

Appendix M

TM-11 - Sensitivity Analysis



Region of Waterloo

Wastewater Treatment Master Plan Update

**Technical Memorandum No. 11
Sensitivity Analysis**



**5935 Airport Road, Suite 500
Mississauga, Ontario
L4V 1W5
Canada
Phone: (905) 695-1005
Fax: 905) 695-0525
www.cima.ca**

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1. Introduction

1.1 Background

The Regional Municipality of Waterloo (Region) is an upper tier municipal government, providing municipal services to seven local area municipalities with a total population of approximately 550,000 people. The Region owns thirteen (13) wastewater treatment plants (WWTPs), one (1) wastewater residuals processing facility, seven (7) sewage pumping stations (SPS), and two (2) wastewater collection systems (Ayr in the Township of North Dumfries and Wellesley in the Township of Wellesley), treating an approximate average of 66 million cubic meters of wastewater annually. Wastewater facilities are operated and maintained by the Ontario Clean Water Agency (OCWA) under contract to the Region. Most of the collection systems and pumping station infrastructure that convey wastewater to the Region's treatment facilities are owned, managed and operated by the area municipalities (City of Cambridge, City of Kitchener, City of Waterloo, Township of Wilmot and Township of Woolwich).

The Region has experienced steady residential and industrial/commercial/institutional (ICI) growth for many years and anticipates that this trend will continue due to a strong local economy, the Province of Ontario's Places to Grow Act and major Regional and Provincial transportation initiatives that are underway. The Region completed a Wastewater Treatment Master Plan (WWTMP) in 2007 (Earth Tech, 2007) to plan for future growth and provision of treatment capacity throughout the Region. In light of changes to population projections, wastewater flows and environmental regulations, the Region has initiated an update to its WWTMP.

1.2 Purpose of Technical Memorandum No. 11 (TM11)

This memorandum has been prepared to identify the sensitivity to timing of recommended projects in the WWTMP relative to the following changes:

- + Population growth rates both higher and lower than the moderate growth planning scenario
- + Per capita flow (PCF) changes from current levels
- + Reduced inflow and infiltration (I/I) in plants that currently exhibit higher than typical levels (i.e., Wellesley, St Jacobs and Elmira).

2. Methodology

2.1 Methodology for Population Projection Sensitivity

The Places to Grow (P2G) population numbers developed by the Province of Ontario were utilized for planning within the Region's 2007 WWTMP Update. Since the completion of the 2007 WWTMP Update, Places to Grow Amendment 2 (P2GA2) has been released (Hemson, June 2013). Amendment 2 updated and extended the time horizon of the growth forecast to 2041 for single-tier and upper-tier municipalities in the Greater Golden Horseshoe.

Based on observed population growth since the completion of the 2007 WWTMP, the P2G numbers were considered aggressive. As a result, the Region's Planning, Development & Legislative Services (Planning) Department developed growth projections based on the more moderate observed growth within the Region to support the development of infrastructure needs and capital budgets. This moderate growth scenario has been used as the baseline growth estimate to plan for projects in this WWTMP Update.

It is important to note that for the population projection sensitivity analysis, the baseline population was kept as the moderate growth scenario and the +/-15% population sensitivities were the only parameter changed. Population sensitivity was assessed based on adjusted growth rates as follows:

- + 15% higher growth rate than the moderate growth scenario.
- + 15% lower growth rate than the moderate growth scenario.
- + P2GA2 growth scenario

For a given PCF, wastewater flow is directly proportional to population. As a result, higher growth rates will result in wastewater treatment facilities approaching their rated capacity sooner than compared to a lower growth rate.

2.2 Methodology for Per Capita Flow Sensitivity

The projected average day wastewater flow to 2051 for each wastewater service area/WWTP was estimated based on the population growth projections provided by the Region (refer to Section 2.1 for details) and the historic 5-year average PCFs (2011-2015) derived from the Region's 2016 Water and Wastewater Monitoring

Report (WWWMR), to provide an indication of the wastewater treatment requirements in the future. As the flow rate approaches 85% of plant rated capacity, the planning process for plant expansion is typically triggered (i.e. Class Environmental Assessment (EA)) (MOECC, 1995).

It should be noted that the historic average PCF is a conservative value based on the Region's observed flows, which includes wastewater discharges from residential, industrial, commercial and institutional (ICI), and extraneous flows such as I/I. If additional water conservation and I/I corrective programs are implemented, and effective, lower future wastewater flows may occur.

