical Support Document for ODWQS, Objectives and Guidelines and relevant guidance from Health Canada are presented for comparison purposes, where applicable. It should be noted that the only water quality parameters that are enforceable are those stated in O.Reg. 169/03. Any parameter identified as an aesthetic objective or operational guideline provided by the MECP is provided for comparative reference, and guidance published by Health Canada are provided as context for potential future regulatory changes. Any parameter identified as an aesthetic objective or operational guideline provided by the MECP is provided for comparative reference, and guidance published by Health Canada are provided as context for potential future regulatory changes.

Table 2-9. Raw Water Quality for Mt. Albert Well 3

Parameter	Drinking Water Standards or Guideline (1)	Well 3		
		Minimum	Average(2)	Maximum
Dissolved Organic Carbon, mg/L	5 (AO)	0.5	0.8	1.0
pH	6.5-8.5 (OG)	7.7	7.9	8.1
Alkalinity, mg/L as $CaCO_3$	30-500 (OG)	231	238	248
Hardness, mg/L as $CaCO_3$	80-100 (OG)	330	338	349
Ammonium and Ammonia, mg/L as N(3)	0.1(4)	0.03	0.05	0.09
Nitrate, mg/L as N	10 (MAC)	4.31	4.83	5.96
Nitrite, mg/L as N	1 (MAC)	0.049	0.077	<0.25
Methane(5), L/m^3	3 (AO)	0.050	0.058	0.071

Parameter	Drinking Water Standards or Guideline [1]	Well 3		
		Minimum	Average[2]	Maximum
Sulfide, mg/L as H_2S[6,7]	0.05 (AO)	<0.005	<0.005	<0.005
Iron, total, mg/L	0.3 (AO)	0.067	0.192	0.522
Manganese, total, mg/L	0.05 (AO) HC: 0.12 (MAC)[8], 0.02 (AO)[9]	0.040	0.048	0.056
Sodium, mg/L	200 (AO)[10]	9.1	10.3	11.3
Calcium, mg/L		94.9	96.6	99.8
Magnesium, mg/L		22.7	23.6	24.3
Chloride, mg/L	250 (AO)	26.0	27.5	31.4
Sulfate, mg/L	500 (AO)	37.3	57.0	62.1
Phosphate, mg/L[6,11,12]		<0.005	<0.02	<0.02

Notes:

1. Ontario Drinking Water Standards (ODWS) O.Reg. 169/03 – Maximum Acceptable Concentration (MAC); Aesthetic Objectives (AO) and Operational Guidelines (OG) as presented in the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (MOE, 2006).
2. Where some of the measured values were reported as less than the MDL, the average was calculated by assigning half the MDL to those values. If all measured values were less than MDL or if the average was less than the MDL, the average is indicated as being less than the MDL.
3. The data reported for ammonia for 2016 to 2018 for Well 3 ranged from a MDL of <0.1 to a RDL of <1.25 mg/L. The unusually high RDL of <1.25 mg/L would skew the results if used as described in Note 2, and therefore the data reported for 2010 to 2015 is presented for this parameter.
4. Health Canada's Drinking Water Guidelines recommend limiting excess free ammonia to below 0.1 mg/L-N to help prevent nitrification; however, there is no aesthetic objective or maximum acceptable concentration noted.
5. Methane results from one sampling event conducted between 2002 and 2018
6. Measurements from all sampling events were lower than the MDL or RDL.
7. Sulfide results from three sampling events conducted between 2001 and 2019.
8. Maximum Acceptable Concentration [MAC] under Health Canada's Drinking Water Guidelines.
9. Aesthetic Objective (AO) under Health Canada's Drinking Water Guidelines.
10. MOE (2006) notes that "The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L, so that this information may be passed on to local physicians".
11. Different MDLs or RDLs reported for different sampling dates. The minimum is reported as the minimum measured value or as the lowest MDL/RDL noted, whichever was lower. The calculated average, as described in Note 2, was compared to the highest MDL/RDL and, where it was lower than this value, is reported as such here. The maximum is reported as the maximum measured value or, where all values were lower than MDL/RDL, as the highest MDL/RDL noted.
12. The data reported for phosphate for 2016 to 2018 for Wells 1, 2 and 3 from the MDL of <0.01 to RDL of <2.5 mg/L. The unusually high RDL of 2.5 mg/L would skew the results if used as described in Note 2, and therefore, the historical values for 2010 to 2015 are presented for this parameter using the method described in Note 2 for values reported as less than the MDL/RDL for this time period.

The following are noted from the review of raw water quality data presented above:

- Generally, the water quality in Well 3 is better than that of Wells 1 and 2.
- Hardness is very high at greater than three times the upper operational guideline.
- Iron concentrations are less than the AO of 0.3 mg/L on average.
- Manganese concentrations are typically below the AO of 0.05 mg/L, with no exceedances of the Health Canada MAC of 0.12 mg/L. The levels exceed the Health Canada (AO) of 0.02 mg/L and the treated water operational goal (OG) of ≤0.015 mg/L to minimize the accumulation of manganese in the distribution system.
- Ammonia concentrations are low and can be easily dealt with through breakpoint chlorination.
- Nitrate concentrations are much higher in Well 3 than in Well 2, with levels generally at 50% of the MAC. This may be a reflection of its location in an agricultural setting.
- Manganese concentrations are around the AO of 0.05 mg/L.

2.2.2.3 Treatment Process

The treatment provided at this facility includes oxidation of iron and manganese and disinfection with gaseous chlorine, followed by sodium silicate addition to the water for iron and manganese sequestration. Chlorine and sodium silicate are added to the well discharge (raw water) header. The water then flows to an in-ground, pressurized, chlorine contact tank that provides the required chlorine contact time for primary disinfection. The treated water then enters the distribution system via a single watermain.

The facility has a standby generator available to power the entire facility. There are duty and standby chlorine and sodium silicate injection points on the well pump discharge. Each chemical system is equipped with a duty and standby feed system. The chlorine gas feed system (Figure 2-4) consists of duty and standby gas cylinders and duty and standby feed systems. The sodium silicate feed system (Figure 2-5) is equipped with a duty and standby chemical feed pump, piping, valves, controls and a common calibration column. The calibration column is available for pump calibration; however, the calibration column tends to clog from sodium silicate crystallization, and therefore, other methods of calibration are used (such as the use of a graduated cylinder).

Figure 2-4. Well 3 Treatment Facility Chlorine Gas Feed Systems

Figure 2-5. Well 3 Treatment Facility Sodium Silicate Metering Pump Panel

The equipment list and facility components are summarized in Table 2-10, and the process-related instrumentation list is presented in Table 2-11.

Table 2-10. Equipment List and Facility Components for Mt. Albert Well 3 Treatment Facility

Item	Equipment/Facility Component
Gaseous Chlorine	• Two (2) chlorinators, capacity of 22.7 kg/d each • Two (2) chlorine booster pumps, each rated at 36.68 L/min at 80.6 m TDH, flow-paced • Two (2) chlorine gas cylinders and weight scales • One (1) chlorine gas scrubber
Sodium Silicate	• Two (2) sodium silicate metering pumps, each rated at 24.42 L/h at 690 kPa, flow-paced based on total discharge flow • One (1) sodium silicate bulk storage tank (5,700 L)
Chlorine Contact Tank	• One (1) in-ground chlorine contact tank • Dimensions: 1.5 m diameter (ID) × 15 m length; total volume of 26.51 m^3 • Baffle factor: 0.7 • Hydraulic retention time (at PTTW flows of 37.88 L/s): 11.66 min • Effective contact time (at 37.88 L/s): 8.16 min

Table 2-11. Instrumentation List for Mt. Albert Well 3 and Treatment Facility

Category	Type/Description	Location
Flow Control and Measurement	Well pump discharge header flow meter, 200 mm dia.	Wellhouse, Pump Room
Level Measurement	Sodium silicate storage tank level transmitter	Wellhouse, Silicate Room
Chlorine Measurement	Pre-chlorine contact tank free chlorine analyzer (process)	Wellhouse, Pump Room
	Post-chlorine contact tank free chlorine analyzer (regulatory)	Wellhouse, Pump Room
Others	Turbidity analyzer	Wellhouse, Pump Room
	Chlorine Cylinder Scale Weight Indication Transmitter	Chlorine Gas Room

The chlorinator is flow paced to the raw water flow signal and the dosage is operator adjustable through SCADA using a dosage factor (0-100%). The chlorine dosage is adjusted to target a free chlorine residual of 1.8 mg/L after the chlorine contact tank. The chlorine gas feed system is also residual feed-back control within a target range as measured upstream of the chlorine contact tank. The dilution water supply to the chlorine gas feed system is equipped with two (2) booster pumps (one duty and one standby). Either booster pump is capable of operating with either Chlorinator; however, when Booster Pump 1 is operated with Chlorinator 2, then Booster Pump 2 and Chlorinator 1 will not be available for standby operation.

The duty silicate feed pump is flow paced to the raw water flow signal. The duty chemical feed pump starts and stops based on the open/close status of the limit switch of the check valve of the duty well pump. The chemical dosage is operator-adjustable through SCADA, or locally at the pump by adjusting the operating speed of the peristaltic metering pump. The starting dosage for silicate is 15 mg/L. Similar dosing challenges for sodium silicate as discussed in Section 2.2.1.3 for Wells 1 and 2 are also experienced at Well 3, with Region analysis showing Na_2SiO_3 measured levels almost twice the SCADA setpoint.

The sodium silicate storage tank is provided with a mixer; however, it is not normally used. Sodium silicate can have a shelf life of 18 months provided that storage conditions are optimized, such as having cone-shaped or sloped bottoms where particulate can settle and providing mixing to avoid silicate dehydration (20 minutes every

24 hours) and regular cleaning of the storage tanks (as recommended by the manufacturer, National Silicates). At design (and PTTW) flows of 37.75 L/s (24 hours per day) and a dosage of 15 mg/L, the plant would use the sodium silicate volume stored on-site in 27 days. At the current plant flow of 30 L/s, the tank capacity would be consumed in about 4.5 months. However, similarly to the Well 1&2 Treatment Facility, the sodium silicate delivered to this facility originates from the bulk storage tanks located at the Aurora Wells 1-4 Treatment Facility, which would add to the chemical age depending on the rate of usage in the Region. Aged or improperly stored sodium silicate can result in:

- A loss in product performance
- Formation of precipitates that can clog chemical injection systems
- Product stratification that can result in under or overdosing

These issues may be improved through the use of smaller storage tanks that can be easily cleaned and through automation or scheduled daily operation for the tank mixer.

2.2.2.4 Treated Water Quality

The treated water quality for this facility is summarized in Table 2-12, based on five (5) years of historical data (2014-2018, unless otherwise noted). The applicable limits as identified in O. Reg. 169/03: Ontario Drinking Water Quality Standards and the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines are presented for comparison purposes.

Table 2-12. Treated Water Quality for Mt. Albert Well 3

Parameter	Drinking Water Standards or Guideline (1)	Well 3		
		Minimum	Average(2)	Maximum
Dissolved Organic Carbon, mg/L	5 (AO)	0.34	0.71	1.06
pH	6.5-8.5 (OG)	7.65	7.84	8.10
Alkalinity, mg/L as $CaCO_3$	30-500 (OG)	214	235	248
Hardness, mg/L as $CaCO_3$	80-100 (OG)	324	338	355
Ammonium and Ammonia, mg/L as N(3,4,5)	0.1(6)	<0.005	<0.1	0.017
Nitrate, mg/L as N	10 (MAC)	4.31	4.78	6.06
Nitrite, mg/L as N (5)	1 (MAC)	<0.008	0.0195	<0.25
Methane, L/m^3	3 (AO)	0.016	0.048	0.071
Iron, total, mg/L	0.3 (AO)	0.066	0.103	0.160
Manganese, total, mg/L	0.05 (AO) HC: 0.12 (MAC)(7), 0.02 (AO)(8)	0.038	0.044	0.051
Sodium, mg/L	200 (AO)(9)	6.3	8.9	11.1
Calcium, mg/L		91.8	96.0	101.0
Magnesium, mg/L		23.1	23.9	25.3

Parameter	Drinking Water Standards or Guideline [1]	Well 3		
		Minimum	Average[2]	Maximum
Chloride, mg/L	250 (AO)	24.60	28.63	32.30
Sulfate, mg/L	500 (AO)	46.20	57.22	64.20
Phosphate, mg/L[5,10]		<0.005	<0.02	<0.02
Chlorine Residual, mg/L	0.05 (minimum)[11] 4.0 mg/L (maximum)[11]	See Figure 2-3		
N-Nitrosodimethylamine, ng/L [12]	9.0 (MAC)	<0.9	<0.9	<0.9
Nitrilotriacetic Acid (NTA), mg/L[13]	0.4 (MAC)	<0.05	<0.05	<0.05

Notes:

1. Ontario Drinking Water Standards (ODWS) O.Reg. 169/03 – Maximum Acceptable Concentration (MAC); Aesthetic Objectives (AO) and Operational Guidelines (OG) as presented in the Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (MOE, 2006)
2. Where some of the measured values were reported as less than the MDL, the average was calculated by assigning half the MDL to those values. If all measured values were less than MDL or if the average was less than the MDL, the average is indicated as being less than the MDL.
3. Note that measured treated water maximum concentration was higher than the raw water maximum concentration. This may have been caused by sampling protocol (when, where and how samples were collected), process changes, disruption of sediment, or fluctuations in raw water quality.
4. The data reported for ammonia for 2016 to 2018 for Wells 1 and 2 ranged from a MDL of <0.1 mg/L to a RDL of <1.25 mg/L. This unusually high RDL of <1.25 mg/L would skew the results if used as described in Note 2, and therefore, the historical values for 2010 to 2015 are presented for this parameter.
5. Different MDLs or RDLs reported for different sampling dates. The minimum is reported as the minimum measured value or as < the lowest MDL/RDL noted, whichever was lower. The calculated average, as described in Note 2, was compared to the highest MDL/RDL and, where it was lower than this value, is reported as such here. The maximum is reported as the maximum measured value or, where all values were lower than MDL/RDL, as the highest MDL/RDL noted.
6. Health Canada's Drinking Water Guidelines recommend limiting excess free ammonia to below 0.1 mg/L-N to help prevent nitrification; however, there is no aesthetic objective or maximum acceptable concentration noted.
7. Maximum Acceptable Concentration [MAC] under Health Canada's Drinking Water Guidelines.
8. Aesthetic Objective (AO) under Health Canada's Drinking Water Guidelines.
9. MOE (2006) notes that "The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L, so that this information may be passed on to local physicians".
10. The values presented are for the period from 2010 to 2015. The data from 2016 to 2018 for Wells 1 and 2 Facility, 3 of the 12 data points were actual reported values ranging from 0.03 to 0.05 mg/L, while the remaining values were reported as either less than the MDL of <0.01 or <0.05 mg/L or less than the RDL of <2.5 mg/L. For Well 3 Facility, all values reported were less than the MDL or RDL. Using the values reported for 2016 to 2018 in the manner described in Note 2 would skew the results, and therefore, the data from 2010 to 2015 are used.
11. Procedure for Disinfection of Drinking water in Ontario (MECP, 2018). Minimum and maximum free chlorine residuals when using chlorine as a secondary disinfectant at a pH of 8.5 or lower. Data shown is from 2012 to 2016.
12. No values were reported for 2014 or 2015. The three values reported from 2016 to 2018 were the MDL of <0.9 ng/L.
13. The values presented are for the period from 2010 to 2013, as there was no data available for NTA from 2014 to 2018. The values reported from 2010 to 2013 were all lower than the MDL.

