JLR No.: 32874-000.1
Revision: R02

June 20, 2025

Design Basis Memorandum

Black Bear Ridge Development Servicing

J.L.Richards
ENGINEERS · ARCHITECTS · PLANNERS

Value through service and commitment

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1.0 Introduction

1.1 Background

J.L. Richards & Associates Limited (JLR) was retained by the City of Belleville (Belleville / City) to complete a Servicing Study for the Black Bear Ridge development area to identify existing conditions and future upgrades to Belleville's water and wastewater infrastructure to accommodate future growth in Belleville and potential future service connection areas, such as Foxboro, Corbyville Village, Harmony School, and Black Bear Ridge. This Servicing Study is being completed in accordance with the Ministry of Environment, Conservation and Parks (MECP) Guidelines. The ultimate objective of the Black Bear Ridge Servicing Study is to develop a strategy to accommodate future service connection areas and growth from 2023 to 2051 and beyond. In 2019, JLR completed the Belleville Wet Weather and Wastewater Servicing Master Plan which assessed the impact of projected future development to existing wastewater infrastructure and identified conceptual-level upgrade requirements. The Belleville Wet Weather and Wastewater Servicing Master Plan will serve as the basis of reference for the wastewater conveyance, pumping and treatment components of this Servicing Study.

This Design Basis Memorandum functions as Phase 1 of the Servicing Study and includes existing and projected demands generated by Belleville and future service areas which will impact Belleville's water and wastewater infrastructure.

Belleville is located along the Highway 401 corridor, on the Moira River and Bay of Quinte. It borders the City of Quinte West and the Township of Tyendinaga in Hastings County. The primary source of drinking water for Belleville is the Bay of Quinte. The Belleville Drinking Water System is operated under Drinking Water Works Permit No. 151-201, Issue No.4, dated December 16th, 2020, and Municipal Drinking Water License No. 151-101, Issue No. 5, dated December 16th, 2020. The Belleville Drinking Water System includes one water treatment plant: the Gerry O'Connor Water Treatment Plant (BWTP as Belleville Water Treatment Plant). BWTP draws raw water from the Bay of Quinte through intake pipes located at 2 Sidney Street, it has a maximum daily rated capacity of 72,700 m^3/day and includes filtration and disinfection. Belleville's water supply and distribution system consists of:

- Gerry O'Connor Water Treatment Plant (BWTP as Belleville Water Treatment Plant) with In-Ground Reservoir (WTP Reservoir)
- The John Street Elevated Water Storage Tank (John Street Elevated Tank)
- The North Park Street In-Ground Reservoir and Booster Pumping Station (North Park Street Reservoir and BPS)
- The Pine Street In-Ground Reservoir and Booster Pumping station (Pine Street Reservoir and BPS)
- The Adam Street Booster Pumping Station (Adam Street BPS)
- Over 224 km of watermains and 1,254 hydrants

The treated water distribution system consists of two main pressure zones: Pressure Zone 1 and Pressure Zone 2, which generally refers to serviced areas south and north of Highway 401, respectively. Pressure Zone 1 includes the John Street Elevated Tank, North Park Street Reservoir and BPS, and Pine Street Reservoir and BPS. The John Street Elevated Tank maintains the hydraulic grade line and required water storage within the distribution system. Pressure Zone 2 is serviced by the Adam Street BPS. Key infrastructure in the Belleville Drinking Water System is shown in Figure 1.

N

Foxboro

Black Bear Ridge

Corbyville Village

Cannifton

Pressure Zone 2

Pressure Zone 1

North Park St Reservoir & PS

Adam St PS

Urban

Loyalist Secondary Plan Area

Pine St Reservoir & PS

Elevated Storage Tower

Bayshore / City Centre

Belleville Water Treatment Plant

WTP Reservoir

Lake Ontario (lac Ontario)

Legend

Water System

- City Owned Water Facilities
- Pressure Zone

Watermain

- < 100mm
- < 200mm
- < 300mm
- < 400mm
- > 400mm

Boundary

- Parcel Fabric
- Planning Areas
- Municipal Boundary

PROJECT:

Black Bear Ridge Servicing Study

Belleville, Ontario

DRAWING:

Belleville Drinking Water Distribution System and Key Infrastructure

J.L.Richards

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DESIGN:	RC
DRAWN:	KTK
CHECKED:	SS
JLR #:	32874

DRAWING #:

Figure 1

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The communal wastewater system consists of approximately 200 km of gravity sewer, one major pressure sewer, three main pumping stations, 10 smaller sub-area pumping stations, and a single wastewater treatment plant that provides secondary treatment and disinfection to wastewater prior to discharging to the Bay of Quinte. Refer to Figure 2 for an overview of key wastewater infrastructure. The Belleville Wastewater Treatment Plant (WWTP) is owned by the City and is located at 131 St. Paul Street in Belleville, ON. The WWTP is currently operated by the Ontario Clean Water Agency (OCWA), has a rated average day capacity of 54,500 m^3/d, a peak flow capacity through primary treatment of 163,440 m^3/d, and a peak flow capacity through secondary treatment of 92,000 m^3/d. The WWTP is operated under Amended Environmental Compliance Approval (ECA) No. 2178-B2ZLM8, dated May 30th, 2019. The City's wastewater collection system is made up of sanitary sewer ranging in diameters from 100 mm to 1500 mm. The municipal sewage collection system operates under ECA No. 151-W601, dated October 6, 2022.

1.2 Future Servicing Areas

The Servicing Study and Design Basis Memorandum will analyse the impact of connecting to new service areas and anticipated growth in Belleville on the City's water and wastewater systems. Potential new service connection areas will include:

- **Black Bear Ridge**, located northeast of Belleville, covers an area of approximately 335 hectares with frontage on Harmony Road. Anticipated build-out will include over 3000 residential units and golf course resort developments in multiple phases over the next 20 to 30 years.
- **Harmony Public School** is located south of the Black Bear Ridge development area with frontage on Harmony Road. Anticipated build-out of the school will include 900 students. It's anticipated that the school will be serviced through Black Bear Ridge wastewater and water infrastructure.
- **Corbyville Village** is located within Belleville's urban serviced boundary, is anticipated to build-out over 700 residential units. Corbyville Village is also an area which may be considered for future servicing.
- **Foxboro** is located northwest of Belleville's urban serviced boundary, is an existing settlement area. Population growth is not anticipated however additional demand on the WWTP is anticipated due to future connection to this service area.

N

Legend

Sanitary System

- Pumping Station
- Pumping Station - Trunk
- Wastewater Treatment Plant
- Forcemain
- Pressure Sewer

Gravity Sewers

- <= 200mm
- <= 400mm
- <= 600mm
- <= 800mm
- > 800mm

Boundary

- Parcel Fabric
- Planning Areas
- Municipal Boundary

Foxboro
Black Bear Ridge
Corbyville Village
Thurlow Bridge
Cannifton
Millennium
Riverside Park
Cascade
College Hill
Urban
West Moria
Loyalist Secondary Plan Area
Roblin Place
Centennial
Avonlough Road
Front Street
Bayshore / City Centre
East End
Dundas / Palmer
Lake Ontario (lac Ontario)

PROJECT:

Black Bear Ridge Servicing Study

Belleville, Ontario

DRAWING:

Wastewater Treatment and Collection Network - Key Infrastructure

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DESIGN:	RC
DRAWN:	KTK
CHECKED:	SS
JLR #:	32874

DRAWING #: Figure 2

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1.3 Summary of Previous and Ongoing Work

The following is a list of recent, previously completed, and ongoing, water, wastewater, and stormwater infrastructure works in Belleville:

- Black Bear Ridge Pre-Consultation Official Plan Amendment, Zoning By-law Amendment (Phase 1), Draft Plan of Subdivision (Phase 1) Documents (Biglieri, 2024)
- Corbyville Land Use and Key Maps (RFA, 2024)
- Belleville Wet Weather and Wastewater Servicing Master Plan (WWMP) (JLR, 2019)
- Cannifton Planning Area Water Pressure Study and Storage Master Plan (XCG, 2012)
- Water Demand Data (2019 to 2023)
- Wastewater Annual Reports (OCWA, 2019 to 2023)
- West Belleville Secondary Plan (Dillon, 2023)
- Municipal Servicing Review and Study Update Cannifton Secondary Plan (Greer Galloway, 2014)
- 2018 Municipal Comprehensive Review of Urban Serviced Area (Waston, 2019)
- Development Charges Background Study (Watson, 2021)

1.4 Objectives of Design Basis Report

This Design Basis Memorandum was prepared to summarize the findings from the first phase of the Servicing Study and to use as a basis for the identification and evaluation of alternative options during Phase 2. The objectives of this Design Basis Memorandum are:

- To define boundary for the existing and future servicing.
- To define the existing population in Belleville serviced areas.
- To establish future growth projections in Belleville and future service areas until 2051.
- To provide a description of existing conditions and constraints associated with the water, and wastewater infrastructure within Belleville, including a summary of historical water/wastewater flows, and findings from models of each system.
- To analyse future impact of growth on Belleville's water treatment, treated water storage/ boosting, sewage conveyance and wastewater treatment infrastructure.
- To analyse the future impact of connecting to settlement areas beyond Belleville's servicing boundary. Impact to water and wastewater infrastructure will be considered under the following scenarios:
    - **Scenario 1:** Projected growth within Belleville (including Corbyville Village).
    - **Scenario 2:** Scenario 1 with connection to Black Bear Ridge, Foxboro and Harmony School.
- To define future water storage and boosting requirements using MECP guidelines for each scenario.
- To determine the residual capacity for water treatment and wastewater treatment under each scenario.
- To provide anticipated timing for when rated capacities of each system will be reached.
- To establish proposed design basis for future servicing needs.
- To identify land use and planning constraints, and natural environment constraints.

1.5 Methodology

1.5.1 Project Initiation Meeting

A Servicing Study Kick-off Meeting was held on April 17th, 2024, with representatives from the City of Belleville, McGlashon Planning Consultants, WJ Watson Engineering; Black Bear Ridge (BBR) Application Team including Black Bear Ridge GP Inc., Biglieri Group and Jewell Engineering; and JLR to confirm roles and responsibilities, project understanding, proposed work plan and schedule and to review current and historical challenges associated with the Belleville's water and wastewater systems. Refer to the attached meeting minutes.

1.5.2 Compilation and Review of Existing Documentation

A comprehensive inventory of available historical reports, permits/approvals, studies, drawings, and GIS data related to the current water, wastewater was developed. The documentation used to support this study was publicly available or provided by Belleville Staff. Several key documents are referenced herein. The data collected was reviewed and analyzed to establish current operating conditions for each system.

A comprehensive list of documents reviewed, and key findings used for the development of the Design Basis Memorandum is attached as Appendix A.

1.5.3 Design Basis Memorandum

This Design Basis Memorandum was prepared to summarize the findings from the first phase of the Servicing Study process and to use as a basis for the identification and evaluation of alternative options during Phase 2. In order to facilitate the evaluation and selection of the preferred solutions during Phase 2, a logical assessment process with key drivers for the decision making will be established based on this Design Basis Memorandum.

2.0 Study Area and Natural Constraints

The Study Area consists of the Planning Areas shown in Figure 3. The Planning Areas consists of the City of Belleville (Loyalist Secondary Plan Area, Urban, Bayshore/City Centre, Cannifton), Corbyville Village, Foxboro, and Black Bear Ridge.

Refer to Figure 3 which identifies significant landforms, municipal boundaries, Abandoned Mines Information System (AMIS) sites, swamp and creek tributary within the Study Area. There are areas of locally significant and evaluated wetlands located near the southeast and north borders of the study, as well as southeast of Foxboro.

Limitations of future upgrades associated with natural environment constraints will be further explored in the Phase 2 Servicing Study.