The free chlorine residual entering the distribution system from the Well 3 Treatment Facility (as measured downstream of the chlorine contact tank, where disinfection contact time is achieved) for the historical period from January 2016 through to December 2017 are presented in Figure 2-7. The graph shows that the treated water free chlorine residual is maintained more consistently day to day since May 2016 when residual feedback control was implemented.

Over the historic period shown in the graph, the daily average chlorine residual leaving the facility was 1.62 mg/L. From January 2016 to May 2016, the average chlorine was 1.59 mg/L with maximum variability of 1.9 mg/L (minimum average day to maximum average day for this period, where 90% of the values fell within 0.68 mg/L of each other). The average maintained since June 2016 has been 1.70 mg/L with a maximum variability of 0.7 mg/L day to day (minimum average day to maximum average day, where 90% of the values fell within 0.39 mg/L of each other).

At this facility, a free chlorine residual of approximately 1.7 mg/L is targeted entering the distribution system (at the chlorine contact tank effluent). The target residual of 1.7 mg/L is based on maintaining free chlorine residuals above the regulatory minimum of 0.05 mg/L and above the minimum operating target of 0.4 mg/L throughout the distribution system. The target residual for the secondary disinfectant residual is based on experience in the system to maintain the residual throughout the distribution system above the regulatory minimum at the ends of the distribution system after allowing for chlorine decay due to water age, to suppress the potential for regrowth in the drinking water system and provide disinfection should contaminants enter the distribution system.

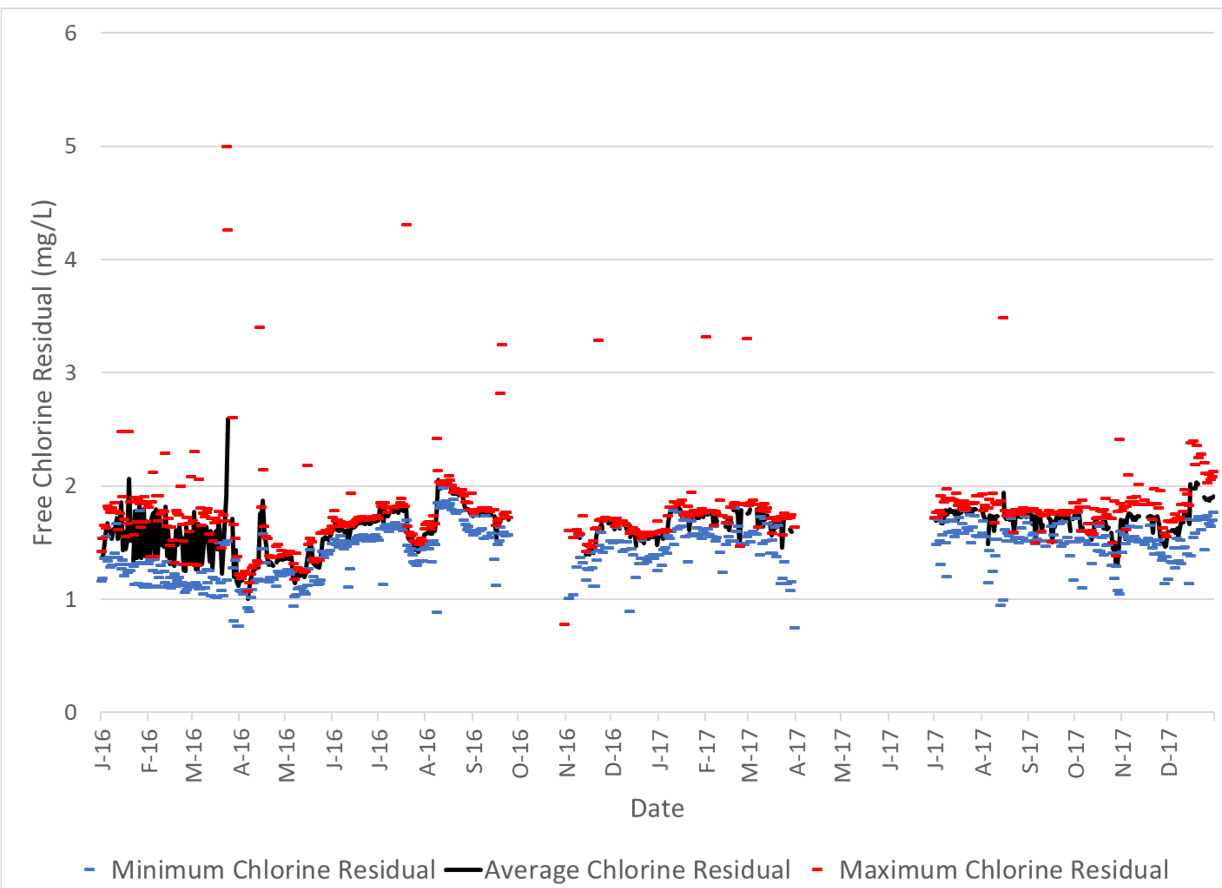


Figure 2-6. Free Chlorine Residual – Chlorine Contact Tank Effluent – Well 3 Treatment Facility

The following observations are made with respect to treated water quality at Well 3:

- Chlorine: The free chlorine residual entering the distribution system is maintained on average at 1.7 mg/L.
- Manganese: Manganese concentrations are usually slightly below the aesthetic objective of 0.05 mg/L, but still average more than double the Health Canada aesthetic objective of 0.02 mg/L and exceed the health Canada OG of 0.015 mg/L.
- Hardness is very high at greater than three times the upper operational guideline. Iron: Treated water iron concentrations are below the aesthetic objective of 0.3 mg/L for iron. The average treated water iron concentration is also below the raw water iron concentration at this facility (0.192 mg/L in raw water and 0.103 mg/L in treated water), indicating that iron is being deposited within the facility. If deposition is occurring, the majority of the deposits will likely be located in the chlorine contact tank.
- Ammonia: Ammonia concentrations are much lower than in the raw water due to the use of breakpoint chlorination to achieve a free chlorine residual.
- Nitrate is greater than half the MAC in the treated water, therefore, it is considered a parameter of concern and increased monitoring is suggested by the Region. Current treatment does not provide any benefit or contribute to the concentration of nitrate.
- Sodium: Sodium concentrations are higher than in the raw water due to the addition of sodium silicate for sequestration, but concentrations are still well below the 20 mg/L level that requires the medical officer of health to be notified.

2.2.2.5 Primary Disinfection

Primary disinfection is achieved in the Mount Albert Water Supply System with the use of a free chlorine residual.

For primary disinfection, to achieve 2-log virus inactivation, a CT of 4 min*mg/L is required under conditions of pH of 6 to 9 and temperature at 5ºC. In order to achieve this in the existing chlorine contact tank at the Wells 3 Treatment Facility at the maximum permitted daily flow of 37.88 L/s, a minimum chlorine residual at the chlorine contact tank effluent of 0.49 mg/L is required to be maintained, well below the current residual target and recorded values.

The current guidance from Health Canada for enteric viruses (which is understood to be in consideration for implementation by MECP) recommends achieving a 4-log virus inactivation or a CT of at least 8 min*mg/L for groundwater. At the maximum permitted daily flow, a minimum free chlorine residual at the chlorine contact tank effluent of 0.98 mg/L would be required, which is regularly met.

2.2.2.6 Well Assessment

The 2018 Performance Evaluation for the Region Production Wells (March 26, 2019) reported stable performance for well 3. Production rates for Well 3 have increased as noted, and minor impacts were noted following the increase; however, they have since stabilized. The efficiency calculations indicated that a performance test was not recommended.

Well 3 had been step-tested in May 2015 and the Step Test report (June 5, 2015) noted a decrease of 16.7% in specific capacity from construction in 2005. While considerably higher than measured in Wells 1 and 2, the report noted that data used in the assessment were not ideal due to complications during testing. The well had been rehabilitated most recently in 2012 and while rehabilitation was not recommended in the short term to restore performance, a subsequent Well and Pump Maintenance Report (June 2017) identified that rehabilitation at the next service interval may be required to recover the losses noted. The Step Test indicated that well replacement and/or major well modifications was not a requirement from a long-term assessment management perspective.

Well 3 pump was cleaned and inspected in March 2017 and found to be in good condition; however, the video inspection showed the screen to have heavy iron precipitate plugging and biofouling that has not been reported in either Well 1 or Well 2 investigations. The well screen was redeveloped, and the well pump was reinstalled.

2.2.2.7 Condition Assessment

A condition assessment was conducted in 2015 (Condition Assessment of Groundwater Production Facilities - Final Report for Mount Albert Well No. 3)). The condition assessment found that of the 248 assets assessed on the site, 236 (95%) required no intervention or only routine maintenance. A summary of key findings has been provided below with well and well pump condition assessment superseded with the information referenced above.

The silicate dosing equipment at Well 3 experiences the same issues with reliability, as previously noted for Wells 1 and 2. Replacement of the current system would be required to improve the consistency of silicate dosing.

Table 2-13. Well 3 Facility Condition Assessment Summary

Intervention Rating	Intervention Description	Number of Occurrences
1	No intervention required – Do Nothing	226
2	Specialist Assessment	5
3	Routine Maintenance (CLAIR)	10
4	Repair	6
5	Replacement	1
	Total	**248**

Additional maintenance may be required to keep the facility in good working order. When the silicate dosing is blocked, no sequestration is possible. Instead, the dissolved iron and manganese will be converted to particulate before going to the contact tank. Even when silicate dosing is functional, it appears that deposition is occurring in the facility, likely in the contact tank where water velocities are lowest. These deposits could reduce the effective volume of the contact tank, increase the risk of particulate iron and manganese being re-entrained in the treated water. Periodic inspection and cleaning of the contact tank should be conducted to ensure that iron and manganese deposits do not accumulate.

2.3 Water Demand and Projections

Recent water demand for the period of 2016-2018 is presented in the figures that follow (Figure 2-7 to Figure 2-9). System demand can be met by any of the wells operating without exceeding the individual wells permitted capacity of 3,280 m^3/d except for an isolated incident in late 2017, as demonstrated in the figures. The reported well pump capacities are slightly less at 3,273 m^3/d, and while minor declines have been reported in well efficiencies, the supply remains more than sufficient to meet current demands of the system.

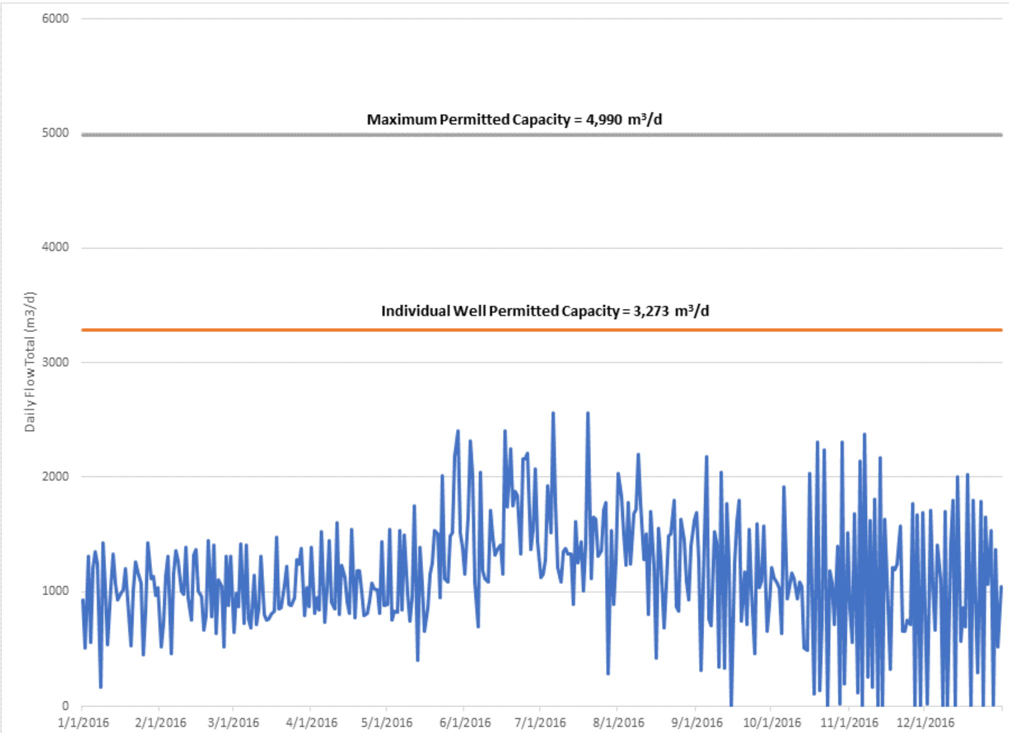


Figure 2-7: 2016 Total Daily Flow Combined from Mount Albert Wells 1,2,3

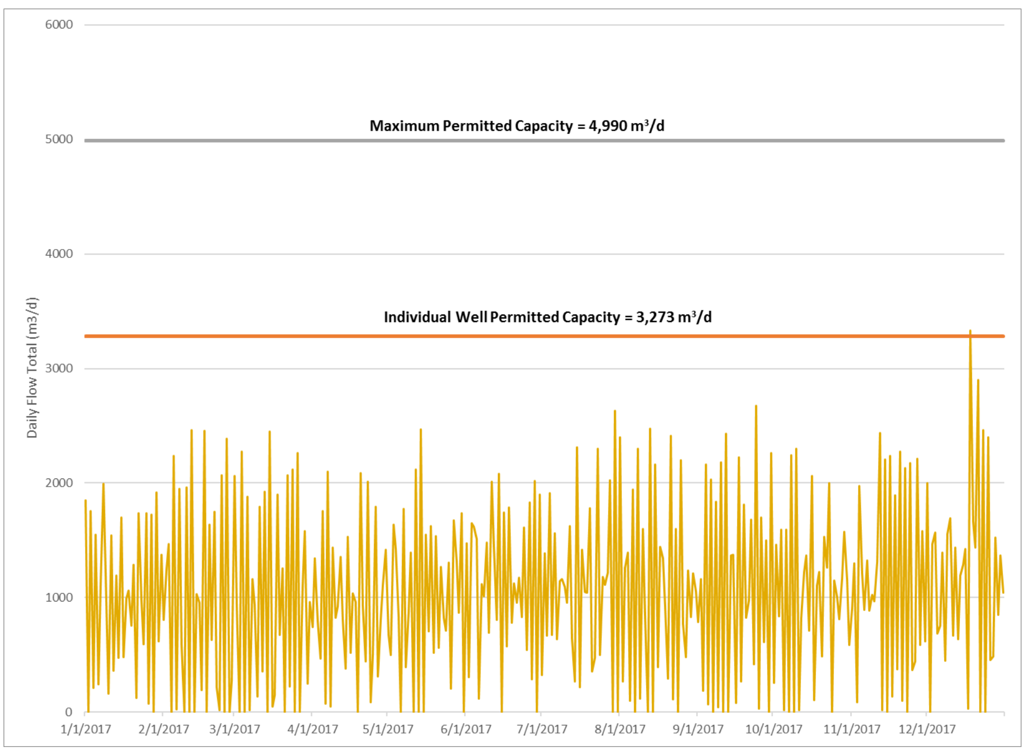


Figure 2-8: 2017 Total Daily Flow Combined from Mount Albert Wells 1,2,3

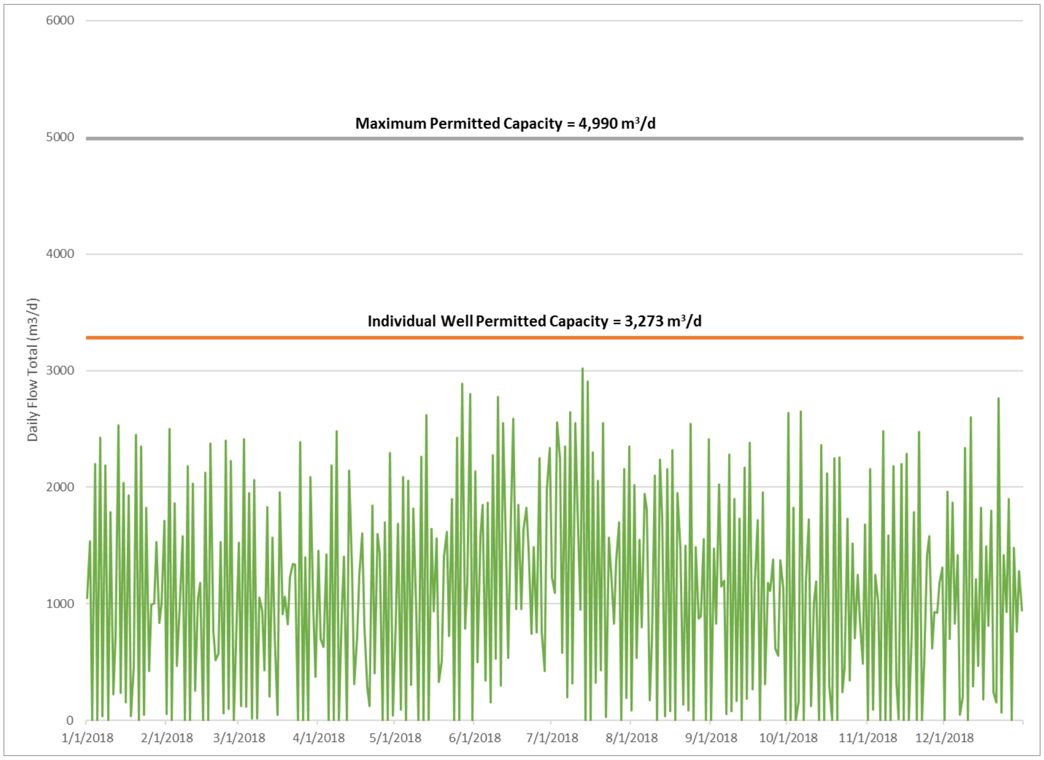


Figure 2-9: 2018 Total Daily Flow Combined from Mount Albert Wells 1,2,3

Over this period of time, system demand has been met through a combination of the wells, as duty has been rotated. As noted previously, Well 1 was removed from service in 2017 and demand was shifted to the other wells, with Well 3 operation continuing to increase as shown in Table 2-14.

Table 2-14. Percent Allocation of Mount Albert Well Operation from 2016-2018

	2016	2017	2018
Well 1	29.9%	7.2%	0.7%
Well 2	24.4%	41.8%	42.6%
Well 3	45.7%	51.0%	56.7%

Current and projected future water demand are summarized in Table 2-15. The projected future water demand presented in this table was provided by the Region from the 2016 Water and Wastewater Master Plan Update (WWWMP).

Table 2-15. Historical and Projected Average Day and Maximum Day Demand

Year	Average Day Demand (MLD)	Maximum Day Demand (MLD)
2014-2018[a]	1.06[b] (1.16)[c]	2.50[b] (3.33)[c]
2021	1.5	3.4
2041	1.4	3.1

Notes:

a) Values estimated from SCADA data from 2014-2018

b) Average of yearly ADD and MDD values calculated for 2014-2018

c) Maximum of yearly ADD and MDD values calculated for 2014-2018

It is noted that there are higher demands projected in 2021 than in subsequent years, including 2041, due to forecasted decline in per capital consumption.

The future projected needs of the system only slightly exceed the capabilities of a single well supply and can easily be met within the current firm capacity of the system, including some decline in well efficiency.

2.4 Distribution System

2.4.1 Watermain Material, Age, and Size

Information on the distribution system pipe composition, diameter, length, and age were provided by the Region from the Region All Pipes database and are summarized in Table 2-16 and Table 2-17. The summary provides the length of each as a percentage of the total distribution system length. Figure 2-10 presents a subset of the information from Table 2-17, showing pipe composition as a percentage of the total distribution system pipe length and showing the pipe length that was installed in a given decade for major pipe materials as a percentage of the total pipe length for each material.

The distribution system contains approximately 32 km of pipe. The majority of the system consists of PVC and ductile iron pipe. Most pipes in the system are between 100 and 300 mm in diameter, with a few larger pipes that are greater than 300 mm in diameter. The pipes greater than 300 mm in diameter are primarily concrete and ductile iron.

The system has a relatively younger stock of watermains, with all the pipes younger than 50 years old. Over half of the pipes in the system have been installed since the year 2000. Water main breaks are rare due to the low age of most of the system.

Table 2-16. Pipe Material and Diameter as a Percentage of Total Distribution System Length

Pipe Material	Total Length(d)		Percentage of Pipe by Diameter Ranges(a,b)			
			≤100 mm(c)	>100 mm to ≤200 mm	>200 mm to ≤300 mm	>300 mm
Concrete	1,609 m	5.0%	<0.01%	<0.01%	0.23%	4.8%
Copper	114 m	0.36%	0.36%	-	-	-
Ductile Iron	10,405 m	33%	0.11%	19%	11%	3.1%
Unknown	108 m	0.34%	0.34%	-	-	-
PVC	19,691 m	62%	0.98%	31%	29%	0.92%
Totals(d)	31,927 m	100%	1.8%	49%	40%	8.8%

Notes:

a) All percentages are shown as a percentage of total distribution system length.

b) Where cells are blank, there was no data indicating a pipe of this description in the system.

c) Pipes less than 50 mm in diameter assumed to be service lines and excluded from the analysis.

d) Totals are rounded to two significant figures; as a result, totals may not sum to exactly 100%.

Table 2-17. Pipe Material and Installation Decade as a Percentage of Total Distribution System Length

Pipe Material	Total Length(d)		Length by Installation Decade(a,b,c)				
			1970s	1980s	1990s	2000s	2010s
Concrete	1,609 m	5.0%	0.04%	-	-	0.23%	4.8%
Copper	114 m	0.36%	-	-	-	0.07%	0.29%
Ductile Iron	10,405 m	33%	27%	3.7%	-	1.4%	0.88%
Unknown	108 m	0.34%	-		-	-	0.34%
PVC	19,691 m	62%	-	-	15%	21%	25%
Totals(d)	31,927 m	100%	27%	3.7%	15%	22%	32%

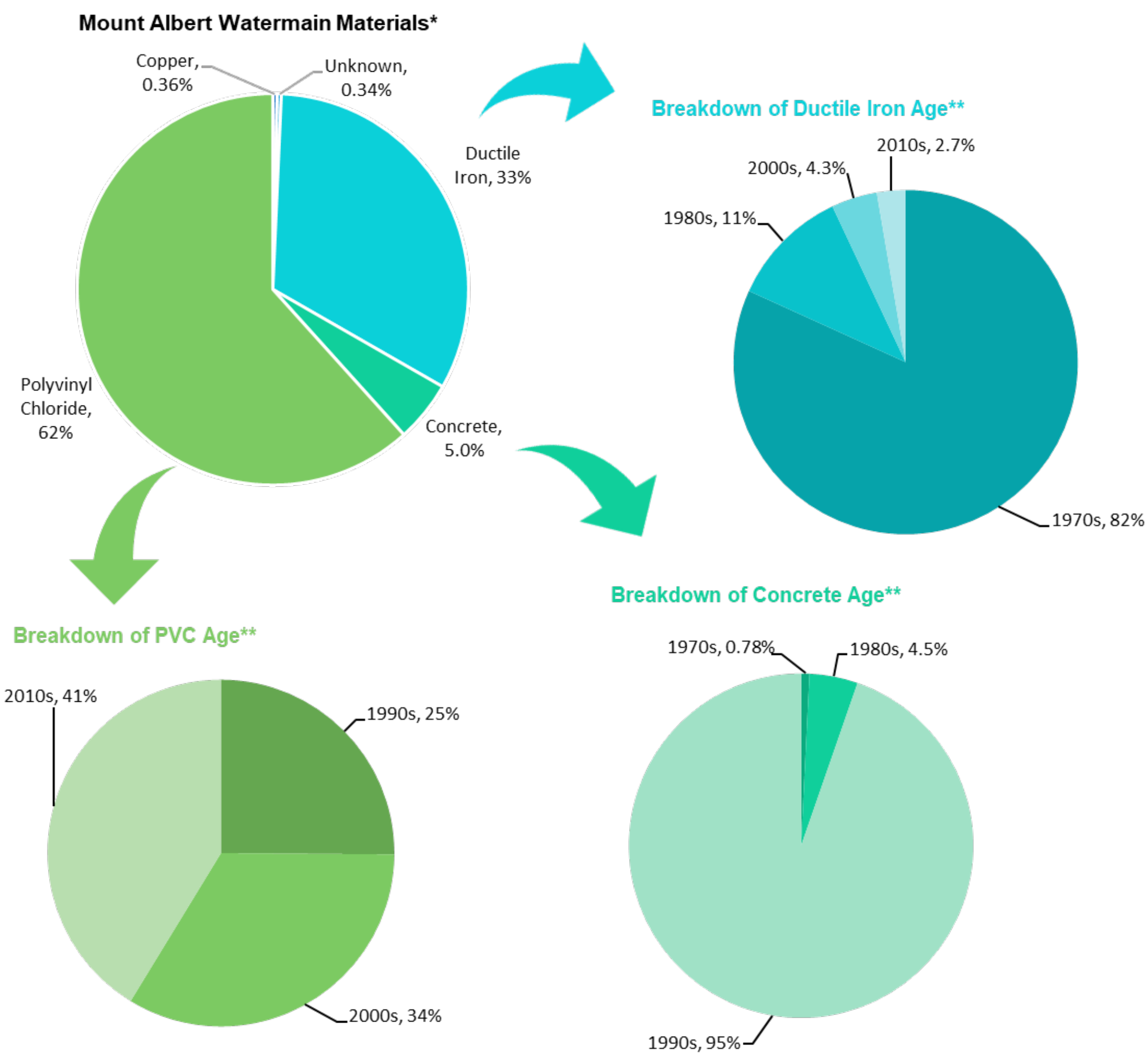
Notes:

a) All percentages are shown as a percentage of total distribution system length.

b) Where cells are blank, there was no data indicating a pipe of this description in the system.

c) Pipes less than 50 mm in diameter assumed to be service lines and excluded from the analysis.

d) Totals are rounded to two significant figures; as a result, totals may not sum to exactly 100%.



Notes:
* Percentages shown are the percentages of the total length of all pipes in the distribution system
** Percentages shown are the percentage of the total length of specified pipe material installed in the distribution system

Figure 2-10. Watermain Material as a Percentage of Total Distribution Length, and Proportion Installed in Various Decades for Major Pipe Materials

2.4.2 Storage Facilities

There are two storage facilities in the Mount Albert system: the Mount Albert North Elevated Tank (North ET) and the Mount Albert South Elevated Tank (South ET). The South ET is currently out-of-service and has been for approximately 15 years.

2.4.2.1 Mount Albert North Elevated Tank

The North ET, located at 19450 Ninth Line, has a design capacity of 2,727 m^3. The tank was commissioned in 2005. The elevations of the key design points are provided in Table 2-18 below.

Table 2-18. Mt. Albert North Elevated Tank Key Design Parameters

Parameter	Value
Total Volume	2,727 m^3
Overflow	9.50 m (El. 314.29 m)[a]
High Water Level (Elevation)	9.15 m (El. 313.94 m)[a]
Top of Inlet Pipe (Elevation)	8.00 m (El. 312.790 m)[a]
Low Water Level (Elevation)	0 m (El. 304.79 m)[a]
Finished Floor Elevation	El. 277.80 m[a]

Notes:

a) Elevations obtained from as-constructed drawings from Contract T-03-27, Drawing P1.

The North ET has separate inlet and outlet pipes to avoid short-circuiting of supply in the tank; however, as the inlet pipe terminates at an elevation of 312.790 m, when the water level in the tank is below this level, inlet supply will cascade into the tank, effectively aerating the water. The North ET has a bi-directional flowmeter on the common inlet/outlet pipe. Control of this tank includes monitoring of water turnover and alarming to notify operators if turnover is insufficient (default 24 hours).

2.4.2.2 Mount Albert South Elevated Tank

The Mount Albert South ET, located at 20 Hi-View Drive along with Wells 1&2 Treatment Facility, has a design capacity of 910 m^3. The tank was constructed in 1979 as the first composite elevated tank built in North America. The elevations of the key design points are provided in Table 2-19 below.

Table 2-19. Mt. Albert South Elevated Tank Key Design Parameters

Parameter	Value
Total Volume	910 m^3
Overflow	El. 314.92 m
High Water Level (Elevation)	El. 313.94 m
Finished Floor Elevation	El. 280.42 m

The tank has been out of service for approximately 15 years due to structural deficiencies.

2.4.2.3 System Storage and Fire Requirements

Mount Albert Water Supply System storage in the Region is designed in accordance with the Ministry of the Environment (MOE) Design Guidelines for Drinking Water Systems (2008), the Region Design Guidelines and design criteria established from hydraulic analysis of the water system. System storage may comprise components for balancing (equalization), fire and emergency storage. Storage facilities are sized using the following equation where the water supply is only capable of supplying the maximum day demand:

Storage Volume = A + B + C

where:

A = Fire Storage; the volume required for firefighting.

B = Equalization Storage (Balance Storage); the storage required to meet the diurnal variation of the maximum day condition, equal to 25% of Maximum Day demand.

C = Emergency Storage; the additional volume for emergency events (e.g. prolonged power loss, watermain breaks, unusual fire demands, higher than usual demands, etc.), equal to 25% of [A + B].

Normally when system storage is designed, the equalization and emergency storage volumes are determined based on the design max day demand. This max day may occur sometime in the future. In order to satisfy the equalization and emergency storage requirements while not compromising water quality due to excessive water age, the equalization and emergency storage volumes maintained can be determined based on the current max day demand in the system.

Where additional pumping capacity is available, less emergency storage may be required.

Fire demands are determined using the "Water Supply for Public Fire Protection - a Guide to Recommended Practice 1991", by the Fire Underwriters Survey. Region Design Guidelines require that all large pressure districts must provide 3,570 m^3 of fire storage (based on that required for a commercial or industrial fire water demand of 17,000 L/min for a duration of 3.5 hours) and for smaller pressure districts with smaller commercial, medium and high-density residential developments, 1,200 m^3 of fire storage is required (based on a fire with a water demand of 10,000 L/min for a duration of 2 hours). Where fire storage volumes are not provided, equivalent pumping capacity for fire flow must be provided, as detailed further below.