Legend

- Amis Site
- Utility Line
- Railway Station Station
- Railway Tracks
- Thermal Regime - Warm
- Thermal Regime - Cold
- Thermal Regime - Warm
- Aggsite Authorized Active
- Evaluated Wetland - Provincial
- Evaluated Wetland - Other
- Wetland -No Significance

Boundary

- Parcel Fabric
- Planning Areas
- Municipal Boundary

Foxboro
Black Bear Ridge
Corbyville Village
Cannifton
Urban
Loyalist Secondary Plan Area
Bayshore / City Centre
Foxboro Swamp
Warm
Hydro Line
Thrash Corners Wetland
37
Corbyville Wetland
401
Bell Creek Swamp Complex
Unknown Transmission Line
Potter Creek Tributary
Belleville Treatment Plant
Belleville Marsh
Blessington Creek Marsh
62
3
Cold
N

PROJECT:

Black Bear Ridge Servicing Study

Belleville, Ontario

DRAWING:

Natural Features

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DESIGN:	RC
DRAWN:	KTK
CHECKED:	SS
JLR #:	32874

DRAWING #: Figure 3

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3.0 Existing and Future Growth Design Basis

Planning Memorandum #1, dated November 4, 2024, includes the methodology to identify the existing (2023) residential population within the City. Planning Memorandum #2, dated November 6, 2024, includes the methodology to identify the potential projected (up to 2051) residential population within the City and future service areas of Foxboro and Black Bear Ridge. Population and ICI growth in Corbyville Village is calculated in case of potential future servicing. Refer to Appendix B for the memoranda. Sections 3.1 and 3.2 provide a summary of the key findings.

3.1 Planning Memorandum #1 – Existing Residential Population

To support the servicing study, JLR's planning team was tasked to identify the spatially distributed existing population by end of 2023. Based on the information gathered from the City, it was decided that the spatial distribution of the population should be divided by City planning areas, including Urban, Bayshore/City Centre, Loyalist Secondary Plan Area, Cannifton, Corbyville Village, Foxboro and Black Bear Ridge. To get the best understanding of the existing population, the 2021 Census data was used as main data source. JLR then overlayed the census boundaries with the City planning areas, and then distributed the census population. 2021-2023 Building Starts, received from the City, were used to fill in the missing population from 2021-2023. The following figure shows the building starts broken down by the broader planning areas.

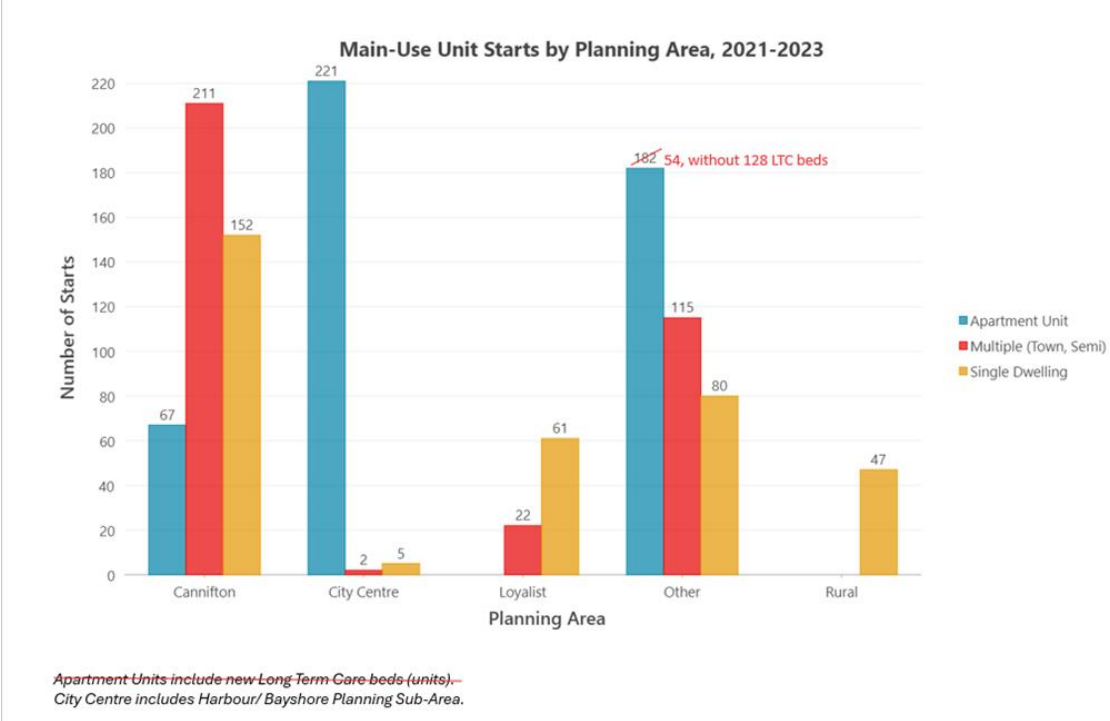

Figure 4: 2021 to 2023 Building Starts Summary Provided by the City of Belleville

A persons per unit (PPU) count was then applied to the building starts to get the total potential population in these areas.

The average PPU by dwelling type are as follows:

a) Low density at 2.77 PPU (single dwelling);
b) Medium density at 2.12 PPU (multiple);
c) High density at 1.57 PPU (apartment).

The existing population by planning area is estimated in **Table 1**. A map of key planning areas in the following table are shown in Figure 5.

Table 1: 2023 Population Counts by Planning Area

Name	Calculated Area (ha)	2021 Census Population	2023 Population	2023 Serviced Population
Urban	1,917	36,438	37,292	37,292
Bayshore/ City Centre	354	2,955	3,325	3,325
Loyalist Secondary Plan Area	1,004	2,651	2,894	2,894
Cannifton	1,007	4,450	5,471	5,471
Black Bear Ridge	-	152	156	-
Foxboro	-	306	307	-
Corbyville Village	-	-	-	-
TOTAL		**46,952**	**49,445**	**48,982**
** Counts do not include Statistics Canada under coverage rate**				

A comprehensive summary of the methodology used to calculate the populations in Table 1 is included in Appendix B – Planning Memorandum #1. These population values represent an estimate of the 2023 population of the City of Belleville. It should be noted that due to inconsistent area boundaries and changing PPU values, the population provided is an estimate. The counts do not include the Statistics Canada under coverage rates, as the up-to-date rates are not available.

For the purpose of defining existing and future demands, existing well and septic connections within the urban servicing boundary were treated as fully serviced connections.

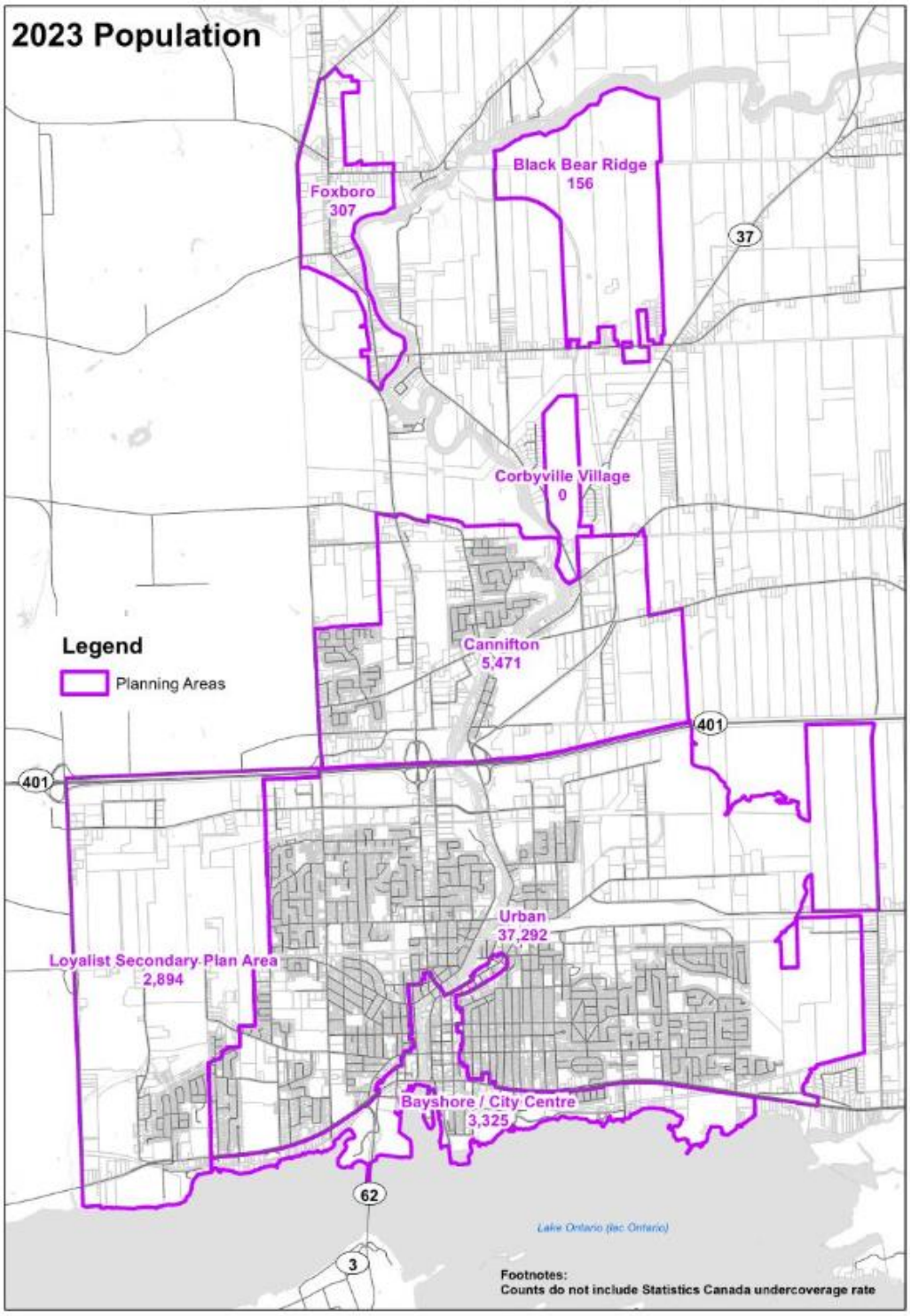

Figure 5: City of Belleville Existing (2023) Population by Planning Area

3.2 Planning Memorandum #2 – Residential Population Growth Projections

3.2.1 Planning Periods

In discussion with the City, it was decided that the short-, mid-, and long-term potential population projections would be identified using the following methodology:

- Short-Term:
  - 0-10 years; 2023 to 2033
  - Includes 2023 (Existing) Population, Residential Land Supply, Avonlough Phase 1, Black Bear Ridge Phase 1.
- Mid-Term:
  - 10-20 years; 2033 to 2043
  - Includes Short-Term Population, Development Control Areas, Avonlough Phase 2, and Black Bear Ridge Phase 2.
- Long-Term:
  - 20+ years; 2043 to 2051
  - Includes Mid-Term Population, Avonlough Phase 3, Black Bear Ridge Phase 3, and Foxboro.

Black Bear Ridge is anticipated to have a total build-out of 3,049 residential units at 3 P.P.U., in alignment with the Functional Servicing Report, completed by Jewell Engineering, dated July 16th, 2024. In discussion with the City and Black Bear Ridge, it was assumed that the following number of units will be built for each Black Bear Ridge Development phase:

- Phase 1: 559 residential units based on the number of Total Net Developable Residential Units included in the Black Bear Ridge Draft Plan of Subdivision, dated June 25th, 2024.
- Phase 2: An estimated 1,245 residential units.
- Phase 3: An estimated 1,245 residential units for the remaining build-out units.

The following sections include a brief description of the methodology used to determine residential growth found. The full methodology and analysis are as described in Planning Memorandum #2 attached as Appendix B.