The Mount Albert Water Water Supply System is considered a small pressure district with a minimum fire storage requirement of 1,200 m^3, based on supplying a demand of 10,000 L/min for a duration of 2 hours. The North ET has a design storage volume of 2,727 m^3. The bottom of the fire storage capacity should maintain a minimum of 140 kPa (20 psi) at the highest elevation in the distribution system. Under static conditions, this elevation would be 296.100 m (based on a service area maximum elevation of 282 m), which is lower than the elevated tank low water level (LWL) elevation of 304.79 m.

The fire storage, equalization storage and emergency equalization storage requirements are summarized for the Mount Albert Water Water Supply System in Table 2- 20, based on projected system maximum day demand for 2041/2051.

Table 2- 20. Projected Storage Requirements for Mt. Albert Water Supply System

Year	Projected Maximum Day Demand (MLD)	Projected Average Day Demand (MLD)	Fire Storage (A) (m^3)	Equalization Storage (B) (m^3)	Emergency Storage (C) (m^3)	Total Storage Required (m^3)
2021	3.4	1.5	1,200	850	513	**2,563**
2041	3.1	1.4	1,200	775	494	**2,469**

Assuming that the emergency and fire storage volumes are above the design LWL of 304.790 m, the top of the emergency and fire storage volume of 1,694 m^3 would translate to an elevated tank level of 6.23 m, as can be seen in Table 2-21.

Table 2-21. Mt. Albert North Elevated Tank Elevations and Available Storage Volume for 2041 Planning Horizon

Elevation Description	Elevation (m)	Level of Water from LWL (m)	Total Volume of Available Water in Tank from LWL (m^3)
Tank Floor	303.214	N/A	N/A
Low Water Level (LWL)	304.790	0	0
Top of Emergency Storage	307.45	2.66	494
Top of Fire Storage	311.02	6.23	1,694
Inlet Pipe Discharge	312.790	8.00	2,324
High Water Level (HWL)	313.940	9.15	2,738
Overflow	314.290	9.5	2,866

The projected water storage requirements, based on using the storage calculations provided above, suggest that the North ET (available storage capacity of 2,738 m^3 between the design LWL and HWL) has sufficient capacity to accommodate storage requirements to 2041/2051. As such, the capacity of the South ET is not required during this period to meet storage requirements.

In the event that the North ET is out-of-service, fire flow could not be adequately supplied from the existing wells. The wells have a combined maximum permitted taking of 3,465.28 L/min, which is insufficient to meet the water demand of 10,000 L/min.

In the event that the permit condition could be waived during an emergency situation, the combined well pump capacity is 6,810 L/min, which still leaves a calculated deficiency of 3,181 L/min. This assumes that the wells can deliver their rated capacities, although minor declines have been reported and it does not take into account the demand in the system at the time. Alternatives sources of water for fire flow would, therefore, have to be developed as a contingency during the time when North ET is out-of-service.

2.4.2.4 Condition Assessment

2.4.2.4.1 Mount Albert North Elevated Tank

A condition assessment was completed for the North ET in November 2018. A draft report (Condition Assessment Report Mount Albert North Composite Elevated Tank (CET)) identified an overall condition score grade is 3 for the facility, meeting the following criteria:

- (1) Acceptable physical condition – Moderate wear & tear, moderate risk of failure.
- (2) Capacity appears adequate (where applicable).
- (3) Performance meets expectation.
- (4) Minimum or no maintenance requirement.

The report identified several immediate remediation measures required including pressure wash and overcoating of the tank exterior which is exhibiting dirt and mildew pickup, spot corrosion and delamination of logo symbols from the undercoating and cleaning and minor repairs to the interior coatings, showing general corrosion and pittings. Additional upgrades included replacing the fall arrest system and relocating the hatch addressing tank appurtenances. Short term (1-5 years) measures included landscaping repairs, replacing doors, recoating the valve room floor and touching up the access tube and corroded valves. Recommendations were also provided with regard to telecommunications and aircraft warning lights on the tank roof.

Full removal of exterior coatings and interior linings is recommended in approximately 11 years.

The report concludes that with routine maintenance and coating/lining repairs, the tank would be expected to have an extended lifespan of service.

The tank is scheduled for cleaning and inspection in 2020, at which point the draft report will be updated with findings and finalized.

2.4.2.4.2 Mount Albert South Elevated Tank

A condition assessment was completed for South ET in 2015. The report rates the elevated tank as “Very Poor” (bad physical condition and/or asset cannot be operated safely without refurbishment or replacement) and is not currently fit for use as the interior lining system has failed beyond any appreciable service life (Figure 2-11).

The report states that although the tank is 40 years old, there is opportunity for rehabilitation and return to service after significant refurbishment of exterior coatings and interior linings. It is understood that a subsequent structural condition assessment has been completed in November 2019, although results are not available at this time.

Figure 2-11. Condition of Interior Roof of South Elevated Tank

2.4.3 Water Age

Managing water age in a drinking water system is important primarily because the chlorine used to maintain secondary disinfection decays with time, and if given enough time, the chlorine will completely decay, removing the ability to disinfect potential contamination entering into the drinking water system. The absence of sufficient residual chlorine can result in the development of a biofilm of accumulated microbial growth on the inside walls of the distribution system. While biofilms are generally considered non-pathogenic, they provide an opportunity to house or protect pathogens, as well as metal oxides and other trace metals that accumulate and can potentially be released into the distribution system. Biofilms also provide the mechanism for microbiologically induced corrosion resulting in pipe degradation and decreased pipe capacity. For systems using silicate for iron and manganese sequestration, it has been found that sequestration performance also degrades with time. By minimizing the water age of a system, a utility can reduce the potential to lose chlorine residual and the potential for iron and manganese and silicate deposition in the distribution system piping.

The hydraulic model was used to evaluate possible solutions for reducing water age (thus improving distribution and storage water quality), while still meeting other distribution requirements such as water storage, fire flow, and pipe velocities. This baseline hydraulic model is based on the current configuration and operation of the Mount Albert Water Supply System (Table 2-22).

Table 2-22. Mount Albert System Volume

Item	Volume (m^3)	Notes
North Elevated Tank	2,727	Currently operated from 45% to 90%
South Elevated Tank	910	Not in service. Requires significant rehabilitation and is therefore not considered further
Cumulative Volume of Water Mains	1,233	From baseline modelling
Total System Volume (in use)	3,960	

The operating cycle uses a relatively short duration of well operation (roughly 8 hours under average day demand conditions), during which time freshly treated water from Well 2 and Well 3 enters the distribution system from the south, supplying water to the system and filling the North ET in the north. Pumping is initiated when the water level in the elevated tank drops to 45% and pumping is stopped when the elevated tank level is at 90%.

The elevated tank is never completely emptied, and when the well pumps, located on opposite sides of the system from the tank, turn on, the freshwater flowing into the distribution system pushes older water from the distribution system pipes into the elevated tank, where it continues to age. As this cycle repeats, there is potential that some component of the water supply does not get consumed, but continues to age as it flows in and out of the tank. Areas in the vicinity of the tank, could, therefore, be receiving significantly aged water supply.

Water age can also be an issue at a number of dead-end water mains, especially around the perimeter of the drinking water system. The Town of East Gwillimbury has installed autoflushers at four of these dead-ends to alleviate local water age issues.

The model was used to predict water age across the system (Figure 2-11) under average day demand (ADD) and maximum day demand (MDD). The average water age was determined from the model from a full-length simulation of 600-hour of normal operation. Modelled water age near the North ET is predicted by the model to be the highest. Water age was found to be lowest near the well facilities. The ADD water age in the North ET stabilizes at an average of about 113 hours (4.7 days), with a maximum of 129 hours (5.4 days), which is in excess of the 72-hour target for sequestration effectiveness identified in the Region's ongoing GWTS. The MDD water age in the elevated tank stabilizes at an average of about 60 hours (2.5 days), with a maximum of 66 hours (2.75 days). The ADD water age in the distribution system ranges from 10 to 146 hours on average, with a maximum of 222 hours (9.2 days), which is in excess of the 72-hours target for sequestration effectiveness identified in the Region’s ongoing GWTS. Additionally, average water age at dead-end pipes is higher than within looped mains, as dead-ends have lower water demands and less flow.

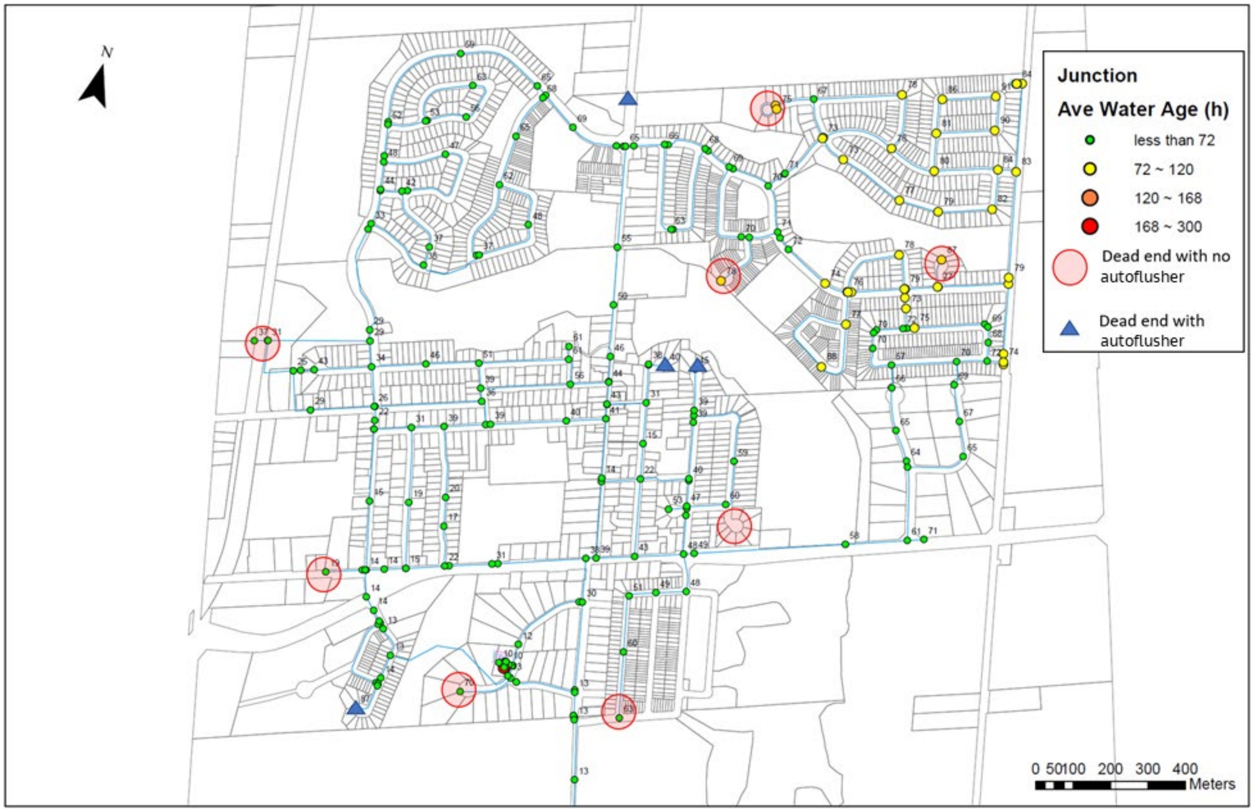


Figure 2-12. Average Water Age (hours) in Mount Albert Water Supply System Showing Location of Dead-Ends and Autoflushers

Water age was found to be the lowest at the southwest end of the system, where water generally comes directly from the wells without mixing with older water from the elevated tank. The average water age in the south end of the distribution system is generally between 10 and 42 hours. High water age was determined to exist at the South ET and adjacent to the Wells 1&2 Treatment Facility in the southwest end of the distribution system, but these are an artifact of the South ET being out of service and are not representative of distribution conditions.

Water age could be decreased by draining the North ET lower than the current 45%; however, draining the tank to 30% full would consume all fire storage volume with only a 10% reduction in average water age from 113 to 101 hours. This is still in excess of the 72-hour target and removes fire protection from the system, which is not recommended. Water age could also be improved by operating the distribution system in pressure mode and not using the elevated tank at all; however, this is not practical as additional equipment would be required to ensure that fire flow and emergency storage requirements are met. Without large modifications to the distribution system, only minor improvements to water age are possible.

Local water age issues at dead-ends may be addressed by connecting the dead-end to another line to create a loop, or by installing an autoflusher. The Town of East Gwillimbury has constructed loops for most water mains in newer developments and installed autoflushers for some other dead-ends. If issues persist on a particular dead-end, its autoflusher can be adjusted to operate at a higher flow rate and/or frequency.

Twelve dead-ends were identified in the distribution system. Four of the dead-ends are equipped with autoflushers. Information on autoflushers was provided by the Town of East Gwillimbury. Table 2-23 summarizes information related to these autoflushers, provided by the Town of East Gwillimbury.

Table 2-23. Mount Albert Autoflusher Details

Autoflusher Name	Location	Type	Settings	Flow Setting (L/s)
Centre St North Flush Box	Across from 19451 Centre Street	Automatic Timed	2:00 am for 10 min	Note (a)
Alice St Flush Box	Outside of 65 Alice Street	Automatic Timed	2:00 am for 10 min	15.0
Royal Oak Rd Flush Box	2 Royal Oak Road	Automatic Timed	2:00 am for 10 min	15.3
Don Rose Blvd Flush Box	Outside of Don Rose Boulevard	Automatic Timed	2:00 am for 10 min	10.7

Notes:

a) No recorded flow rate available

Eight (8) dead-ends in the system do not have autoflushers, with the longest one at Cupples Farm Lane/Robb Thompson Road along the south edge of Mount Albert. Potential water quality issues at this dead-end are expected to be mitigated as housing construction continues. The dead-end will be addressed by connecting the south end of the dead-end to the main line to the west under Centre Street and/or to loop it with the parallel streets under construction to the east (Fredrick Taylor Way). The remaining seven (7) dead-ends are much shorter or tend to be in areas with low water age.

2.4.4 Distribution System Water Quality

The main concern for distribution system water quality is the maintenance of consistent free chlorine residual for secondary disinfection. As noted previously, this is essential to provide the ability to disinfect potential contamination entering into the drinking water system and to control biofilm development. For Mount Albert, iron and manganese are the next most important water quality parameters. Sediments and precipitates of iron and manganese can accumulate in the distribution system and the occurrence of coloured water at a customer tap leads to complaints due to aesthetic concerns of laundry and fixture staining and potential damage to premise plumbing components such as softeners and hot water heaters.

2.4.4.1 Free Chlorine Residual

In July 2019, samples were collected at each of the well facilities to undertake bulk chlorine decay analysis. Free chlorine was measured at 0, 0.5, 1, 2, 4, 6, 24, 48, and 72 hours, with duplicate measurements performed at each time interval and results are summarized in Table 2-24 and Figure 2-13.