3.2.1.1 Short Term (0 to 10 Years; 2023 to 2033)

In order to identify the short-term population, JLR applied the existing population identified in Planning Memo #1, in addition to the Residential Land Supply (RLS), Avonlough Phase 1 and Black Bear Ridge Phase 1.

The RLS identifies Plans of Subdivision (Registered and Draft), along with Vacant Lands Zoned Residential within the City. The RLS also identified both proposed and complete apartment units.

The growth within Black Bear Ridge Phase 1 was based on the 559 Total Net Developable Residential Units included in the Black Bear Ridge Draft Plan of Subdivision, dated June 25th, 2024. A P.P.U of 3 was applied to the unit counts for an additional population of 1,677. In addition to the Black Bear Ridge's existing population, this yields a 2033 population of 1,833.

For Avonlough Phase 1, the projected number of units served was taken from the Council Report from December 6, 2023 – Capital Budget Item 24-1.001. The report showed 1,800 units

serviced by the end of Phase 1 (2026-2034). A P.P.U. of 2.7 was applied to these units to arrive at a total population on 4,860.

Table 2: Short-Term (2033) Population by Planning Area

Planning Area	Calculated Area (ha)	2023 Population	2023 Serviced Population	2033 Population	2033 Serviced Population
Urban	1,917	37,292	37,292	40,392	40,392
Bayshore/City Centre	354	3,325	3,325	4,595	4,595
Avonlough SPS Phase 1	-	-	-	4,860	4,860
Loyalist Secondary Plan Area	1,004	2,894	2,894	5,687 (1)	5,687 (1)
Cannifton	1,007	5,471	5,471	6,539	6,539
Corbyville Village	75	-	-	-	-
Black Bear Ridge	381	156	-	1,833	1,833
Foxboro	195	307	-	307	-
TOTAL		**49,445**	**48,982**	**64,213**	**63,906**

Counts do not include Statistics Canada under coverage rate

(1) The population projection is intended for areas within Loyalist Secondary Plan Area that are not serviced by Avonlough SPS.

3.2.1.2 Mid-Term Growth (10 to 20 Years; 2033 to 2043)

In order to identify the mid-term population, JLR applied the short-term population as outlined above, in addition to the Development Control Areas (DCA), Avonlough Phase 2, and Black Bear Ridge Phase 2. The DCAs are identified through a zoning layer and are vacant lands projected for growth within the City.

JLR identified the types of lands within the DCAs that are residential through the zoning by-law mapping (refer to Figure 7) and found the associated hectarage. The DCAs were organized into the planning areas known as Urban, Bayshore/City Centre, Cannifton, and Corbyville. Directed by the City, a density of 18 units per net hectare was applied to the amount of DCA land in each planning area, as shown in Table 2. The low density P.P.U. was applied to the potential number of units to get to the potential population.

The anticipated growth for Black Bear Ridge Phase 2 has not been defined. In order to disperse the large number of units throughout the planning timeframes, it was assumed that 1,245 out of the 3,049 (build-out) units would be completed in the mid-term. A density of 3 P.P.U. was used to project population growth.

Table 3: Additional Units Based on Development Control Areas

Planning Area	Area (ha) of Residential DCA	Potential Units	Potential Population
Urban	95.7	1,723	4,772
Bayshore/City Centre	4.3	77	214
Cannifton	81.0	1,458	4,039
Corbyville	41.7	700	1,712

While Corbyville shows a potential of an additional 750 units in the DCA, as calculated from the DCA area with a density of 18 units per net hectare, the Belleville Official Plan outlines that the maximum number of residential uses in Corbyville Village should not exceed 850 residential units on the basis that the industrial area is redeveloped for residential units or 700 units should the industrial area remain non-residential (Policy 4.3.2a). Therefore, JLR have adjusted the potential units for Corbyville to 700 units in alignment with the current land use. 350 of these units being low density (2.77 P.P.U.) and 350 being medium density (2.12 P.P.U.). This brings the total projected population for Corbyville to 1,712 as shown in Table 3. The total population projection was split evenly between the mid-term and long-term therefore, Corbyville is projected to have a mid-term population of 856.

For Avonlough Phase 2, the projected number of units served was taken from the Council Report from December 6, 2023 – Capital Budget Item 24-1.001. The report shows 5,600 units serviced by the end of Phase 2 (2034-2045). A P.P.U. of 2.77 was applied to these units to get a total population of 18,120.

Table 4: Mid-Term (2043) Population by Planning Area

Planning Area	Calculated Area (ha)	2033 Population	2033 Serviced Population	2043 Population	2043 Serviced Population
Urban	1,917	40,392	40,392	45,164	45,164
Bayshore/City Centre	354	4,595	4,595	4,809	4,809
Avonlough SPS Phase 2	N/A	4,860	4,860	15,120	15,120
Loyalist Secondary Plan Area(1)	1,004	5,687 (1)	5,687 (1)	5,687 (1)	5,687 (1)
Cannifton	1,007	6,539	6,539	10,578	10,578
Corbyville Village	75	-	-	856	856
Black Bear Ridge	381	1,833	1,833	5,568	5,568
Foxboro	195	307	-	307	-
		64,213	**63,906**	**88,089**	**87,782**

Counts do not include Statistics Canada under coverage rate

(1) The population projection is intended for areas within Loyalist Secondary Plan Area that are not serviced by Avonlough SPS.

3.2.1.3 Long-Term Growth (20+ Years; 2043 to 2051)

Per the Functional Servicing Report by Jewell Engineering, 3,049 residential dwellings at 3 P.P.U. yielded a total estimated long-term population for Black Bear Ridge of 9,147.

For Avonlough Phase 3, the projected number of units served was taken from the Council Report from December 6, 2023 – Capital Budget Item 24-1.001. The report shows 9,000 units serviced by the end of Phase 3 (beyond 2045. A P.P.U. of 2.77 was applied to these units to get a total population of 24,300.

The remaining 350 units allocated for Corbyville was split evenly between medium- and low-density units, for a total population of 1,715 in the long-term.

Table 5: Long-Term (2043+) Population by Planning Area

Planning Area	Calculated Area (ha)	2043 Population	2043 Serviced Population	2043+ Population	2043+ Serviced Population
Urban	1,917	45,164	45,164	45,164	45,164
Bayshore/ City Centre	354	4,809	4,809	4,809	4,809
Loyalist Secondary Plan Area	1,004	5,687	5,687	5,687	5,687
Avonlough SPS Phase 3	N/A	15,120	15,120	24,300	24,300
Cannifton	1,007	10,578	10,578	10,578	10,578
Black Bear Ridge	381	5,568	5,568	9,303	9,303
Foxboro	195	307	-	307	307
Corbyville Village	75	856	-	1,712	1,712
TOTAL		**88,089**	**87,782**	**101,860**	**101,860**

Figure 6 shows the spatial distribution of short-, mid- and long-term growth projections. These population values represent our best estimate of the future population projections of the City of Belleville, using data available. It should be noted that due to inconsistent area boundaries and changing P.P.U. values, the population provided is an estimate. The counts do not include the Statistics Canada under coverage rates, as the up-to-date rates are not available.

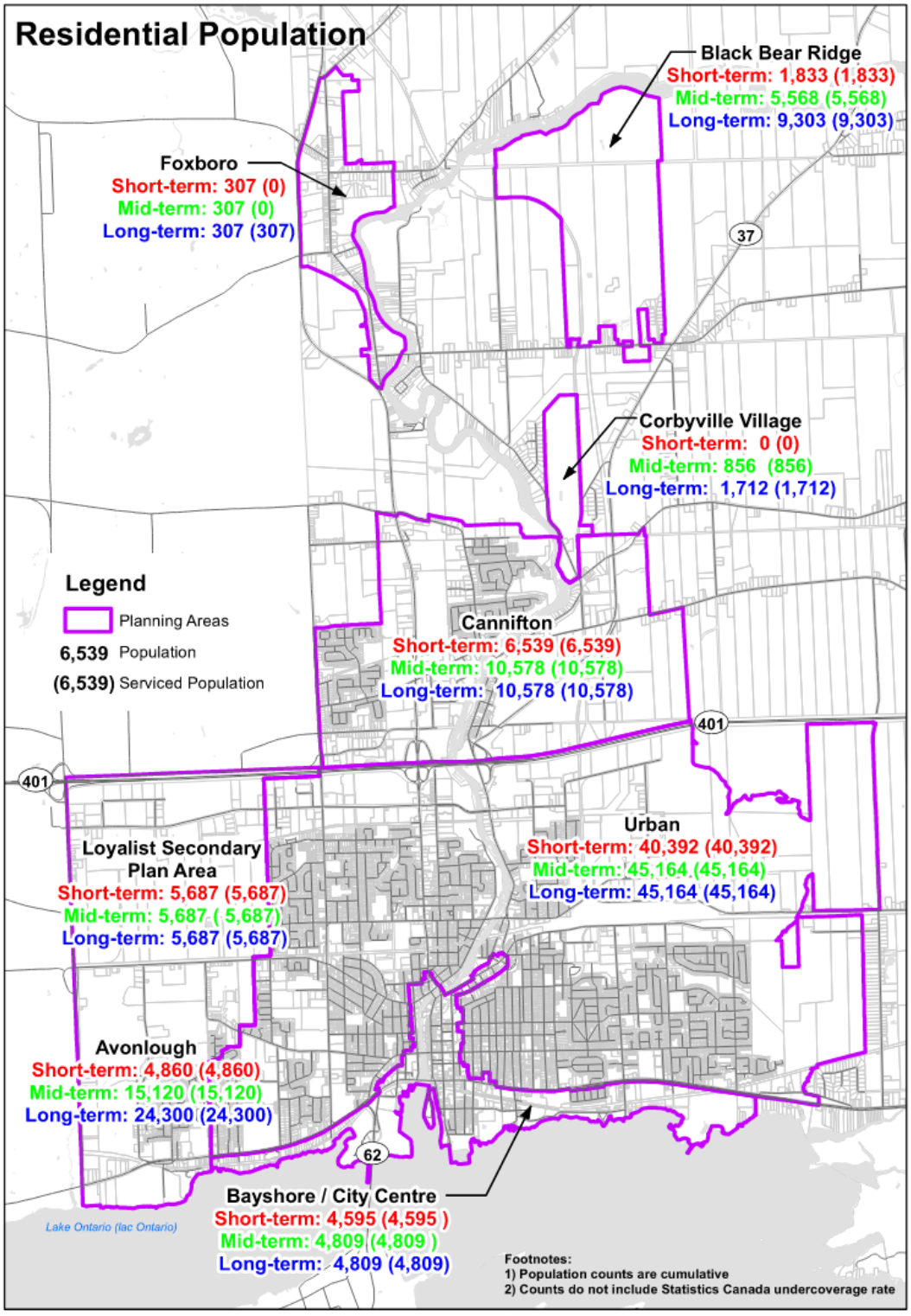

Figure 6: Short-, Mid-, and Long-Term Residential Population Projections by Planning Area

3.2.2 Demand Scenarios

A critical component of this assignment is to define the development areas to be serviced. As discussed with City Staff, the following scenarios will be considered for short-, mid-, and long-term planning periods:

- **Scenario 1:** Projected growth within Belleville (including the Urban Area, Bayshore/City Centre, Loyalist Secondary Plan Area, Avonlough, Cannifton, and Corbyville).
- **Scenario 2:** Scenario 1 with Black Bear Ridge (including Foxboro and Harmony School)

Table 6 summarizes the projected residential population growth based on the findings in the Planning Memos.

Table 6: Projected Serviced Residential Population Summary

Demand Scenario	Planning Area	Existing (2023)	Short-Term (2023-2033)	Mid-Term (2033-2043)	Long-Term (2043-2051)
Scenario 1	Bayshore / City Centre	3,325	4,595	4,809	4,809
	Urban Area	37,292	40,392	45,164	45,164
	Loyalist Secondary Plan Area	2,894	5,687	5,687	5,687
	Avonlough	0	4,860	15,120	24,300
	Cannifton	5,471	6,539	10,578	10,578
	Corbyville Village	0	0	856	1,712
	Scenario 1 Subtotal	**48,982**	**62,073**	**82,214**	**92,250**
Scenario 2	Black Bear Ridge	0	1,833	5,568	9,303
	Foxboro	0	0	0	307
	Scenario 2 Subtotal	**0**	**1,833**	**5,568**	**9,610**
TOTAL		**48,982**	**63,906**	**87,782**	**101,860**

3.2.3 Institutional, Commercial and Industrial (ICI) Growth

Additional ICI demand in the Short-Term included developments in Scenario 2 Areas (Black Bear Ridge and Harmony School).

ICI developments within Black Bear Ridge were obtained from Black Bear Ridge Pre-Consultation Documents, dated August 25, 2024. The commercial and hotel developments listed in the following table were based on the Draft Plan of Subdivision, dated June 25th, 2024 (Appendix D). Based on the planning periods listed in Section 3.2.1, these developments within Black Bear Ridge would be serviced in the short-term.

Harmony School is an existing school south of the Black Bear Ridge development area. It was assumed that the total build out of the school will include 900 students. Since the school development is existing, it was assumed that the school will be serviced in the short-term. It was assumed that the school would be serviced through Black Bear Ridge Infrastructure.

Table 7: Short-Term ICI Growth (Scenario 2)

Development Type [units]	Black Bear Ridge
Harmony School [Students]	900
Commercial [ha]	18
Hotel [Bed space]	500

Additional ICI demand in the Mid-Term included Development Control Areas (DCA) as defined by the City. As shown in Figure 7, Employment, Institutional and Commercial Lands were identified within the City's DCA Layers. The DCA layers provided by the City was accompanied with an excel document (Appendix E) which provided a breakdown of the hectarage associated with each DCA as prescribed by the Belleville Official Plan. Table 8 is a summary of potential development types within each planning area. In alignment with the planning periods listed in Section 3.2.1, it was assumed that all ICI growth within the City would occur in the mid-term. Employment DCA were assumed to be equivalent to commercial land use for the purpose of demand analysis.

Table 8: Mid-Term ICI Growth (Scenario 1)

Development Type [units]	Cannifton	Urban	Avonlough	Corbyville
Institutional [ha]		1		
Commercial [ha]	252	210	20	
Typical Industrial [ha]				1

N

Foxboro

Black Bear Ridge

37

Corbyville Village

Cannifton

401

Urban

Loyalist Secondary Plan Area

Bayshore / City Centre

Lake Ontario (lac Ontario)

3

Legend

Development Control Areas

- Residential
- Commercial
- Institutional
- Typical Industrial

Boundary

- Parcel Fabric
- Planning Areas
- Municipal Boundary

PROJECT:

Black Bear Ridge Servicing Study

Belleville, Ontario

DRAWING:

Development Control Areas

J.L.Richards
ENGINEERS · ARCHITECTS · PLANNERS
www.jlrichards.ca

DESIGN:	RC
DRAWN:	KTK
CHECKED:	SS
JLR #:	32874

DRAWING #:

Figure 7

File Location: P:\32000\32874-000 - Belleville Black Bear Ridge\03-Production\07-Plan\GIS\32874_DevelopmentControl.mxd

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4.0 Water Facilities

4.1 Water Treatment

The City of Belleville operates one water treatment plant: the Gerry O'Connor Water Treatment Plant (a.k.a.) Belleville Water Treatment Plant (BWTP). BWTP is located at 2 Sidney St, Belleville ON and draws raw water from the Bay of Quinte through intake. BWTP has a maximum daily rated capacity of 72,700 m^3/day is also equipped with an in-ground treated water storage reservoir with a volume of 4,500 m^3.

Belleville's water supply and distribution system consists of:

- Gerry O'Connor Water Treatment Plant (BWTP as Belleville Water Treatment Plant) with In-Ground Reservoir (WTP Reservoir)
- The John Street Elevated Water Storage Tank (John Street Elevated Tank)
- The North Park Street In-Ground Reservoir and Booster Pumping Station (North Park Street Reservoir and BPS)
- The Pine Street In-Ground Reservoir and Booster Pumping Station (Pine Street Reservoir and BPS)
- The Adam Street Booster Pumping Station (Adam Street BPS)
- Over 224 km of watermains and 1,254 hydrants.

4.1.1 Historic Flow Rates

Annual Drinking Water System Reports over five (5) years, from 2019 to 2023, was provided by the City. The reports were used to determine the current water demands for the water distribution system. Table 9 summarizes the average day, maximum day, and peak hour demands for Belleville.

Table 9: Belleville Water Demands (2019-2023)

Years	Average Day (m^3/day)	Maximum Day (m^3/day)	Peak Hour (m^3/day)
2019	21,050	28,130	Not available
2020	21,039	29,170	Not available
2021	20,855	27,790	Not available
2022	21,802	28,160	Not available
2023	23,197	30,310	Not available
5-Year Demand (m^3/day)	21,589	30,310	45,465(1)
5-Year Demand (L/s)	250	351	526(1)
Rated Capacity	Not applicable	72,700	Not applicable
Percent (%) of Rated Capacity	Not applicable	42%	Not applicable

(1) Peak hour demand calculated using a theoretical peaking factor of 1.5 times the maximum day demand, MECP Design Guidelines for Drinking Water Systems (2008) Table 3-1: Peaking Factor.

The 5-year average day demand was taken as the average treated water flow reported every day between 2019 and 2023, which was calculated to be 21,589 m^3/day (250 L/s). The maximum day

demand, 30,310 m^3/day (351 L/s), taken from the maximum flow reported from 2019 to 2023. As the peak hourly data was not specifically recorded, the peak hour demand was estimated using a theoretical peaking factor of 1.5 times the maximum day demand, as recommended in Ministry of the Environment, Conservation, and Parks (MECP) Design Guidelines for Drinking Water Systems (2008) for a community of this size, which resulted in a peak hour demand of 45,465 m^3/d (526 L/s). 42% of the total WTP rated capacity is utilized under existing maximum day demand.

4.1.2 Future Water Demand

The design parameters in Table 10 were used to calculate future water demand presented in Table 11 and Table 12. The rated capacity of the WTP can accommodate anticipated growth from the City (Scenario 1). The additional demand from Foxboro and Black Bear Ridge (Scenario 2) will require a WTP expansion in the Long-Term.

Table 10: Design Parameters – Future Water Demand

Parameter	Residential	Industrial / Commercial / Institutional (ICI)
Average Day Flow (1)	350 L/cap/day	Industrial (35,000 L/ha/day)
		Commercial (28,000 L/ha/day)
		Institutional (28,000 L/ha/day)
		School (105 L/student/day)
		Hotel (225 L/bed space/day)
Maximum Day Flow (2)	1.4 x Average Day	1.4 x Average Day
Peak Hour Flow (3)	1.5 x Maximum Day	1.5 x Maximum Day
(1) MECP Design Guidelines for Drinking Water Systems Table 3-2 for ICI water demand and Section 3.4.2 for residential water demand. (2) Maximum Day Flow Factor determined by dividing 5-year Maximum Day Demand by 5-year Average Day Demand in Table 9. (3) MECP Design Guidelines for Drinking Water Systems Table 3-1		

Table 11: Future Water Demand – Scenario 1: City Growth

	Existing (2023)	Short-Term (2023-2033)	Mid-Term (2033-2043)	Long-Term (2043-2051)
Total Population (cap)	48,982	62,073	82,214	92,250
Population Growth (cap)		13,091	20,141	10,036
Institutional, Commercial, Industrial (ICI) Growth (ha)			484	
Residential Average Day Demand (ADD) Growth (m^3/d)		4,582	7,049	3,513
ICI ADD Growth (m^3/d)			13,565	0
Total ADD Growth (m^3/d)		4,582	20,614	3,513
Total ADD (m^3/d)	21,589	26,170	46,784	50,297
Total Maximum Day Demand (MDD) (m^3/d)	30,310	36,639	65,498	70,416
WTP Rated Capacity (m^3/d)	72,700			
Surplus (m^3/d)	**42,390**	**36,061**	**7,202**	**2,284**

Table 12: Future Water Demand - Scenario 2: Scenario 1 with Black Bear and Foxboro

	Existing (2023)	Short-Term (2023-2033)	Mid-Term (2033-2043)	Long-Term (2043-2051)
Total Population (cap)	48,982	63,906	87,782	101,860
Population Growth (cap)		14,924	23,876	14,078
Institutional, Commercial, Industrial (ICI) Growth (ha)		18	484	
School (Students)		900		
Hotel (Bed Spaces)		500		
Residential Average Day Demand (ADD) Growth (m^3/d)		5,223	8,357	4,927
ICI ADD Growth (m^3/d)		711	13,565	
Total ADD Growth (m^3/d)		5,934	21,921	4,927
Total ADD (m^3/d)	21,589	27,523	49,444	54,371
Total Maximum Day Demand (MDD) (m^3/d)	30,310	38,532	69,222	76,120
WTP Rated Capacity (m^3/d)	72,700			
Surplus (m^3/d)	**42,390**	**34,168**	**3,478**	**-3,420**

4.1.3 Projected Timing for WTP Expansion

Figure 8 represents the projected maximum day water demand and anticipated timing to reach 80%, 90% and 100% of the WTP rated capacity:

- Under Scenario 1:
  - 80% Capacity will be reached in 2040;
  - 90% Capacity will be reached in 2042, and
  - 100% Capacity will be reached beyond 2051 (beyond the Master Plan time frame).
- Under Scenario 2:
  - 80% Capacity will be reached in 2039;
  - 90% Capacity will be reached in 2041, and
  - 100% Capacity will be reached in 2046.