While there was some variability in reported decay observed in the early tests, likely due to changing conditions during field testing, generally, the testing indicated that chlorine decays by about 0.4 mg/L over 72 hours for treated water from both Well 2 and from Well 3. Ignoring other factors causing chlorine decay, areas receiving water from Well 2 should expect chlorine concentrations to be roughly 1.0 mg/L after 72 hours, while areas receiving water from Well 3 should expect chlorine concentrations of 1.4 mg/L. Areas receiving a mixture of water from both sources (the majority of Mount Albert) should have chlorine concentrations around 1.2 mg/L after 72 hours.

Table 2-24. Bulk Decay Test Free Chlorine Results

Elapsed Time (hours)	Wells 2	Well 3
0	1.37	1.78
0.5	1.39	1.75
1	1.48	1.70
2	1.26	1.79
4	1.26	1.62
6	1.17	1.64
24	1.27	1.49
48	1.07	1.42
72	1.02	1.39

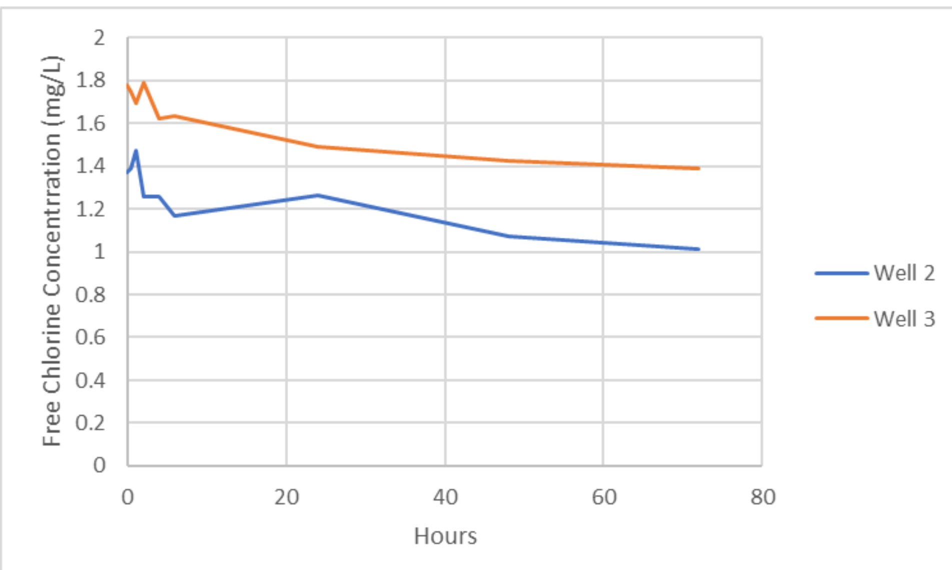


Figure 2-13. Bulk Decay Test Results for Well 2 and Well 3, Beginning July 2019

Pipe wall impacts on chlorine concentration are dependent on the water velocity, pipe material, age, diameter, presence of deposits, corrosion and biofilm. PVC pipes in the Mount Albert DWS have the least amount of chlorine decay, while the ductile iron pipes used in the older areas of Mount Albert lower the chlorine concentration the most. Baseline modelling (Figure 2-14) of chlorine concentrations predicts that chlorine concentrations are lowest in areas of high water age (near the elevated tank and at dead-ends) and where pipes tend to be iron rather than PVC (near the middle and toward the west of Mount Albert).

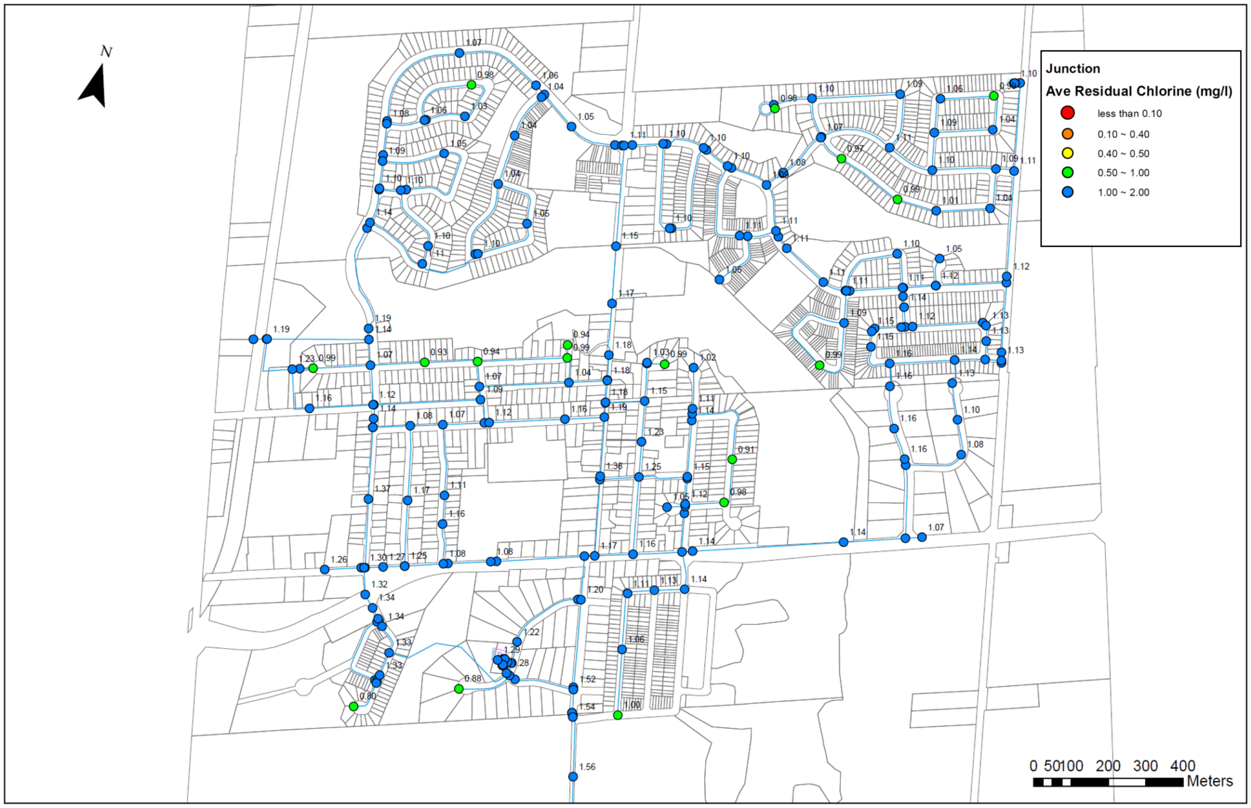


Figure 2-14. Modelled Average Free Chlorine Concentrations for Mount Albert

The modelling-predicted chlorine concentrations in the DWS compared well with distribution system monitoring samples. The modelled predicted a range of residuals from 0.9 and 1.5 mg/L, while 845 free chlorine measurements from the distribution system sampling stations measurements from January 2015 through to December 2016 reported an average free chlorine residual of 1.21 mg/L, with the lowest reading of 0.52 mg/L (Table 2-25, Figure 2-15). The majority of readings fell between 1.0 and 1.5 mg/L, similar to the model predictions. Readings outside this band occurred with no apparent trend that could be attributed to seasonality.

Table 2-25. Summary of Free Chlorine from Distribution Sampling Stations, January 2015 to December 2016

Parameter	Free Chlorine (mg/L) in 2015	Free Chlorine (mg/L) in 2016
Minimum	0.62	0.52
Maximum	2.06	1.82
Average	1.21	1.21
No. of Data Points	359	486

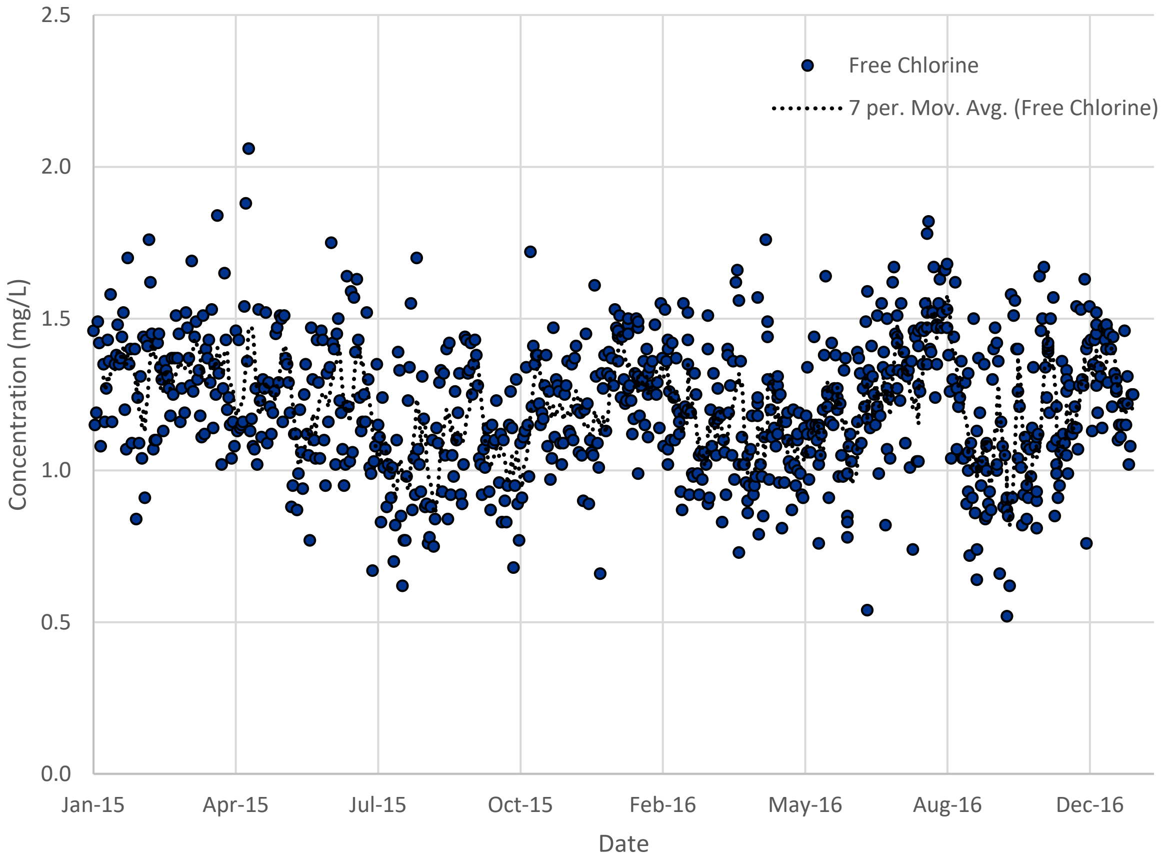


Figure 2-15. Distribution Chlorine Concentrations from January 2015 to December 2016

Similar results were obtained from distribution sampling conducted in July and August 2019 (Table 2-26 through Table 2-28). Free chlorine residuals were generally above 1.0 mg/L and remained steady for the duration of testing, and well above 0.4 mg/L. Further, there was little variation between the free chlorine residual and total chlorine residual measurements and no obvious trends, indicating a consistent biostability in the distribution system.

As expected, chlorine concentrations during the isolated sampling events in July and August 2019 were found to be generally lower where water age was calculated to be highest, but still remained within target. Further, it is noted that sample stations with warmer water reported lower chlorine residuals since chlorine decay rates are generally expected to double with each 10°C increase in temperature.

Table 2-26. Summary of Water Sampling 2019 DWS Results

Parameters	Minimum (July 17 and 18)	Average (July 17 and 18)	Maximum (July 17 and 18)	Minimum (August 1 and 2)	Average (August 1 and 2)	Maximum (August 1 and 2)
Free Chlorine (mg/L)	1.03	1.30	1.70	0.91	1.19	1.68
Temperature (°C)	9.8	13.9	17.0	9.7	14.55	17.75
pH	7.39	7.76	7.90	7.42	7.66	7.77

Table 2-27. Average Chlorine Concentrations, Sample event 1: July 17-18, 2019

Location	Total Cl (mg/L)	Free Cl (mg/L)	Total Cl – Free Cl (mg/L)
Well 2	1.37	1.25	0.12
Well 3	1.74	1.62	0.12
Sample Station 1	1.37	1.26	0.12
Sample Station 2	1.26	1.11	0.14
Sample Station 3	1.40	1.24	0.16
Sample Station 4	1.34	1.17	0.16
Sample Station 5	1.55	1.40	0.15
Sample Station 6	1.54	1.36	0.18
Sample Station 7	1.82	1.63	0.18
Sample Station 8	1.37	1.22	0.15

Table 2-28. Average Chlorine Concentrations, Sample event 1: August 1-2, 2019

Location	Total Cl (mg/L)	Free Cl (mg/L)	Total Cl – Free Cl (mg/L)
Well 2	1.27	1.14	0.13
Well 3	1.87	1.78	0.09
Sample Station 1	1.25	1.12	0.13
Sample Station 2	1.21	1.08	0.13
Sample Station 3	1.23	1.11	0.12
Sample Station 4	1.21	1.11	0.10
Sample Station 5	1.33	1.23	0.10
Sample Station 6	1.34	1.21	0.14
Sample Station 7	1.64	1.50	0.15
Sample Station 8	1.32	1.18	0.13

Because of the low DOC concentration in the system, there is little opportunity for the formation of disinfection byproducts (DBPs) with chlorination. The DBP concentrations reported to the MECP from 2015 to 2018 all show low total trihalomethanes (TTHMs) and haloacetic acids (HAAs) concentrations (Table 2-29).

Table 2-29. Average yearly THM and HAA Concentrations in Mount Albert Water Supply System, from MECP Annual Reports

Year	Average TTHM (µg/L)	Average HAAs (µg/L)
2015	6.5	NA
2016	8.9	NA
2017	10.3	<20
2018	5.2	<20, <8

2.4.4.2 Iron and Manganese

Iron and manganese concentrations were measured in the distribution system during the development of the hydraulic model for Mount Albert. The results are reported in Appendix F of the Hydraulic Analysis Report with findings summarized below. This work sampled iron and manganese (total and dissolved) at Well 2 and Well 3 as well as eight sampling stations around the DWS (Table 2-30) over a 30-hour period from August 1 to Aug 2, 2019. Samples were collected once during the filling cycle and three times during the subsequent drain cycle. The sampling was conducted to develop an understanding of the total and dissolved iron and manganese levels in the distribution system under existing conditions and to evaluate whether sequestration is currently maintaining iron and manganese in the dissolved form throughout the distribution system and preventing deposition.