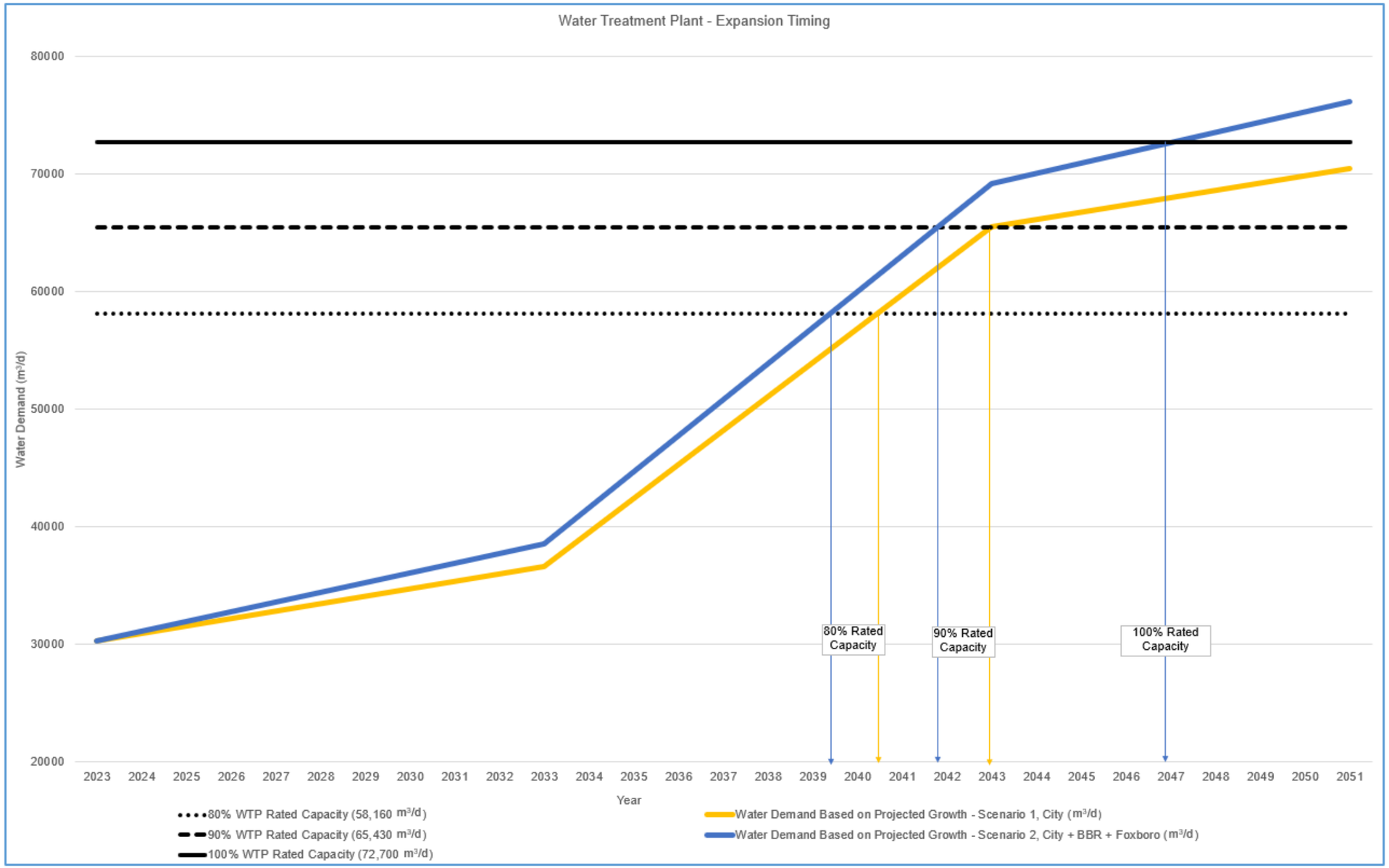

Figure 8: Projected Water Treatment Plant Expansion Timing

4.2 Water Storage

4.2.1 Existing Water Storage and Booster Pumping Stations

The existing water storage of Belleville is made up of above ground and in ground water storage systems including WTP high lift wet wells, treated water reservoir, one elevated tank and two reservoirs. Major parameters and dimensions of each storage facility could be found in Table 13. As-built drawings by Gore & Storrie Ltd., operation manuals by Belleville Water Treatment Plant were used as resources for tank dimensions and operating setpoints. Values in Table 13 were confirmed with the City of Belleville.

The water distribution system within Belleville consists of two main pressure zones: Pressure Zone 1 and Pressure Zone 2, which generally refers to serviced areas south and north of Highway 401, respectively. Pressure Zone 1 storage is being provided by the WTP reservoir and high lift pump wells, John Street Elevated Tank, North Park Street Reservoir and BPS, and Pine Street Reservoir and BPS. Pressure Zone 2 is serviced by the Adam Street BPS and does not have dedicated treated water storage facility. Refer to Figure 1 for pressure zones and location of key water distribution infrastructure.

Water Treatment Plant Storage, High Lift Wet Wells, and High Lift Pumps:
The WTP includes one main in-ground reservoir which was originally built in 1986 and underwent significant rehabilitation and expansion. The WTP Reservoir is filled from the High Lift Pump Well. Under current demands, 3 out of 5 high lift pumps, located at the wet wells, are required to provide potable water for distribution and supply water for the WTP process. The WTP Reservoir and wet well transfer system operate under the set points outlined in Table 13. Based on the high and low water level set points and tank dimensions at each facility, a total useable storage of 4,121m^3, 209 m^3, and 161 m^3 was calculated at the WTP Reservoir, Pump Well, and Transfer Well, respectively.

Other tanks which hold treated water at the WTP include the following. However, these tanks are not considered to be part of the City's potable water storage as these tanks store treated water to support treatment process (e.g., filter backwash water). According to Section 8.4.4 Treatment Plant Storage of the MECP Design Guidelines, plant storage should be sized such that in-plant water needs can be met.

- Two backwash holding tanks – 400 m^3 capacity per tank.
- Two baffled post-filtration chlorine contact tanks – 1350 m^3 capacity for tank 1 and 550 m^3 for tank 2.

North Park Street Reservoir and Booster Pumping Station (Zone 1)
The North Park Street Reservoir was constructed in 1957 and is a concrete grade level reservoir for the storage of potable drinking water with two separate cells. The reservoir is filled from a hydraulic back pressure valve at night when water demand is low. The treated water is then distributed back to Pressure Zone 1 through the North Park Street Booster Pumping Station during the day when water demand is high. The North Park Street Reservoir was calculated to have a total usable volume of 8,294 m^3 based on the pump system's operating setpoints and reservoir dimensions. The start and stop modes of the North Park Street Booster Pumping Station are based on the water level at the John Street Elevated Tank.

Pine Street Reservoir and Booster Pumping Station (Zone 1)

The Pine Street Reservoir in Belleville is concrete at-grade reservoir, constructed in 1957, primarily used for storing treated water to ensure a steady supply during peak usage times and emergencies. The reservoir is filled with an electric control valve at night, during low demand. The treated water is then distributed to Pressure Zone 1 through the Pine Street Booster Pumping Station in the daytime, during high demand. The Pine Street Reservoir was calculated to have a total usable volume of 9,647 m^3 based on the pump system's operating setpoints and reservoir dimensions. The start and stop modes of the Pine Street Booster Pumping Station are based on the water level at the John Street Elevated Tank.

John Street Elevated Tank (Zone 1)

The John Street Elevated Tank is a steel storage tank constructed in 1972 and is a key component of Belleville's water distribution system ensuring adequate water pressure. The fill valves close at the North Park Street and Pine Street Reservoirs when water level in the John Street Elevated Tank drops below 2.8m from the bottom of the tank. The tank is filled from an altitude valve which opens or closes based on pressure in the distribution system. The InfoWater model (Section 5.0) confirmed that even when the John Street Elevated Tank is at its minimum level (0.1m), the pressure in the system remains above 20 psi under max day demand conditions, therefore, the 20 psi tank level is 0.1m or a corresponding hydraulic grade line (HGL) of 130.5m, providing 98.68% volume that is available for treated water storage at John St. Elevated Water Tank. 0.1 m from the bottom of the tank was used as the low water level to calculate the total usable volume of 3,954 m^3 for the John Street Elevated Tank.

Adam Street Booster Pumping Station (Zone 2)

The Adam Street Booster Pumping Station services Pressure Zone 2 and does not have a dedicated reservoir. The Adam Street BPS consists of three variable speed pumps (1 duty for domestic flow, 2 for fire flow). The operating setpoints are based on system pressure from Zone 1. A low-pressure alarm is triggered when a pressure below 275 kPa (40 psi) is detected at the inlet. A high-pressure alarm is triggered when a pressure above 690 kPa (100 psi) is detected at the outlet.

The Adam Street BPS is not connected to a dedicated reservoir and therefore needs to draw treated water supply from storage found in Pressure Zone 1. The following section will analyse if the 26,614 m^3 of total storage is sufficient for future water demand in both pressure zones.

Table 13: Belleville Water Storage Facilities and Parameters

	WTP Reservoir	WTP High Lift Wet Well – Pump Well	WTP High Lift Wet Well – Transfer Well	North Park St. Reservoir	Pine St. Reservoir	John St. Elevated Tank
Number of Cells	1	2	1	2	1	1
Cell Width (1)(2)	23	8	17	13	36	27(3)
Cell Length (1)(2)	48	6	480	60	56	
High Water Elevation (1)(2) (m)	79	75	75	102	95	138
Low Water Elevation (m)	76	73	73	97	90	131
Total Storage Volume, per cell (m^3)	4,121	105	161	4,147	9,647	4,181
Total Effective Tank Volume (m^3)	4,121	209	161	8,294	9,647	4,181
Total Volume (m^3)	**26,614**					

(1) From Belleville Water Treatment Plant Operations Manual:
Section 20 for North Park St. Reservoir
Section 18 for WTP Reservoir.
Section 19 for Pine Street Reservoir.
Section 21 for John Street Elevated Tank.
Section 16 for High Lift Wet Well - Pump Well.
Section 16 for High Lift Wet Well - Transfer Well.

(2) As-built Drawings:
North Park Street Reservoir Drawings.
1995 Water Treatment Plant Improvement Drawings.
Pine Street Reservoir Drawings.
From EPANET Water Model 2019.
Belleville WTP Treatment Plant Improvements Expansion of Filters, Highlight & Admin As-Built Drawings (1995).

(3) Tank Diameter

4.2.2 Future Water Storage Requirements

Per MECP Design Guidelines for Drinking-Water Systems (2008), total available treated water storage within the system should at least amount to the sum of the required fire storage (A), equalization storage (B), and emergency storage (C) allowances, as depicted in Figure 9.

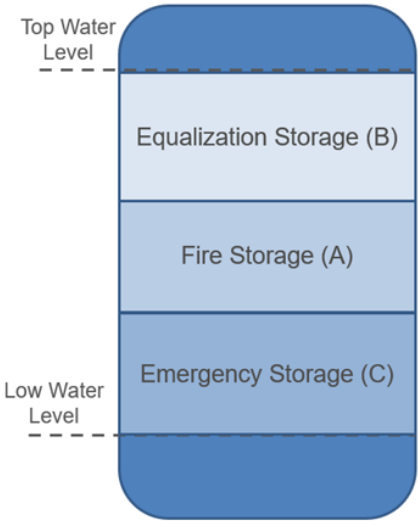

Figure 9: Total Required Treated Water Storage

The total water storage requirement was compared against the existing available storage in Table 13. Based on these guidelines, Table 14 provides a summary of the estimated existing, short, mid, and long-term total storage requirements for Belleville. Note that the equivalent population is not equal to the service population as used in previous sections of this report. The service population is the number of residents living in Belleville, obtained from the 2021 Census. The equivalent population considers contributions from residential and ICI water demand and was calculated using the following equation:

$$\text{Equivalent Population} = \frac{\text{Average Day Demand}}{\text{Average Per Capita Water Consumption}}$$

Where,

Average Day Demand is in m^3/day and presented in Table 9.

Average Per Capita Water Consumption 350 L/cap/day residential consumption design parameter as listed in Table 10: Design Parameters – Future Water Demand

Table 8-1 of the MECP Design Guidelines for Drinking Water Systems was used to identify fire flow requirements. The calculated 2023 equivalent population of 61,682 exceeded the maximum equivalent population of 40,000 in Table 8-1. The following methods were compared to identify a reasonable approximation of the fire flow requirements for an equivalent population that exceeds Table 8-1:

1. Use the maximum Table 8-1 fire flow criteria of 378 L/s for a duration of 6 hours.

2. Extrapolate the equivalent fire flow duration and equivalent population based on Table 8-1.

By extrapolation of Table 8-1, an equivalent population of 61,682 would require 464 L/s for a 7-hour fire duration. This was deemed to be unreasonable for existing storage requirements. Additionally, through discussion with Belleville Operating Staff, significant draw down of the City's water storage has not been observed during past fire events. Therefore, the fire flow criteria of 378 L/s for a 6-hour duration was used for existing and future storage demand projections. The projected storage requirements for Scenario 1 and Scenario 2 are summarized in Table 14 and Table 15, respectively.