Table 2-30. Sample Station Locations for Distribution Sampling

Sample Station Number	Address	Type
1	126 Mainprize Crescent	Exterior Sampling Station
2	19451 Centre St	Exterior Sampling Station
3	405 King St E	Exterior Sampling Station
4	74 Manor Glen Crescent	Exterior Sampling Station
5	Millennium Park at King St and Albert St	Exterior Sampling Station
6	5517 Mt Albert Rd	Exterior Sampling Station
7	18855 Centre St	Exterior Sampling Station
8	19178 Ninth Line	Elevated Tank

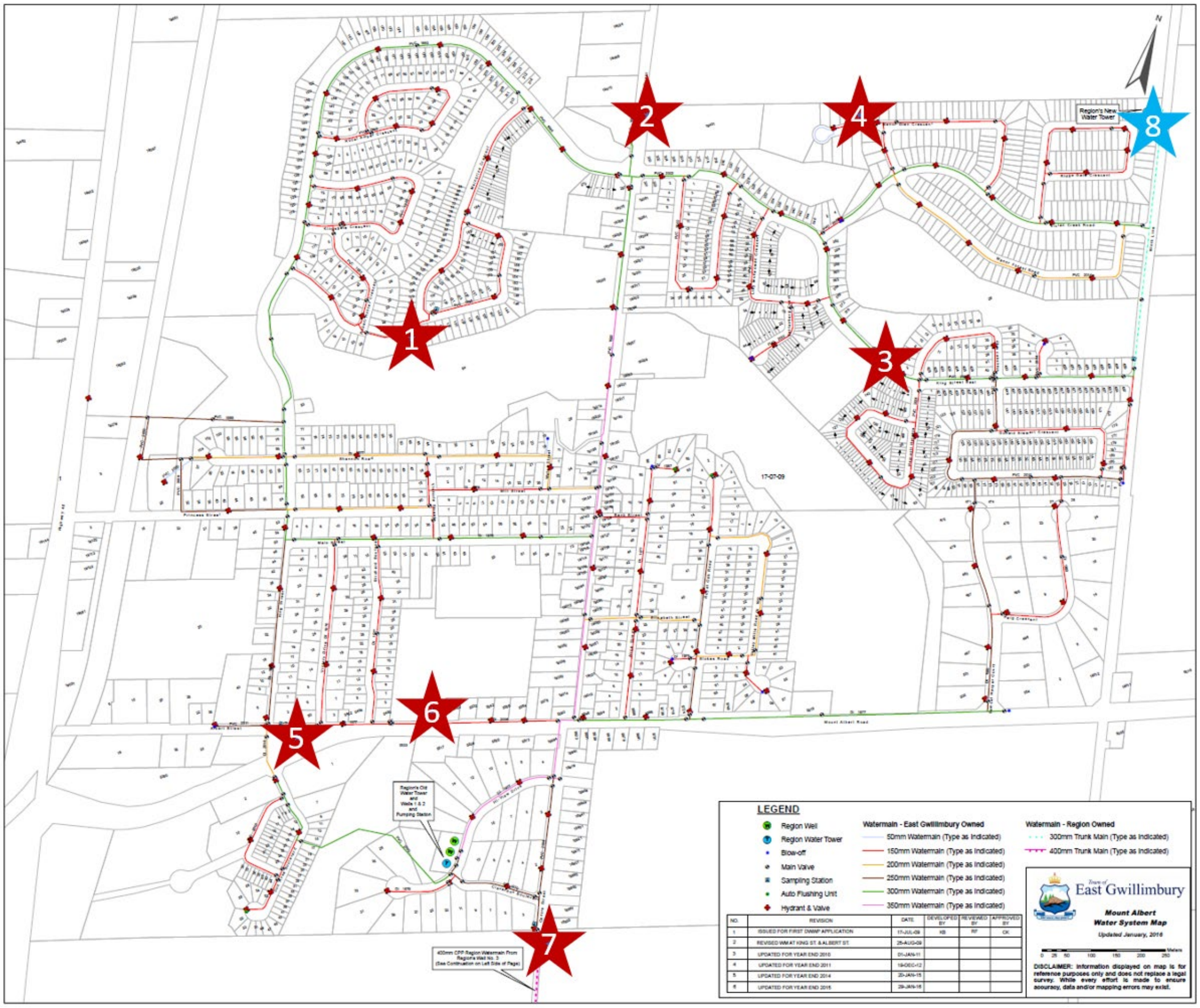


Figure 2-16 Distribution System Sample Locations

Red = Existing Sampling station, Blue = elevated tank

During sampling, distribution iron concentrations were consistently below the AO, with an overall average total iron concentration of 0.142 mg/L (Figure 2-17). Results of the sampling showed that overall total iron concentrations tended to decrease with time, indicating that deposition was occurring in the distribution system despite sodium silicate addition. Silicate addition was effective in maintaining more than 90% of the iron in dissolved form in areas of the distribution system that were not fed by the North ET (Sample Stations 1, 5, 6 and 7). However, when a sample station received water from the elevated tank the iron was mainly particulate (generally 75% to 95% particulate). While water from the elevated tank had a clear impact on the form of iron, there was no obvious impact on total iron concentrations. All sample locations appeared to have some decrease in iron concentrations regardless of the proportion of iron that was maintained in the dissolved form. Based on these results, the maintenance of iron in the dissolved form does not necessarily indicate the prevention of deposition.

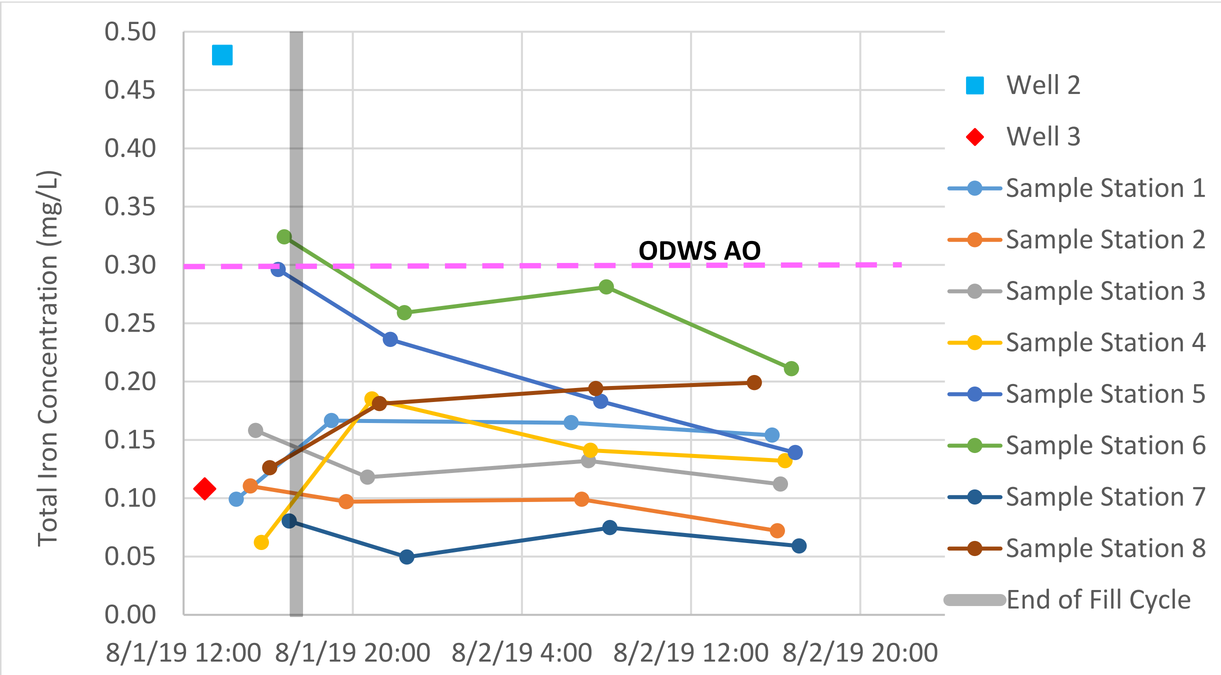


Figure 2-17. Total Iron Concentration from Mount Albert Wells and Sampling Stations

The average total manganese concentration for the distribution system during the sampling period was 0.024 mg/L (Figure 2-18). Manganese concentrations were above the Health Canada treated water operational goal of 0.015 mg/L but below the Health Canada MAC of 0.120 mg/L. Total manganese concentrations followed a similar pattern to iron concentrations, with a general decrease in total manganese concentrations with time. Areas receiving water from the elevated tank had a much higher proportion of particulate manganese, but a lower total manganese concentration (Sample Stations 2, 3, 4). Areas that were not influenced by the elevated tank tended to maintain most of the manganese in the dissolved form, generally between 80% and 100%. However, toward the end of the drain cycle, the manganese concentrations were lower than expected in all sampling locations, indicating that manganese deposition occurred throughout the distribution system. In addition, measured manganese concentration at Station 7 was substantially higher (almost 1.5 times) the concentration of the supply from Well 3, suggesting a release of legacy manganese from the distribution system.

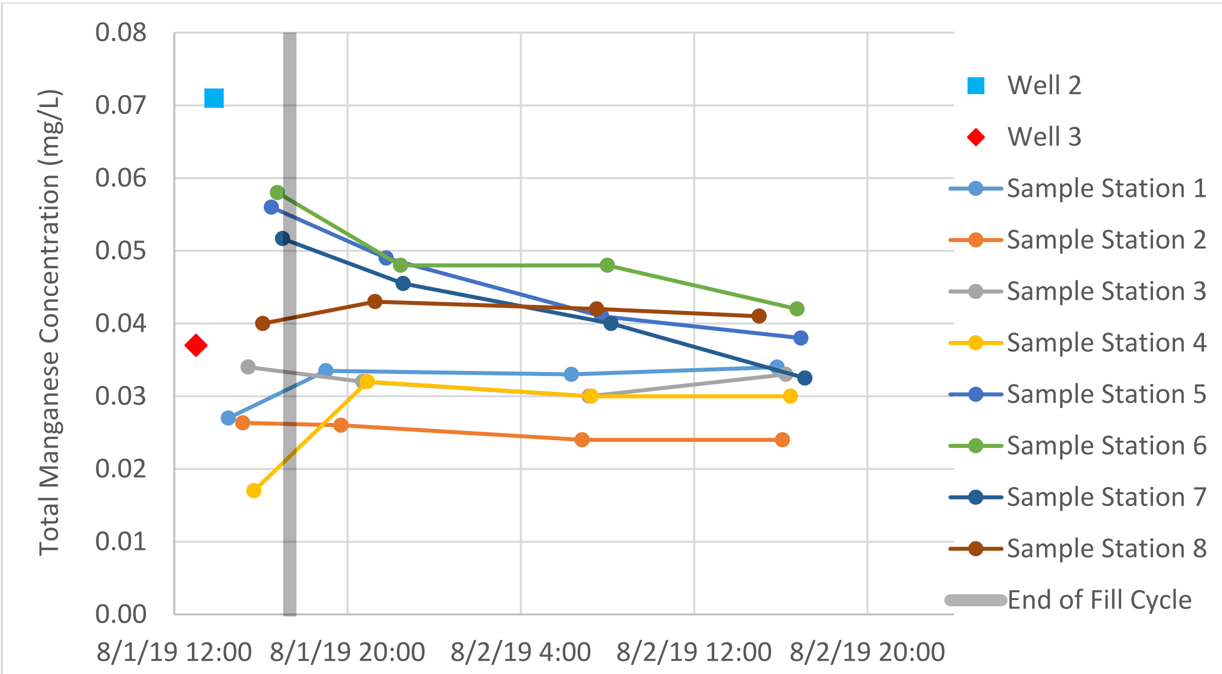


Figure 2-18. Total Manganese Concentration from Mount Albert Wells and Sampling Stations

The major finding of the sampling was that iron and manganese concentrations were generally lower in the distribution system than at the well facility outputs, regardless of whether iron and manganese were dissolved. Iron and manganese deposition was occurring regardless of water age, pipe material, pipe age or pipe diameter. More importantly, iron and manganese deposition was occurring regardless of the amount of iron and manganese in the dissolved form, suggesting that changes to the silicate dosing will not substantially improve sequestration in the drinking water system. Based on these results, silicate addition may be helpful in reducing discoloured water issues, but currently, the data suggests that silicate is not effective at preventing iron and manganese deposition in the Mount Albert distribution system. Silicate measurements collected during the sampling (Figure 2-19) showed concentrations at sampling stations less than initially measured at both wells (Sample locations 1,2,3, 7) which could reflect the impact of dosage variability during the sampling event, or that the silicate was depositing within the distribution system between Well 3 and the sampling stations. It was also noted that several sampling locations (1,3,4,7) showed an increase in silicate concentration over time, which could suggest remobilization of silicate previously deposited in the system.

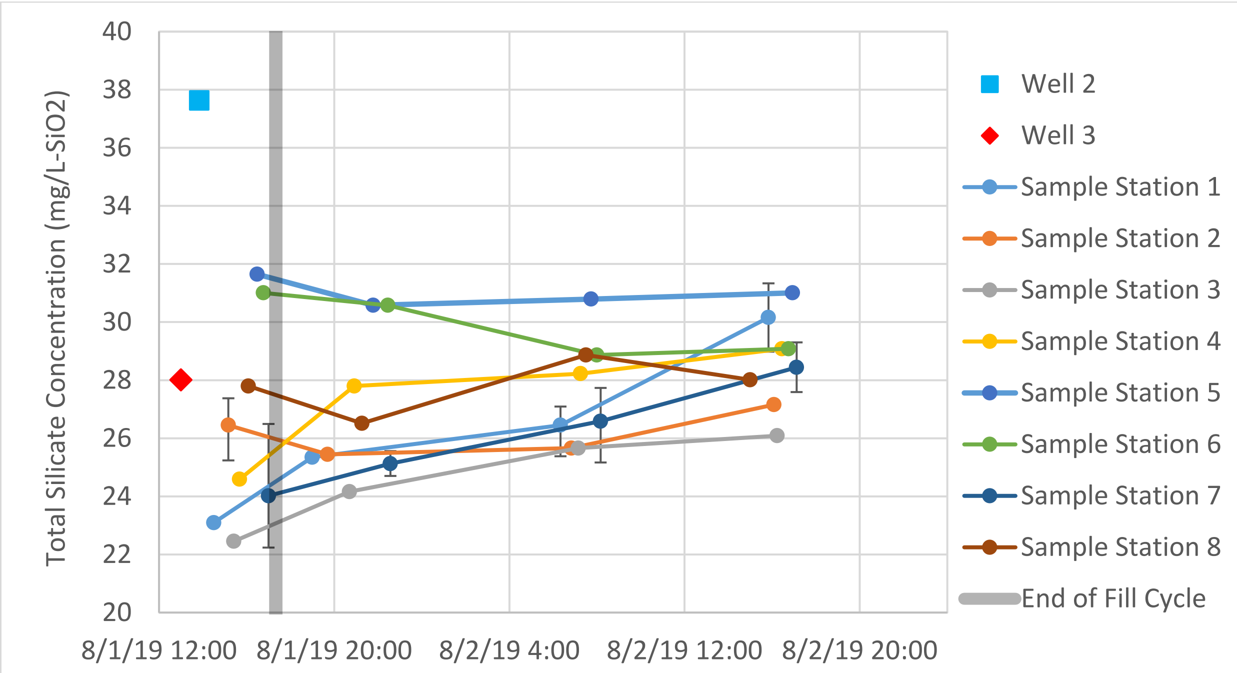


Figure 2-19. Silicate Sampling Results from Mount Albert Wells and Sampling Stations

Once water enters the elevated tank, the majority of iron and manganese is quickly converted to particulates. At this time, it is unclear whether this is due to higher water age in the tank, mixing with possible accumulated sediments or the impact of aeration through the configuration of the inlet. Bench-scale testing conducted as part of the GWTS project did not identify aeration as a factor contributing to the failure of silicate sequestration. The aeration did provide a useful diagnostic for determining whether water at a sample station was receiving water from the elevated tank; water from the wells had very low dissolved oxygen concentrations (between 0 and 1 mg/L) while water from the elevated tank had between 3 to 6 mg/L dissolved oxygen. Intermediate dissolved oxygen concentrations should indicate mixing of well water with water from the elevated tank.