Table 14: Future Water Storage Requirements – Scenario 1: City Growth

Parameter	Existing	Short-Term	Mid-Term	Long-Term
	(2023)	(2023-2033)	(2033-2043)	(2043-2051)
Cumulative Potential Equivalent Population (1)	61,682	74,773	133,670	143,706
Fire Flow (2) (L/s)	378	378	378	378
Duration (2) (Hours)	6	6	6	6
A – Fire Storage (3) (m^3)	8,165	8,165	8,165	8,165
B – Equalization Storage (4) (m^3)	7,578	9,160	16,375	17,604
C – Emergency Storage (5) (m^3)	3,936	4,331	6,135	6,442
Total Storage Requirement (m^3)	19,678	21,656	30,674	32,211
Existing Available Storage (m^3)	26,614	26,614	26,614	26,614
Surplus (m^3)	6,936	4,958	-4,060	-5,597

(1) Estimated to be equal to average day demand / per capita usage of 350 L/cap/d. The equivalent population also includes ICI flow contribution.

(2) Values interpolated from Table 8-1 of the MECP Design Guidelines (2008) for maximum fire flow and duration. Fire flow is described as the largest expected fire flow requirement in L/s and duration is length of time fire flow shall be sustained.

(3) Largest expected fire volume = fire flow x duration

(4) 25% of Maximum Day Demand

(5) 25% of the sum of 'A' and 'B'

Table 15: Future Water Storage Requirements – Scenario 2: Scenario 1 + Black Bear Ridge and Foxboro

Parameter	Existing (2023)	Short-Term (2023-2033)	Mid-Term (2033-2043)	Long-Term (2043-2051)
Cumulative Potential Equivalent Population (1)	61,682	78,637	141,269	155,347
Fire Flow (2) (L/s)	378	378	378	378
Duration (2) (Hours)	6	6	6	6
A – Fire Storage (3) (m^3)	8,165	8,165	8,165	8,165
B – Equalization Storage (4) (m^3)	7,578	9,633	17,305	19,030
C – Emergency Storage (5) (m^3)	3,936	4,449	6,368	6,799
Total Storage Requirement (m^3)	19,678	22,247	31,838	33,994
Existing Available Storage (m^3)	26,614	26,614	26,614	26,614
Surplus (m^3)	6,936	4,367	-5,224	-7,380

(1) Estimated to be equal to average day demand / per capita usage of 350 L/cap/d. The equivalent population also includes ICI flow contribution.

(2) Values interpolated from Table 8-1 of the MECP Design Guidelines (2008) for maximum fire flow and duration. Fire flow is described as the largest expected fire flow requirement in L/s and duration is length of time fire flow shall be sustained.

(3) Largest expected fire volume = fire flow x duration

(4) 25% of Maximum Day Demand

(5) 25% of the sum of 'A' and 'B'

4.2.3 Projected Timing for Water Storage Expansion

Based on the storage requirements calculated in Table 14, the City has sufficient water storage for existing and short-term demand. Note that the storage analysis was completed for the entire system, regardless of Pressure Zone 1 and Zone 2. This is because Pressure Zone 2, serviced by the Adam Street BPS, does not have a dedicated storage reservoir and that storage for Zone 2 is currently being provided by Zone 1.

Figure 10 represents the projected water storage requirements for each scenario and anticipated timing to reach 80%, 90%, and 100% of the total treated water storage capacity:

- Under Scenario 1:
  - 80% Capacity will be reached in 2031;
  - 90% Capacity will be reached in 2035, and
  - 100% Capacity will be reached by 2038.
- Under Scenario 2:
  - 80% Capacity will be reached by 2029;
  - 90% Capacity will be reached by 2034, and
  - 100% Capacity will be reached by 2037.

This projection applies to both scenarios, under the assumption there will be no storage facilities downstream of Adam Street BPS.

The next phase of the servicing study will review alternatives to provide sufficient water storage for the mid-term and long-term horizons for both Zone 1 and Zone 2. Alternatives may include storage downstream of the Adam Street BPS; In this case, the available storage for each pressure zone will need to be considered separately.

4.3 Water Facilities Capacity Summary

Based on available information, the WTP's rated capacity is sufficient for existing, short-, and mid-term water demand under both scenarios. It is anticipated that the WTP will reach 80% of its rated capacity in 2039 (mid-term). The Phase 2 of the Servicing Study will provide recommendations to provide sufficient water supply for long-term projected demands.

The City has sufficient storage for existing and short-term water demand in both pressure zones. Expansion of treated water storage will be required before the end of the mid-term. The City's water storage will reach 80% capacity by 2030 (short-term). Phase 2 will consider alternatives to provide sufficient treated water storage for the City, Black Bear Ridge, and Foxboro.

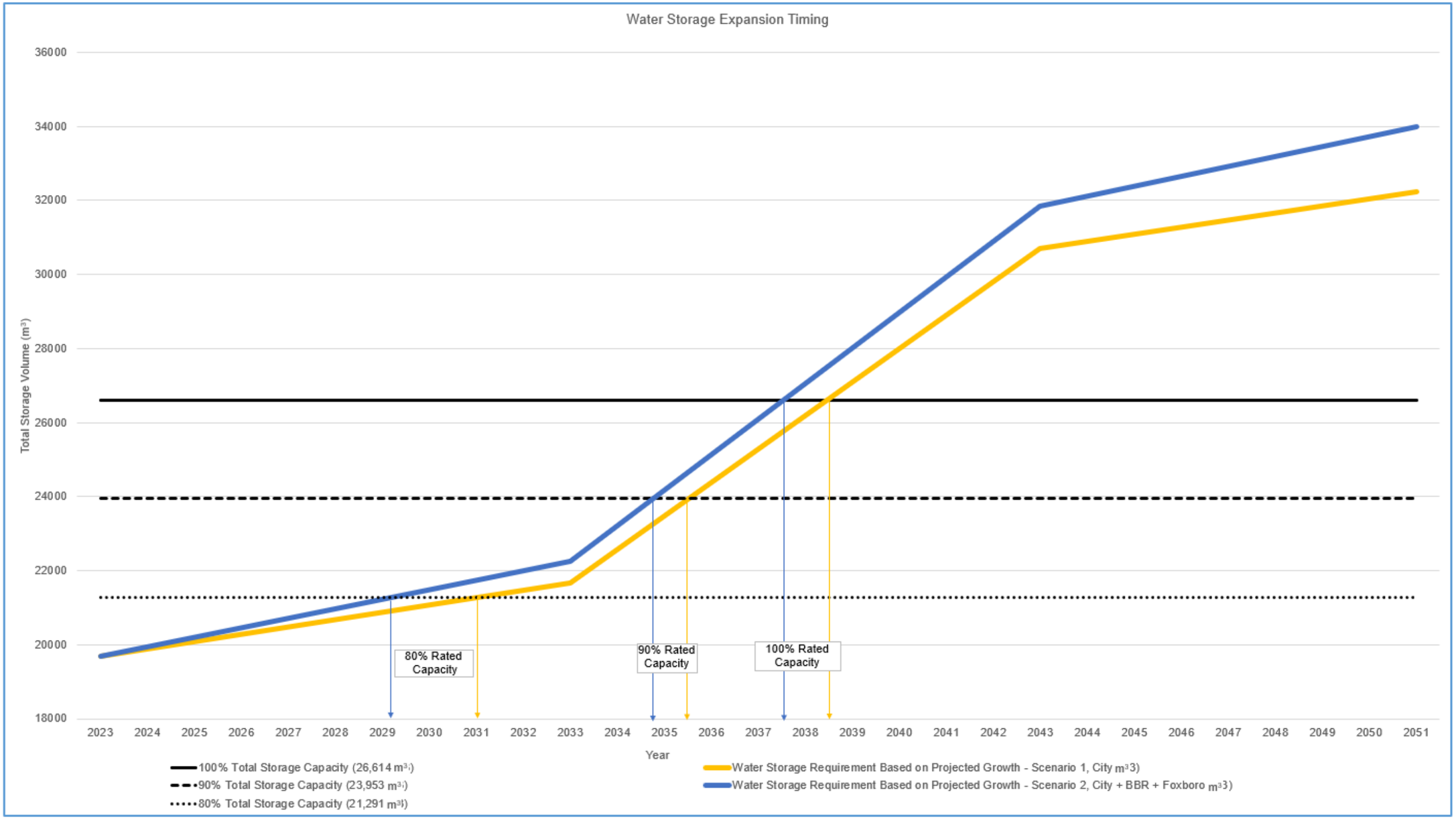

Figure 10: Treated Water Storage Expansion Timing

5.0 Water Distribution

The hydraulic water model for the City of Belleville (City) was previously updated in 2020 by GHD. To assess the impacts of the Black Bear Ridge development in combination with other future developments to the water distribution system, the existing water model first required an update to establish current baseline conditions.

5.1 Hydraulic Water Model Update for Existing Conditions

The Belleville Water Treatment Plant (WTP) Treated Daily Flow data over the past five (5) years (2019-2023) was provided by the City and used to determine the current water demands for the water distribution system. Table 16 below summarizes the average day, maximum day and peak hour demands within Belleville.

Table 16: Belleville Water Usage (2019-2023)

Years	Average Day m^3/day	Maximum Day m^3/day	Peak Hour m^3/day
2019	21,050	28,130	Not available
2020	21,039	29,170	Not available
2021	20,855	27,790	Not available
2022	21,802	28,160	Not available
2023	23,197	30,310	Not available
5-Year Demand (m^3/day)	21,589	30,310	45,465
5-Year Demand (L/s)	250	351	526
Rated Capacity (m^3/day)		72,700	
Percent (%) of Rated Capacity Used	Not applicable	42%	Not applicable

To update the water model for existing conditions, the existing model, which was created within EPANET, was imported into Autodesk's InfoWater Pro software platform. InfoWater Pro works within ArcGIS Pro, and using ArcGIS Pro, the spatial reference of the model was changed to UTM Zone 18N to match other GIS data provided by the City.

Eight (8) new and existing developments that were not included in the last model update were added to the model, as summarized in Table 17. The developments that were missing from the model were determined based on the parcel fabric provided by the City. In the eight (8) new areas that were added to the model, many parcels of land were visible, and no watermains were included in these areas in the model. The City confirmed the extent of completed development within these areas as per the email correspondence in Appendix C.

Table 17: Summary of New Areas Added into the Model

Location	Development Type
North of Ridgeway Place	Residential
Kawartha Court and Lanark Drive	Residential
Lincoln Drive East of Hanlyn Crescent	Residential
Summit Crescent	Residential
North Front Street, Raycroft Drive and Covington Crescent	Residential, Industrial and Commercial
Redwood Drive and Primrose Crescent	Residential
North of Wims Way and East of Essex Drive	Residential
Holmes Road	Residential

A total of 549 residential units were found within the eight areas equating to a total population of 1,647 persons, based on a residential population density of 3 persons per unit provided in memorandum produced by GHD for the most recent water model update in 2020. 20.63 ha and 1.99 ha of commercial and industrial developments, respectively, were found along North Front Street.

In all new areas identified in Table 17, the watermains were added to the model based on pipe diameters, lengths and materials obtained from the GIS data provided by the City. The pipe roughness coefficients were selected based on pipe diameter using the values in Table 18 that are provided in the Ministry of Environment, Conservation and Parks Design (MECP) Guidelines for Drinking Water Systems (2008). The elevations of all new junction nodes were extracted from the digital terrain model file provided by the City.

Table 18: Pipe Roughness Coefficients

Nominal Diameter	Hazen-Williams Roughness Coefficient (C-Factor)
150 mm	100
200 mm – 250 mm	110
300 mm – 600 mm	120
Greater than 600 mm	130

The existing water demands from the 2020 model update were maintained at all existing junction nodes. The demands at all new junction nodes added to the model were calculated based on consumption rates and peaking factors provided in the MECP Guidelines for Drinking Water Systems. The maximum day peaking factor was determined based on the ratio of the actual reported maximum and average day system demand in Table 16. The following consumption rates and peaking factors were used in design:

- A residential consumption rate of 350 L/cap/day
- A commercial consumption rate of 28,000 L/ha/day
- An industrial consumption rate of 35,000 L/ha/day
- A maximum day demand of 1.4 times the average day demand.
- A peak hour demand of 1.5 times the maximum day demand.

The new demands were calculated and assigned to each new junction node added to the model. Once the new demands were added to the model, the demands throughout the model were

prorated such that the total demand across all junction nodes in the model was equal to the 5-year demands provided in Table 16 for the maximum day plus fire flow and peak hour demand scenarios, respectively.

5.2 Water Distribution System Design Criteria and Operating Parameters

For the design criteria under the average day, maximum day and peak hour scenarios, the following guidelines apply based on Ministry of the Environment, Conservation and Parks (MECP) Design Guidelines for Drinking Water Systems (2008) and the Ontario Building Code (OBC):

- The maximum pressure at any point in the distribution system in unoccupied areas shall not exceed 689 kPa (100 psi), and while in occupied areas, shall not exceed 552 kPa (80 psi).
- Maximum Day + Fire Flow: Residual pressures at any point in the distribution system shall not be less than 140 kPa (20 psi).
- Peak Hour: Pressures shall be a minimum of 276 kPa (40 psi).
- A required fire flow of 45 L/s per the OBC for a typical two-storey residential dwelling.

Following the hydraulic water model update for existing conditions, the model was used to simulate the performance of the current water distribution system under existing flow conditions. The following operating parameters, as confirmed by the City of Belleville, were used in the steady-state model simulations:

Peak Hour Demand

- Two (2) high-lift pumps (labelled HL-5440-VFD and HL-5610-VFD in the model) are operating at the WTP.
- The wet well and reservoir at the WTP are operating at their average low levels of 1.29 m and 2.29 m, respectively.
- One (1) pump (labelled M-6510-VFD in the model) is operating at the North Park Street Booster Pumping Station.
- The North Park Street Reservoir is operating at its average low level of 2.13 m.
- One (1) pump (labelled M-6310 in the model) is operating at the Pine Street Booster Pumping Station.
- The Pine Street Reservoir is operating at its average low level of 2.29m.
- One (1) pump (labelled TH2 in the model) is operating at the Adam Street Booster Pumping Station.
- The Sydney Street bypass is closed, allowing no flow north of Highway 401.
- The Bell Boulevard check valve is active and only allows flow to travel from? west to east.

Maximum Day Demand Plus Fire Flow

- Two (2) high-lift pumps (labelled HL-5440-VFD and HL-5610-VFD in the model) are operating at the WTP.
- The wet well and reservoir at the WTP are operating at their average low levels of 1.29 m and 2.29 m, respectively.
- One (1) pump (labelled M-6510-VFD in the model) is operating at the North Park Street Booster Pumping Station.
- The North Park Street Reservoir is operating at its average low level of 2.13 m.
- One (1) pump (labelled M-6320 in the model) is operating at the Pine Street Booster Pumping Station.

- The Pine Street Reservoir is operating at its average low level of 2.29m.
- One (1) pump (labelled TH1 in the model) is operating at the Adam Street Booster Pumping Station.
- The Sydney Street bypass is open, allowing flow north of Highway 401. The City noted that the bypass would only open if a fire occurred in Pressure Zone 2 north of Highway 401 and the Adam Street Booster Pumping Station could not supply adequate pressure north of the highway, but to achieve the maximum possible fire flow in the system, the valve has been opened in the steady state run.
- The Bell Boulevard check valve is active and only allows flow to travel eastwardly.

5.3 Model Simulation Results

The results of the model simulations are summarized in Table 19 and Table 20, where the percentage of junction nodes within each applicable range is reported. The model schematic results are included in Appendix C.

Table 19: Existing Pressures Under Peak Hour Demand

Pressure Range			Percentage of Junctions
Pressure Range (kPa)			Existing Peak Hour Demand
	Less than	276	2.4%
276	up to	350	33.3%
350	up to	480	55.0%
480	up to	552	9.3%
552	up to	689	0.0%
	Greater than	689	0.0%

Under the existing peak hour demand condition, most junction nodes (97.4%) fall within the recommended pressure range of 276 kPa to 552 kPa (40-80 psi), as per the MECP design guidelines. The remaining junction nodes fall below the minimum recommended pressure of 276 kPa (40 psi). Most of the nodes below the minimum pressure requirement are located at the pumping stations and along dead-end pipes. However, at the west end of Bell Boulevard and near the intersection of Moira Street West and Sidney Street, there are several junction nodes along the trunk watermain that do not meet the minimum pressure requirement. The pressures at the west end of Bell Boulevard are likely low due to the area being at a higher elevation than regions further east and the area being a dead-end watermain with no looping. The pressures near the intersection of Moira Street West and Sidney Street are generally only slightly lower than 276 kPa (40 psi) with the lowest pressures being at nodes with higher elevations than the surrounding area.

Table 20: Existing Available Fire Flows under Maximum Day Demand

Maximum Day Demand + Fire Flow			Percentage of Junctions
Fire Flow Range (L/s)			Existing Maximum Day Demand
	Less than	45	4.9%

45	up to	75	7.9%
75	up to	100	9.8%
100	up to	150	18.0%
	Greater than	150	59.4%

Under the maximum day plus fire flow condition, most junction nodes (95.3%) have an available fire flow greater than the minimum fire flow requirement of 45 L/s for a typical two-storey residential dwelling provided in the OBC. The junction nodes with available fire flows below 45 L/s are found throughout the system, the majority of which are along watermains with a diameter equal to or lower than 150 mm. This is considered acceptable as the minimum watermain diameter to supply a hydrant is 150 mm. The remaining junction nodes that do not achieve 45 L/s of available fire flow are nearly all found along watermains with a diameter of 150 mm or at dead-ends. A map of the junction nodes not achieving 45 L/s of available fire flow and located along watermains with a diameter equal to or greater than 150 mm is available in Appendix C.

When future growth is applied for the Phase 2 Servicing Study, recommendation for distribution upgrades will only be triggered under the following conditions:

- Under domestic usage, pressure shall maintain between 40-80 psi under average day, max day and peak hour conditions. When pressure falls outside of this range, an upgrade will be recommended.

- Fire flow shall be maintained within 5% of existing condition InfoWater model output for each node. If the fire flow is reduced by 5% or greater, an upgrade will be recommended.

6.0 Wastewater Facilities

The City's wastewater treatment and collection system is made up of over 200km of sanitary sewer (ranging in diameters from 100mm to 1500m), one major pressure sewer, three main pumping stations, 10 smaller sub-area SPSs, and one wastewater treatment plant. The locations of key wastewater collection and treatment infrastructure are shown in Figure 2. The City's wastewater treatment and collection system is currently operated under Amended Environmental Compliance Approval (ECA) No. 2178-B2ZLM8, Issued May 30th, 2019 and ECA No. 151-W601, dated October 6, 2022.

6.1 Wastewater Treatment Plant

The Belleville Wastewater Treatment Plant (Belleville WWTP) is owned by the City and currently operated by the Ontario Clean Water Agency (OCWA), is located at 131 St. Paul Street, Belleville, ON. The WWTP has a rated average daily flow (ADF) capacity of 54,500m^3/d, a rated peak daily flow (PDF) capacity through primary treatment of 163,440m^3/d, and a rated peak daily flow capacity through secondary treatment of 92,000m^3/d.

The WWTP provides treatment of wastewater through a conventional activated sludge system that includes preliminary treatment (grit removal and screening), primary treatment, secondary treatment (aeration and secondary clarification through two independent treatment trains – 'Plant 1' and 'Plant 2'), disinfection (chlorination and dechlorination), as well as chemical feed systems for phosphorus removal. Solids are removed from the primary treatment tanks, stabilized in an anaerobic digester, and stored as liquid biosolids in five on-site biosolids storage tanks prior to being hauled off-site for seasonal land application. The final effluent is released at the Bay of Quinte.

The following sections will discuss the residual ADF capacity of the Belleville WWTP under existing and projected demand. Additional studies are required to analyze the WWTP's capabilities of meeting effluent concentration parameters under the WWTP ECA.

6.1.1 Historic Flow Rates

Annual reports and monthly and daily flow data for the WWTP were reviewed for 2019 to 2023. As summarized in Table 21, the WWTP is currently operating at approximately half of its rated ADF capacity of 54,500m^3/d. It noted that flows have fluctuated considerably over the past several years, ranging from a very dry year and low ADF in 2021 (drought conditions) to very wet years and higher AADFs in 2019 and 2023. Annual precipitation data for the review period has been reviewed. It has been reported by the OCWA that there have been several raw sewage overflows in the collection system or bypasses of the primary treatment system at the WWTP during the review period due to heavy rainfall event or significant amount of rainfall with snowmelt. During the development of the 2019 WW Master Plan, it was noted by the City that in general, AADF during the Master Plan study period (2012 to 2017) was on the low end compared to the previous 10-years. The AADF observed between 2019 and 2023 were also within the same magnitude; where ADF was within the order of 30,000m^3/d between 2020 and 2022. This reduction in ADF could be due to below normal wet weather conditions during the review period (with the exception of 2019 and 2023), but also due to City efforts to "tighten up" the collection system (i.e. reduce inflow and infiltration) and success with water use reduction measures.

Based on the flow data reviewed and the WW Master Plan, the Belleville wastewater collection system appears to be heavily influenced by wet weather events, as evidenced by notifications of secondary bypass at the Belleville Water Pollution Control Plant (WPCP) from the OCWA's annual reports of 2019 to 2023. It is also understood that while the City has been making efforts to identify and separate combined sewers, some storm outlets, including catch basins, roof leaders and foundation drains are still directly connected to the sanitary system, making the system a Partially Separated Sewer System, under the Amended ECA.

Table 21: WWTP Flow Summary (2019-2023)

Year	Annual Average Day Flow (m^3/d)
2019	33,048
2020	29,333
2021	26,446
2022	27,953
2023	33,205
5-Year Average (2019-2023)	29,997 (55% of Rated Capacity)
ECA Rated Capacity	54,500

6.1.2 Future Wastewater Flow

Table 22 lists the average day demand applied to future development growth as described in Section 3.2.2. The following are typical average day demand values obtained from MECP Design Guidelines for Sewage Works Table 5-3.

Table 22: Design Parameters - Future Average Day Wastewater Flow

Parameter	Residential	Industrial / Commercial / Institutional (ICI)
Average Day Flow	350 L/cap/day	Industrial (35,000 L/ha/day)
		Commercial (28,000 L/ha/day)
		Institutional (28,000 L/ha/day)
		School (105 L/student/day)
		Hotel (225 L/bed space/day)

Using the parameters above, the future wastewater flow anticipated to occur in each planning period and scenario is summarized in Table 23. The WWTP's rated capacity is sufficient for existing and short-term conditions. The WWTP rated capacity will be exceeded in the mid-term.