Since it appears that the existing treatment regime is unable to fully prevent iron and manganese deposition from occurring, greater emphasis should be placed on system maintenance (swabbing and unidirectional flushing) as detailed in subsequent sections.

2.4.4.3 Aesthetic Water Quality

A review of customer complaints received from 2017 to 2019 indicates that the predominant concern is related to discoloured water (brown or rusty discoloured water), caused by iron and manganese oxides. The majority of complaints from 2017 to 2019 were from residents in the northeast of Mount Albert, near the elevated tank (especially Manor Glen Crescent, Ridge Gate Crescent, Vivian Creek Road and Manor Forest Road). A smaller group of complaints originated in the southwest of Mount Albert (Princess Street, Victory Drive, Shannon Road).

To investigate discoloured water issues in the distribution system, the sampling carried out for iron and manganese on August 1-2, 2019 also used filter membranes to identify locations with high particulate iron concentrations, as evidenced by filter staining. The details of the sampling are included in Appendix F of the Hydraulic Analysis Report and summarized below.

Stained filter membranes were only observed when two conditions were met:

- sample stations received water with dissolved oxygen concentrations above 2 mg/L, indicating that the water was from the North Elevated Tank, and

- particulate iron concentrations were high enough that iron oxides on the filter were noticeable (generally, particulate iron concentrations above 0.08 mg/L)

Staining was observed at Sample Stations 2, 3, 4 and 8 (Table 2-31) in the northeast area of the system. As watermains in this area are predominantly PVC, the staining would not be related to pipe corrosion and more likely due to particulate iron formed in the elevated tank. It is unclear whether the formation of particulate iron is due to water age in the elevated tank, aeration or contact with sediments in the elevated tank and the cleaning and inspection of the tank, scheduled for early 2020, will provide additional clarity in this regard.

Table 2-31. Coloured Filter Membrane Results from Distribution Iron and Manganese Sampling

Location with visible filter membrane staining	Rounds Staining was Observed	Notes
Sample Station 2	1, 2, 3 and 4	Staining observed for all four samples. Sample Station 2 is located at a dead-end, equipped with an autoflusher.
Sample Station 3	2, 3, 4	No staining during fill cycle when receiving water directly from wells (no dissolved oxygen, iron mainly in dissolved form). Staining only visible during drain cycle (dissolved oxygen >2 mg/L and most iron as particulate).
Sample Station 4	3, 4	Sample Station is at a dead-end with no autoflusher. Dissolved oxygen was always above 2 mg/L. During Round 1, iron was in particulate form (92%) but total iron concentration was only 0.057 mg/L.
Sample Station 8 (North ET)	2, 3, 4	No staining during fill cycle when receiving water directly from wells (no dissolved oxygen, iron mainly in dissolved form). Staining only visible during drain cycle (dissolved oxygen >2 mg/L and most iron as particulate).

Some discoloured water complaints were also logged in the southwest area of the system. While water age is low in the area due to proximity to Wells 1 and 2, the watermains are predominantly older, ductile iron and the baseline model identified the area as having the lowest chlorine residuals due to the impact of the piping on chlorine decay. Sample Stations 5 and 6 located in this area showed no filter membrane staining or elevated dissolved oxygen; however, significant total and dissolved iron concentration was observed at these stations. Additional investigation into the condition of watermain in the area may provide an indication of the discoloured water complaints.

2.4.5 System Pressures

The community of Mount Albert was built in an area of the Oak Ridges Moraine with variable topography. Homes on the west side of Mount Albert are approximately 37 m lower in elevation than homes at the intersection of Centre Street and Mount Albert Road, the highest point of the community. This difference in elevation creates a theoretical difference in water pressure of 37 m of water head or 363 kPa (53 psi) of range. Section 16.7.2 of the Region Design Guidelines has pressure design criteria that suggest systems maintain a pressure range of less than 30 m (295 kPa/43 psi) throughout the pressure zone.

Region Design Guidelines also state that the operating pressure ranges should be between 275 and 700 kPa (40 and 100 psi), with emergency pressure being more than 140 kPa (20 psi). Baseline hydraulic modelling, carried out as part of this study, found that maximum pressure in the system under ADD conditions was highest along the west side of Mount Albert where the ground elevation is the lowest. Under these conditions, pressure in system town was generally between 328 and 742 kPa (47.6 and 107.6 psi), with an operating range of 414 kPa (60 psi).

To evaluate minimum pressures, the model was run under MDD conditions with a low water level (El. 309.4 m) in the elevated tank, well pumps off, and under day time water demand conditions. This scenario identified an area in the south of Mount Albert with water pressure as low as 242 kPa (35.1 psi), while pressures on the west edge of Mount Albert were as high as 657 kPa (95 psi).

Under both scenarios, there are areas within the distribution system that are modelled to be operating just outside the recommended operating ranges for pressure.

Fire flow target flow rates were developed as part of the modelling. Based on the hydraulic model, the distribution system will be able to produce the desired hydrant flow at 73% of modelled locations in the system (Refer to the Hydraulic Analysis Study for details regarding the fire flows). Developing fire flow targets is a useful planning exercise for sizing water system equipment but meeting fire flow at all locations is not a regulated requirement for distribution systems. Overall, the Mount Albert distribution system appears to meet requirements for fire flow, though there are some areas where fire flow could be improved.

3. Identification and Evaluation of Performance Enhancement and Optimization Options

3.1 Introduction

The review of the existing system and development of a baseline for existing conditions allows for an assessment of the available opportunities to address identified system constraints or issues through means that would not require major capital investment. Options could include performance enhancements or optimization of existing facilities through operational improvements or limited infrastructure upgrades that could be implemented in the short term. Opportunities are assessed based on their ability to address the constraint without negatively impacting current levels of service or introducing additional operational complexity.

In the sections that follow, the assessment presented in Section 2 is consolidated to summarize existing conditions and constraints as they relate to the Well Treatment Facilities, well supply, the water distribution system and water storage, in terms of water quality, asset condition, operations and redundancy. Opportunities to address identified constraints through operational adjustments or relatively minor capital upgrades are outlined for further consideration to inform the development and evaluation of alternatives under subsequent phases of the Class Environmental Assessment.

3.2 Well Treatment Facilities

3.2.1 Summary of Existing Conditions

3.2.1.1 Water Quality

Iron and manganese represent the most significant water quality issues in the Mount Albert Water Supply System. Iron levels in the treated water exceed the Aesthetic Objective of 0.3 mg/L regularly at Well 1 and Well 2 with some exceedances at Well 3. Average manganese concentrations at Well 1 are higher than the Aesthetic Objective of 0.05 mg/L, while at Well 2 and 3, results are in close proximity to the objective with the maximum value just slightly exceeding the AO. It is noted that no values reported between 2014 and 2019 exceed the Health Canada proposed MAC of 0.12 mg/L, but manganese results from all wells consistently exceed Health Canada's lowered AO of 0.02 mg/L.

The current practice of sequestration with sodium silicate to complex iron and manganese and prevent deposition in the distribution system and subsequent water quality problems (turbidity, colour, staining, etc.) are not providing complete control, given increasing customers complaints, sampling results that would indicate iron deposition in the distribution system and silicate release, combined with observations of significant volumes of discoloured water discharged during recent fire flow testing.

Research to date has not identified a successful method to assess the effectiveness of sequestration directly. However, the Region has undertaken multiple investigations in well systems with iron and manganese through the ongoing GWTS to identify means to address these water quality challenges. Through the study, raw groundwater characteristics were considered to potentially impact on sequestration effectiveness amongst 33 groundwater wells used for water supply throughout the Region. Through on-site testing and review of the limited scientific research on the effectiveness of sequestration, the study identified the following considerations:

Sequestration for drinking water treatment is generally limited to water that contains less than 0.6 mg/L of iron and less than 0.1 mg/L of manganese, according to Civardi and Tompek, *AWWA Iron and Manganese Removal Handbook (2015)*. Additional studies (*Sequestering Methods of Iron and Manganese Treatment* - The American Water Works Association Research Foundation (AWWARF) - 1990 and *Iron and Manganese Sequestration Facilities using Sodium Silicate*, 1992 Robinson, et. al - 1992 concluded that sodium silicate does not effectively sequester manganese due to the relatively slower oxidation rate and the different mechanism of interaction.

Average manganese concentrations in Well 1 of 0.104 mg/L exceed the target while Well 2 and Well 3 are within the target with averages of 0.06 mg/L and 0.05 mg/L, respectively.

Iron concentrations in Well 1 and Well 2 are 1.11 mg/L and 0.6 mg/L, respectively, which exceed the target for effective sequestration, while average levels in Well 3 at 0.2 mg/L are less than the Aesthetic Objective.

The raw water quality of Well 3 would suggest that it is a candidate for effective sequestration; however, the current practice is not providing complete control, as evidenced by the observed decrease in iron levels between raw and treated water, even at the higher silicate dosages being applied.

Research into influences on sequestration has suggested various interactions that could play a role. Several studies (*Assessment of Iron and Manganese Sequestration* Volpe (2012), *Sequestration of Iron in Groundwater by Polyphosphates* Klueh and Robinson, *(1989)* and *Effects of Several Ions on Treatment by Sodium Silicate and Hypochlorite* Robinson, Minear, and Holden, *(1987)* investigated calcium inhibition of sequestration and concluded sequestration in facilities with groundwater hardness of 237 mg/L and alkalinity of 198 mg/L was not recommended. Levels in all of the wells exceed both the targets for hardness and alkalinity.

In addition, there is consideration that higher phosphate contents in raw water could interfere with iron complexing with the silicate sequestrant while it is still active. A 2010 study to improve sequestration at Mount Albert explored this hypothesis with no definitive results; however, it could be expected as polyphosphates are often used as sequestering agents. The study also explored whether there was a benefit of reducing pH during sequestration, as it is noted that the use of chlorine gas at Well 3 results in a marginally lower pH. Investigations are continuing in order to provide validation of the impact of these factors.

It is recognized that there are likely many compounding influences on the effectiveness of sequestration, in addition to raw water characteristics, including sodium silicate dosage control, impacted by dosing accuracy, chemical quality and contact chamber condition. The wide variations observed between measured Silicate (SiO_3) and the SCADA dosage setpoints may be addressed with the recent replacement of feed pumps at Wells 1 and 2; however, Well 3 continues to dose sodium silicate using a peristaltic pump. There is also consideration that the bulk storage of sodium silicate could also be contributing to dosage issues as the current method of storage, combined with the practice of transfer from the Aurora Treatment Facility, may result in the use of aged chemical with reduced product performance.

Assessment of free chlorine residual though both sampling and modelling shows a stable residual typically ranging between 1.0 and 1.5 mg/L, with no occurrences below the regulatory minimum of 0.05 mg/L and the majority of results in excess of the systems recommended operating minimum target of 0.4 mg/L. The associated CT calculated for each facility provides for 4-log virus inactivation.

3.2.1.2 Asset Condition

Based on recently completed condition assessments of the wells and the treatment facilities, the assets were assigned a facility condition grade of 2.3 for Well 1 and 2.0 for Well 2 and 2.0 for Well 3, which is representative of assets in good physical condition with minor and reasonably expected wear and tear. Replacement of the limited number of assets in condition grades of 4 or 5 is currently underway.

Routine maintenance that includes repainting of equipment and wall and floor coatings exhibiting corrosion is recommended as an ongoing practice. Monitoring of Well 3 performance may indicate the requirement for further investigation and possibly well rehabilitation.

3.2.1.3 Facility Operation and Redundancy

The well treatment facilities are each designed with duty and standby equipment to avoid service interruptions in the event of component failure.

It is noted that currently, water system demand can be met by any of the wells in operation; and the addition of standby power generation at Wells 1 and 2, scheduled for completion in early 2020, will allow for back-up to Well 3 in the event of a power failure.

As detailed in the section above, ongoing investigations are exploring means to improve the stability of treatment for iron and manganese treatment process; however, as the raw water characteristics approach or exceed the target levels for effective sequestration, compounded by high hardness levels and potential impacts of raw water phosphate levels, it is unlikely that significant improvement can be achieved. Process control improvements to well facilities in 2016 have improved chlorine dosage control for disinfection, resulting in more consistent chlorine residuals in the plant output and distribution system.

The chlorine contact chambers at the facilities have not recently been inspected, but given the drop between inlet and outlet iron concentrations, there could be significant accumulations of iron deposits, impacting available volume for chlorination and perhaps impacting iron depositions elsewhere in the distribution system. Cleaning and inspecting the chlorine contact tanks would provide useful information in this regard.

3.2.1.4 Opportunities for Optimization

As the ability to maintain acceptable treated water quality is highly reliant on consistent sodium silicate application, measures to improve the reliability of the sodium silicate feed system should continue to be implemented. Retesting at Well 2, following completion of the upgrade project, could provide an indication of the degree of improvement of dosage control, realized through the use of diaphragm pumps. Regular use of the calibration column for dosage verification and filter testing should be continued on a regular basis to verify that the sodium silicate target dose remains appropriate for each well. With more consistent operation of the silicate feed system, an assessment can be undertaken to validate whether dosage improvements would allow for effective sequestration at Wells 1 and 2; however, it is noted that the raw water quality exceeds the recommended targets for effective treatment and in practice and Region investigation, limited effectiveness has been observed.

The relatively improved raw water quality at Well 3 would suggest that improvements to the treatment process for more effective dosage control may increase the effectiveness of sequestration. These include the recently completed upgrades at Wells 1 and 2 that included pump replacement and flushing and flow indicator improvements on silicate injection lines; improvements to chemical handling through reducing chemical age and improved mixing would reduce chemical degradation; consideration of modifying the draw-off point from chemical storage to avoid sediment accumulations. It is noted, however, that the interference of the identified factors of hardness, alkalinity and potentially phosphate on the treatment process cannot be easily avoided, and there remains the potential that water quality issues will remain.

Even if water quality in Well 3 could be improved, the supply is insufficient on its own to meet the long-term needs of the community, and more extensive capital investments beyond the scope of system optimization, such as alternative treatment of Wells 1 and 2 or development of an alternate source would be required to provide redundancy.

These options would be further evaluated through subsequent phases of the Class EA, and to that end, the Region has initiated the investigation of alternative supplies and completed a Groundwater Exploration Study in 2019. Test well MW18 was drilled in the vicinity of Well 3 and testing identified that the well could provide sufficient water supply; however, similar concerns with raw water quality would exist, based on limited testing results. Reported iron concentrations were 0.22 mg/L, which, while still within the Aesthetic Objective of 0.3 mg/L, were generally twice the concentrations currently measured in Well 3. Manganese, hardness and phosphate concentrations were all similar to Well 3 reading. While an improvement over Wells 1 and 2 water quality, as with Well 3, water quality issues may still occur.

3.3 Distribution System

3.3.1 Summary of Existing Conditions

3.3.1.1 Water Quality

Water quality in the distribution system is directly impacted by water age within the system. By minimizing the water age of a system, a utility can reduce the potential to lose chlorine residual and the potential for iron and manganese and silicate deposition in the distribution system piping. Distribution system water ages were modelled using the system hydraulic model described previously, with modelled water age near the North ET predicted to be the highest and water age was found to be lowest near the well facilities. Additionally, average water age at dead-end pipes is higher than within looped mains due to the lower water demands.