Table 23: Future Wastewater Demand – Scenario 1: City Growth

	Existing (2023)	Short-Term (2023-2033)	Mid-Term (2033-2043)	Long-Term (2043-2051)
Total Population (cap)	48,982	62,073	82,214	92,250
Population Growth (cap)		13,091	20,141	10,036
Institutional, Commercial, Industrial (ICI) Growth (ha)			484	
Residential Average Day Demand (ADD) Growth (m^3/d)		4,582	7,049	3,513
ICI ADD Growth (m^3/d)			13,565	
Total ADD Growth (m^3/d)		4,582	20,614	3,513
Total ADD (m^3/d)	29,997	34,579	55,193	58,705
WWTP Rated Capacity (m^3/d)	54,500			
Surplus (m^3/d)	24,503	19,921	-693	-4,205

Table 24: Future Wastewater Demand – Scenario 1: Scenario 2 + Black Bear Ridge and Foxboro

	Existing (2023)	Short-Term (2023-2033)	Mid-Term (2033-2043)	Long-Term (2043-2051)
Population Growth (cap)	48,982	63,906	87,782	101,860
Total Population (cap)		14,924	23,876	14,078
Institutional, Commercial, Industrial (ICI) Growth (ha)		18	484	
School (Students)		900		
Hotel (Bed Spaces)		500		
Residential Average Day Demand (ADD) Growth (m^3/d)		5,223	8,357	4,927
ICI ADD Growth (m^3/d)		711	13,565	
Total ADD Growth (m^3/d)		5,934	21,921	4,927
Total ADD (m^3/d)	29,997	35,917	58,541	63,360
WWTP Rated Capacity (m^3/d)	54,500			
Surplus (m^3/d)	24,503	18,583	-4,041	-8,860

6.1.3 Projected Wastewater Treatment Plant Expansion

Figure 11 represents the projected average day wastewater flows and anticipated timing to reach 80%, 90%, and 100% of the WWTP rated capacity:

- Under Scenario 1:
  - 80% Capacity will be reached in 2036;

  - 90% Capacity will be reached in 2038, and
  - 100% Capacity will be reached in 2041.
- Under Scenario 2:
  - 80% Capacity will be reached in 2037;
  - 90% Capacity will be reached in 2039, and
  - 100% Capacity will be reached in 2042.

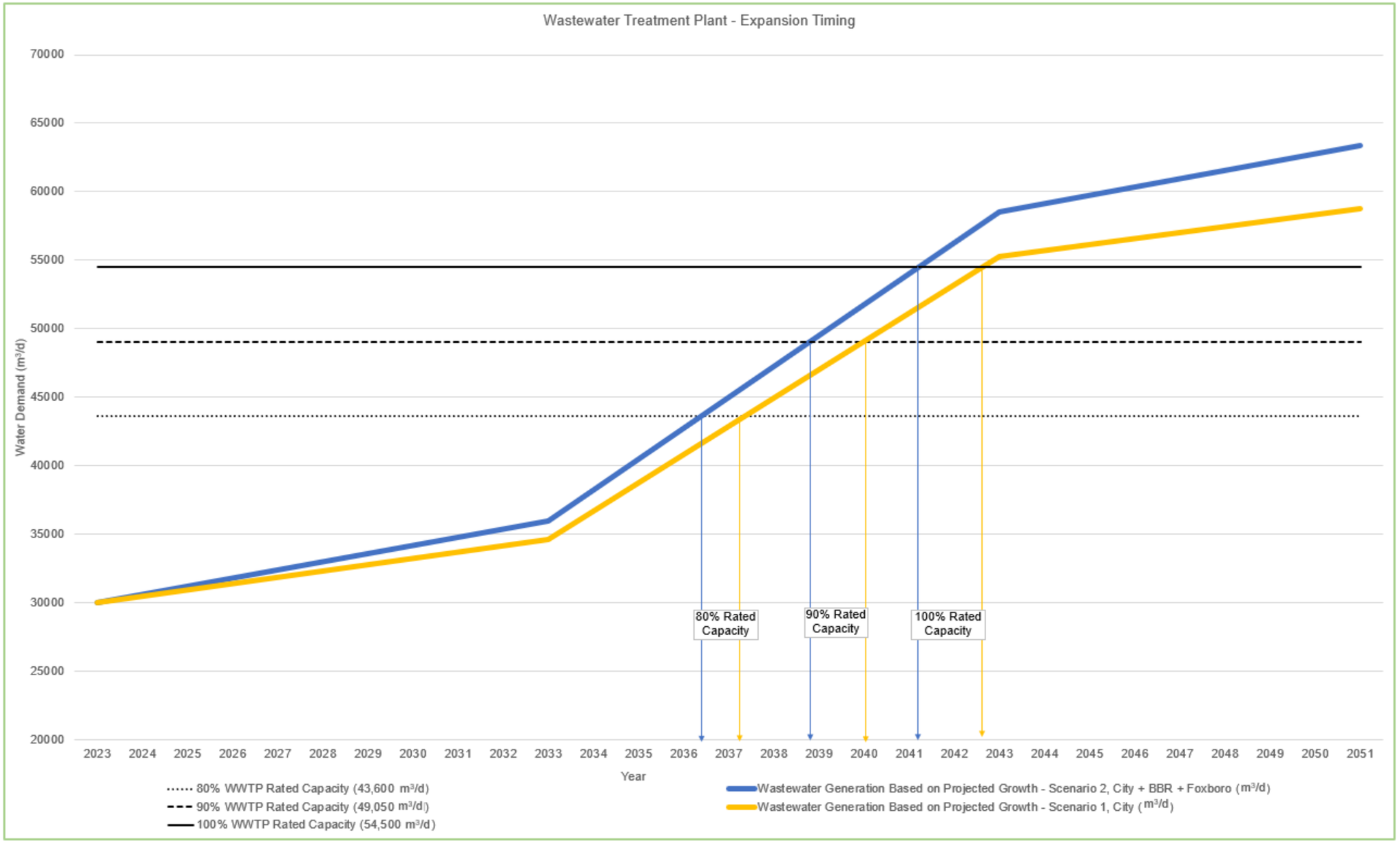

Figure 11: Projected Timing for WWTP Expansion

6.2 Wastewater Facilities Capacity Summary

Average day flow is used as the bases for WWTP rated capacity, in accordance with MECP Design Guidelines for Sewage Works. The discussion in Section 6.0 identified that the WWTP rated capacity is sufficient for existing and short-term demand conditions. The WWTP rated capacity will need to be increased in order to meet mid-term and long-term demands under Scenario 1 and Scenario 2.

7.0 Wastewater Collection

7.1 2019 Wet Weather and Wastewater Servicing Master Plan

As part of Belleville Wet Weather and Wastewater Servicing Master Plan (WWMP) an assessment of the conveyance system was undertaken. The work included development of a calibrated model of the trunk sewer network. Twelve (12) flow monitoring sites were strategically located at the downstream end of sections of the trunk sewer network and data collected over a three (3) month period in March to June 2018. Calibration to dry weather flows and wet weather events was undertaken using the flow monitoring results.

The level of service for the network was defined in the 2019 WWMP is as follows:

- Gravity Sewers:
  - Sewer capacity greater than dry weather flow
  - HGL within 300mm of the pipe obvert or greater than 2m below finished ground during the specified rainfall derived infiltration and inflow (RDII) event

- Pumping Stations
  - Pump station firm capacity greater than the 1:10-year RDII flow
  - Pump station peak capacity greater than the 1:100-year RDII flow

- Pressure Sewers
  - Velocity greater than 0.9 m/s in dry weather flow

The RDII event for the HGL level of service in the gravity sewer network was not confirmed as part of the wet weather master plan, however, the 1:100-year event was used in the plan figures under the existing condition.

7.2 Model Population Update

The population of the City of Belleville has changed since the modelling for the 2019 Wet Weather and Wastewater Servicing Master Plan was completed. As part of the calibration work a loading rate of sanitary flow per person was calculated for each of the flow monitoring catchments. An average rate was used in areas where there was no downstream monitor. In order to account for the population increase, the loading rate was applied to the new population and the flow rates in the model increased to the new calculated flow.

The population at the time of the 2019 Master Plan was estimated from the census data and the population difference between the 2019 Master Plan modelling and the latest 2023 population

calculation is less than 1%. This has resulted in negligible change in the flows in the system and the level of service identified.

7.2.1 Model Results and Level of Service

Figure 12 shows the level of service for the gravity system and Figure 13 shows the level of service for the pressure system. There is no change from the level of service simulated in 2019. No capacity constraints are identified on the Moira Parkway Trunk Sewer from the intersection of Cannifton Road and Maitland Drive to the connection to the pressure sewer along the Moira River. There are sections of the pressure trunk where velocities are insufficient to achieve self-cleansing flows, however this can be managed with a maintenance program.

N

Foxboro

Black Bear Ridge

37

Corbyville Village

Cannifton

401

401

Loyalist Secondary Plan Area

Urban

Bayshore / City Centre

62

Lake Ontario (lac Ontario)

3

Legend

Gravity System

- Flooding
- HGL Above Limits (within 2m of surface or over 300mm above sewer obvert)
- DWF Below Capacity
- Existing Pipes

Boundary

- Parcel Fabric
- Planning Areas
- Municipal Boundary

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Plot Date: November 8, 2024 4:13:26 PM

PROJECT:

Black Bear Ridge Servicing Study

Belleville, Ontario

DRAWING:

Level of Service - Gravity System - 1:100 year RDII

J.L.Richards

ENGINEERS · ARCHITECTS · PLANNERS

www.jlrichards.ca

DESIGN:	BP
DRAWN:	KTK
CHECKED:	SS
JLR #:	32874

DRAWING #:

Figure 12

N

Foxboro

Black Bear Ridge

37

Corbyville Village

Cannifton

401

401

Loyalist Secondary Plan Area

Urban

Bayshore / City Centre

62

Lake Ontario (lac Ontario)

3

Legend

Pressure System

- DWF and 1:100 year Velocity greater than 0.9 m/s
- Only 1:100 year Velocity greater than 0.9 m/s
- DWF and 1:100 year Velocity less than 0.9 m/s
- Existing Pipes

Boundary

- Parcel Fabric
- Planning Areas
- Municipal Boundary

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Plot Date: November 8, 2024 4:15:22 PM

PROJECT:

Black Bear Ridge Servicing Study

Belleville, Ontario

DRAWING:

Level of Service - Pressure System - 1:100 year RDII

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DESIGN:	BP
DRAWN:	KTK
CHECKED:	SS
JLR #:	32874

DRAWING #:

Figure 13

7.3 Sewage Pumping Stations and Level of Service

The 2019 Master Plan identified capacity constraints at the Front Street Pump Station, which continue in the model with the revised population. Table below shows the flows for the various events with the pump station firm and peak capacities.

At the Front Street Pump Station, the 1:10-year wet weather event is greater than the firm capacity of the pump station. The flows during the 1:10-year and 1:100-year wet weather events at the Front Street pump station are similar due to upstream flooding in the system resulting in the limited flow downstream. The other pump stations have sufficient capacity under existing conditions.

Table 25: Sewage Pumping Station Model Results Under Existing Population Conditions

Pump Station	Firm Capacity (L/s)	Peak Capacity (L/s)	DWF (l/s)	1:10 year Storm (L/s)	1:100 year Storm (L/s)
East End	550	800	104	371	708
Front Street	975	1290	276	**1149**	**1153**
Dundas	289	519	16	127	173

8.0 Next Steps

This Design Basis Memorandum functions as Phase 1 of the Servicing Study and includes existing and projected flows and demands generated by Belleville and future service areas which will impact Belleville's water and wastewater infrastructure.

This Design Basis Memo has been developed to summarize the Phase 1 work undertaken as part of the Servicing Study. It has been used to identify the existing conditions and constraints associated with the current system. Phase 2 of the Servicing Study will involve further definition of these systems through the development of hydraulic models and will ultimately include the identification of preferred strategies and actions to address the servicing constraints. More specifically, the following are planned for Phase 2:

- Model of the water and wastewater systems for future development.
- Identify servicing route options for Black Bear Ridge, Harmony School, Corbyville, and Foxboro.
- Identify and evaluate alternative solutions to support future servicing.
- Develop a list of alternatives and their proposed timelines and associated costs.
- A Servicing Study will be prepared to summarize Phase 2 findings.

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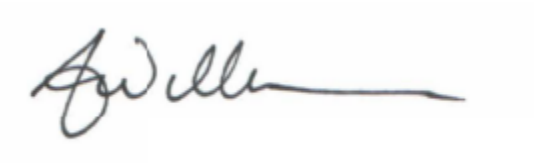

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