Free chlorine residuals in the distribution system are stable and remain consistently above the minimum operating target of 0.4 mg/L Modelling identified free chlorine residuals in the distribution system ranging between 0.9 and 1.5 mg/L, in line with measured results of average free chlorine residual of 1.21 mg/L. These levels approach the higher end of Health Canada's reported range for customer acceptance of chlorinous taste and odours (0.4-2.0 mg/L) on occasion; however, there is little reported evidence of community concerns about chorine residual to date. Because of the low DOC concentration in the system, DBP concentrations reported from 2015 to 2018 all show trihalomethane (THM) and haloacetic acid concentrations well below standards.

Distribution sampling of the total and dissolved iron in the distribution system showed that iron and manganese deposition was occurring throughout the system, independent of correlation to water age, pipe material, pipe age or pipe diameter. More importantly, iron and manganese deposition was occurring regardless of the amount of iron and manganese in the dissolved form, suggesting that changes to the silicate dosing will not substantially improve sequestration in the drinking water system.

The majority of customer complaints from 2017 to 2019 were from residents in the northeast of Mount Albert, near the North ET (especially Manor Glen Crescent, Ridge Gate Crescent, Vivian Creek Road and Manor Forest Road). A smaller group of complaints originated in the southwest of Mount Albert (Princess Street, Victory Drive, Shannon Road).

3.3.1.2 Asset Condition

The distribution system has a relatively younger stock of watermains, with all the pipes younger than 50 years old. Over half of the pipes in the system have been installed since the year 2000. According to results from the 2018 Municipal Survey undertaken through the GWTS there were no watermain breaks in the system between 2012 and 2017.

The distribution system is maintained and operated by the Town of East Gwillimbury, and no specific maintenance issues have been identified; however, as noted previously, sampling has identified the presence of iron and silicate deposition in the distribution system, as well as the potential release of legacy manganese. Head loss through the distribution system, assessed through the Hydraulic Analysis was identified as usually low; however, lower hydrant flow results may be an indicator of pipe deposits reducing the carrying capacity of the system in some areas.

3.3.1.3 Facility Operation and Redundancy

Baseline hydraulic modelling found that maximum pressure in the system under ADD conditions was highest along the west side of Mount Albert where the ground elevation is the lowest. Under these conditions, pressure in the system ranged between 328 and 742 kPa (47.6 and 107.6 psi). Under MDD conditions, when the water level in the tank reaches its low operating level of 45%, with the well pumps off, water pressure can drop as low as 242 kPa (35.1 psi) in the vicinity of Wells 1 and 2. Ideally, water pressures in the system should range between 276-689 kPa (40-100 psi). Both ends of the range are exceeded in areas throughout the system.

Most areas in the distribution system were identified to meet fire flow targets. The hydraulic modelling exercise identified that approximately 73% of the junctions meet their fire flow target (i.e. available fire flow is greater or equal to the target). The areas that failed to meet the fire flow target are typically located at dead-ends, and in some commercial areas, school areas and higher density townhouses with a higher fire flow target.

The Town of East Gwillimbury maintains an active program of flushing to improve water quality consisting of the following:

- Annual unidirectional flushing in the summer to remove sediment build-up,
- Monthly proactive flushing using conventional flushing without valve isolation,
- Reactive flushing as needed for water turnover in response to water quality complaints using conventional flushing, and
- Dead-end flushing daily for water turnover using autoflushers.

When flushing is conducted, the flush volume, duration, chlorine residual, colour, and visual description of the water are collected and documented. The Town evaluates flushing effectiveness based on complaint data for colour.

3.3.1.4 Opportunities for Optimization

The GWTS identifies a tailored monitoring program to assess whether sequestration is effective under existing operational protocols in the distribution system. Information collected can be used to help optimize treatment and distribution system operations and identify areas that are at high risk for negative water quality events related to iron and manganese (e.g. conversion of dissolved Fe to particulate, or areas prone to Fe deposition). The monitoring program would include routine distribution system monitoring for apparent colour and combined with customer complaint tracking, set alert levels for potential actions/investigations. This could include more comprehensive testing of key parameters that could inform adjustments to operational practices to improve water quality.

An effective monitoring and flushing program is key to controlling the deposition of iron and manganese resulting in customer complaints. Best practices were summarized through the GWTS and are summarized below.

In collaboration with the Town of East Gwillimbury, the effectiveness of the current flushing and cleaning programs could be assessed to identify the optimal program for the distribution system. Research undertaken for The Water Research Foundation suggests that a system with a moderate Fe/Mn loading, such as the Mount Albert distribution system, should consider aggressive cleaning every 5-10 years with unidirectional flushing undertaken on a 2-year frequency (Metals Accumulation and Release Within the Distribution System: Evaluation and Mitigation, 2016). As identified in GWTS, the UDF program should include identification of optimal flush velocities, and appropriate flush termination targets in line with industry best practices: chlorine residual consistent with Ontario regulations, a suitable turbidity target of 5 NTU, achieving 1 to 2 pipe volume turnovers, and supplemented by a visual observation of water clarity. Distribution system iron and manganese sampling showed that deposition was occurring throughout the system, indicating that the distribution cleaning efforts should cover all areas of the system. Consideration can also be given to a more rigorous swabbing program to clear problematic depositions.

A marginal decrease in system water age could be achieved by operating water storage to drain to a lower elevation before refilling; however, this operational improvement does not reduce the water age below the Region recommended target for sequestration effectiveness and may also reduce operational flexibility with reduced tank volumes, in terms of fire storage and operating pressures.

Addressing dead-ends in the system can provide for increased operational flexibility for system maintenance and improvements in local water age. Creating loops to provide interconnections or other similar piping configuration can be considered for inclusion in Town watermain replacement projects. While additional autoflushers or adjusting existing autoflushers to operate at a higher flow rate and/or frequency may also be considered to improve local water age, water age on its own has not been identified as a key contributor to water quality. While sampling does show lower chlorine residuals in these areas, levels remain above operational guidelines and within compliance, suggesting that no immediate intervention is required.

The Region Design Guidelines suggest that pressure zones be limited to less than 30 m of elevation while the theoretical elevation difference in Mount Albert is 37 m. Addressing low pressure near the South ET could be achieved by modifying the well pump set-points; however, operating the elevated tank at a higher low water level would then reduce turnover in the tank and increase water age. The installation of pressure reducing valves in high-pressure zones may be warranted, though it would have secondary impacts for fire flow and flow patterns in the distribution system. Given the topography of the community, there is little opportunity to address low pressures with only operational adjustments, without creating negative side effects elsewhere. As the pressures identified through the modelling exercise were determined to be marginally outside the recommended range for operation, it is recommended that additional field verification and subsequent hydraulic modelling be undertaken to determine whether additional action is required.

3.4 Water Storage and Supply

3.4.1 Summary of Existing Conditions

3.4.1.1 Water Quality

Analysis has identified that while the silicate dose is sufficient to prevent the formation of iron and manganese particulates in the system, once water enters the elevated tank, the majority of iron and manganese are quickly converted to particulates.

As the North ET has not been removed from service in some time, it is unknown if there are sediments in the tank that are disturbed with the tank fill and draw cycle. Factors associated with the North ET may be currently having a negative impact on the water quality and sequestration performance in the distribution system, such as water age in the tank, the presence of tank sediments, or the impact of aeration of the inlet increasing the dissolved oxygen levels.

3.4.1.2 Asset Condition

The North ET has undergone no significant maintenance or rehabilitation since construction in 2005. A condition assessment has recently been completed and recommended minor interventions, including pressure washing and coating upgrades and routine maintenance to achieve an extended lifespan of service. Internal inspection and cleaning scheduled for Spring 2020 would identify additional internals repairs/upgrades that may be required.

The South ET is reported to be in “Very Poor” condition and not currently fit for use. The tank would require significant refurbishment to permit a return to service. It is understood that pending results of a subsequent structural condition assessment completed in November 2019, there is consideration of returning the tank to limited service following significant rehabilitation.

3.4.1.3 Facility Operation and Redundancy

The future projected Maximum Day Demand needs of the system of 3,400 m^3/d, which only slightly exceeds the permitted capacity of 3,280 m^3/d for a single well supply. Considering a slightly lower reported well pump capacity, some additional decline in well efficiency and assuming that Well 1 supply is available, the future demand can easily be met within the current firm capacity of the system, with two wells in operation.

The projected water storage requirements suggest that the North ET (available storage capacity of 2,738 m^3 between the design LWL and HWL) has sufficient capacity to accommodate storage requirements to 2041 and beyond.

If the structural assessment reveals that returning the South ET to service for a limited period is not feasible, the ability to remove the North ET from service for the period of time to undertake potential rehabilitation or repairs represents a significant operational constraint.

3.4.1.4 Opportunities for Optimization

Based on the conversion of dissolved iron and manganese to particulates in the North ET, there are likely deposits of iron and manganese accumulated in the bottom of the tank. The elevated tank will be inspected and cleaned, which will reduce the opportunity for old sediments to mix with freshwater. If mixing of the sediments with fresh water in the elevated tank is not responsible for degrading sequestration, consideration could be given to further investigating whether the aeration that is provided by the cascading inlet impacts performance. The inlet configuration was intended to minimize short-circuiting and therefore, additional measures would need to be considered to promote mixing and turnover of the storage volume. It is noted though, that Region testing has shown a significant impact of the presence of sediment on sequestration effectiveness, perhaps acting as a catalyst for precipitation, and it is anticipated that the modifications required would provide little additional value. Efforts should, therefore, be focused on cleaning the tank of sediment accumulations.

Since the South ET is currently out of service, there are operational barriers to removing the North ET from service for cleaning. Inspection and cleaning of the North ET, while it is in service with remote equipment, has not been effective and therefore removing this tank from service is contingent on either the feasibility of refurbishing the South ET or operating the distribution system in pressure mode.

Based on information available on the Well 3 pump and control narrative, it would appear feasible to operate the system in pressure mode, supplied by the Well 3 pump, which is equipped with a variable frequency drive that would be controlled to achieve identified system pressures. Well 3 has sufficient capacity to meet the current system demand range of 12 and 20 L/s, depending on the season and time of day. The well pump curve indicates that the well pump operates most efficiently when flows are above 12 L/s. Since the minimum demands during the night may drop to 3 L/s, a community communication program may be required during the rehab period to maintain water demand above 12 L/s, perhaps by scheduling flushing and encouraging outdoor water use to be scheduled during night time hours to maintain demand. In addition, the reported flow settings on the auto-flushers would provide this demand; however, the impact of discharging this volume to the environment would need to be carefully controlled to avoid environmental and property impact.

Assessment of the ability of the chlorine and sodium silicate feed systems to dose accurately at lower flows would also be required to ensure that water quality is not negatively impacted during that period. Full-scale testing with the North ET still in service is recommended to confirm operability before committing to cleaning the elevated tank. A testing protocol can be developed with Regional and Town operating staff to confirm programming and operation of the system, design of an appropriate pressure and monitoring program, investigation the operation of the well VFD’s to gain a field understanding of range of control with the elevated tank in service to ensure that system pressures are controlled and provided acceptable results, followed by undertaking a limited trial with the elevated tank isolated, but still full, to avoid system disruption. The results of well operation, and system pressure and residual testing would provide an indication of whether pressure operation is feasible.

It is noted that neither required fire flows nor fire storage would be available during pressure mode operations and operation of all three wells together would not meet the 10,000 L/min design fire flow. Contingency plans could be developed with Fire Services for operation during the maintenance period, to bring on the additional Well on an emergency basis and investigate alternate means to meet fire flow demands. This would require the development of a detailed operational strategy and response procedures to prevent over-pressurization of the water system and potential watermain damage.

3.5 Summary of Opportunities for Improvements

The following items have been identified as opportunities to improve the operation of the existing system. These items will be further considered in the subsequent Needs and Justification Study and latter phases of the Class Environmental Assessment process. Those alternatives considered viable in terms of meeting the defined screening criteria will be further assessed by applying a triple bottom line analysis that considers both natural and socio-economic impacts of alternatives with relationship to long term capital and operating costs.

- Silicate dosing systems:
  - Implement improvements undertaken at Wells 1 and 2 and Well 3 to allow for tempered flushing and cleaning of the calibration columns and injection points
  - Supply a pressure or flow switch to provide a more positive indication of silicate application
  - Increase regular mixing and changeover in sodium silicate tanks to maintain silicate product quality
  - Continued monitoring and validation of dosage accuracy for continuous process improvements
  - Review of impact of raw water chemistry on sequestration effectiveness, as infrastructure issues are addressed.
- Clean and inspect chlorine contact chambers at Wells 1 and 2 and Well 3
- Collaborate with Town of East Gwillimbury to develop and implement a tailored monitoring program for the distribution system to assess and track iron and manganese sequestration effectiveness
- Collaborate with Town of East Gwillimbury to refine a unidirectional flushing program to identify optimal flushing conditions and frequency and implement a swabbing program to address accumulated deposits
- Inspect and clean the North Elevated Tank. Assess the ability of pressure-mode operation at all well facilities to meet system demands and develop detailed operational strategy and response procedures
- Validate the low pressure detected by the hydraulic model is occurring in the distribution system, then investigate operational adjustments to address the low-pressure issues in the distribution system, without compromising the water quality.

Appendix A. Additional Information

Hydraulic Analysis Study (March 2020)

O. Reg. 169/03: Ontario Drinking Water Quality Standards (ODWQS)

Procedure for Disinfection of Drinking Water in Ontario (MECP, 2018

Guidelines for Canadian Drinking Water Quality, Health Canada

2018 Performance Evaluation for York Region Production Wells (March 26, 2019)

Mt. Albert PW1 Step Test Conducted on May 30, 2017 (May 30, 2017)

Mt. Albert PW 2 Step Test Conducted on November 7, 2016 (December 22, 2016)

Groundwater Facility Condition Assessment Report, (May 2014)

Mount Albert PW3 Step Test Conducted on May 7, 2015 (June 5, 2015)

Well and Pump Maintenance Report (June 2017)

Condition Assessment of Groundwater Production Facilities - Final Report for Mount Albert Well No. 3 (July 2015)

Ministry of the Environment (MOE) Guidelines for the Design of Water Storage and Water Distribution Systems (1985)

Water Supply for Public Fire Protection - a Guide to Recommended Practice, Fire Underwriters Survey (1991)

York Region Design Guidelines

Condition Assessment Report Mount Albert North Composite Elevated Tank Draft (October 31, 2018)

Condition Assessment Report Mount Albert South Composite Elevated Tank (December 28, 2015)

Civardi and Tompek, AWWA Iron and Manganese Removal Handbook (2015).

Sequestering Methods of Iron and Manganese Treatment - The American Water Works Association Research Foundation (AWWARF) - 1990

Iron and Manganese Sequestration Facilities using Sodium Silicate, Robinson, et. al – 1992

Assessment of Iron and Manganese Sequestration Volpe (2012),

Sequestration of Iron in Groundwater by Polyphosphates Klueh and Robinson, (1989)

Effects of Several Ions on Treatment by Sodium Silicate and Hypochlorite Robinson, Minear, and Holden, (1987)

Silicate Sequestration Studies at Mt Albert, Ontario, (November 19, 2010)

Mount Albert Groundwater Exploration Study (July 2019)

Metals Accumulation and Release Within the Distribution System: Evaluation and Mitigation, Water Research Foundation, 2016