In addition, it is assumed that the ICI to residential flow ratio in the future will be similar to the current ratio in each service area. This approach was considered best suited to estimate flows based on current available information, with the exception of the Elmira WWTP. The Elmira WWTP currently has high industrial flow and loading contributions; therefore, it was considered more appropriate to use projections that represent a "mid-point" between existing and typical residential per capita rates.

A summary of the historic 5-year average PCFs are presented in Table 1. It is noted that Galt, Preston, St Jacobs and Elmira have higher PCF rates, which is attributed to additional contribution from industrial sources and/or historical I/I issues experienced at these WWTPs.

The average historic PCF coupled with the moderate population projections were used to develop the baseline wastewater flow projections in each service area. It is important to note that the population forecasts were kept as the moderate growth scenario and the per capita rate was the only parameter changed. To understand the sensitivity of timing recommendations based on PCFs, the following bounds were considered:

- + Upper bound based on using an 85% confidence level PCF. This corresponds to a flow with an 85% probability of not being exceeded. This accounts for seasonal variations in flow and is consistent with the "Adjusted Flow" included in the Region's 2016 WWWMR.
- + 15% decrease in PCFs relative to the historic average.

Table 1 Historic Average PCFs

WWTP Service Area	5-Year Average PCF (m ³ /cap/d) ⁽¹⁾
Kitchener	0.296
Waterloo	0.334
Galt	0.405
Preston	0.433
Hespeler	0.275
Ayr	0.274
New Hamburg	0.293
Wellesley	0.233
St Jacobs	0.497
Elmira	0.427

Notes:

1. Based on the Region’s 2016 Water and Wastewater Monitoring Report (RMOW, 2016).

These boundary conditions were applied to both the existing population base as well as the new growth in each service area. This accounts for many existing homes which are upgrading to water conserving toilets, faucets and appliances.

It is important to note that when considering changes to PCFs, the overall loadings of key wastewater constituents (e.g., biochemical oxygen demand (BOD₅), total suspended solids (TSS), etc.) will remain unchanged since loadings are directly proportional to population. Overall, higher PCFs will result in a more dilute, lower concentration wastewater influent, while lower PCFs will result in a more concentrated wastewater influent. As a result, while lower PCFs may defer expansion timing in terms of the rated plant capacity, upgrades may still be required to address capacity limitations in key unit processes. The unit processes controlled by loadings rather than flow limitations include:

- + Aeration Tanks
- + Oxygenation or Process Air Systems
- + Secondary Clarifier Solids Loading Rate (SLR)
- + Digestion.

Graphs were prepared to illustrate the capacity of the treatment process that was considered the limiting capacity for a given facility. Per capita sensitivity was only completed for plants that require expansion within the 2051 timeframe based on the moderate growth scenario including:

- + Waterloo WWTP
- + Hespeler WWTP
- + Wellesley WWTP
- + St Jacobs WWTP
- + Elmira WWTP

2.3 Methodology for Inflow/Infiltration (I/I) Sensitivity

I/I sensitivity was considered for the following wastewater facilities that historically have higher than typical inflow/infiltration rates:

- + Wellesley WWTP
- + St Jacobs WWTP
- + Elmira WWTP

Reduced inflow/infiltration has the potential to reduce both the average PCF as well as the extreme wet weather flows handled at the facility. The first component (PCF reduction) is already considered as part of the PCF sensitivity analysis. The I/I sensitivity analysis in this memorandum focused on the impacts of reduced peak wet weather flows on infrastructure needs. In general, lower peak wet weather flows can reduce infrastructure needs on processes designed around peak flows including headworks, primary and secondary clarifiers, tertiary filters and disinfection.

The I/I sensitivity analysis considered a reduction in peak flow to the WWTPs as follows:

- + 15% reduction in peak flow for the Wellesley WWTP, which will allow the capacity limiting processes (i.e. secondary clarifier surface overflow rate (SOR)) during high flows at the plant to meet the current rated capacity of the plant.
- + 25% reduction in peak flow for the St Jacobs and Elmira WWTPs, which will allow the capacity limiting processes (i.e., tertiary filtration and UV disinfection at the St

Jacobs WWTP; and primary clarification SOR at the Elmira WWTP) during high flows to meet the current rated plant capacity.

3. Population Growth Sensitivity Analysis

3.1 Kitchener WWTP

The Kitchener WWTP is a conventional activated sludge plant that provides treatment for wastewater generated in the City of Kitchener. The plant has a rated average day flow (ADF) capacity of 122,750 m³/d.

3.1.1 Kitchener WWTP (without ESLs)

The projected residential service population for the Kitchener WWTP to 2051, not including the population within the East Side Lands (ESL) growth area, is shown in Figure 1.

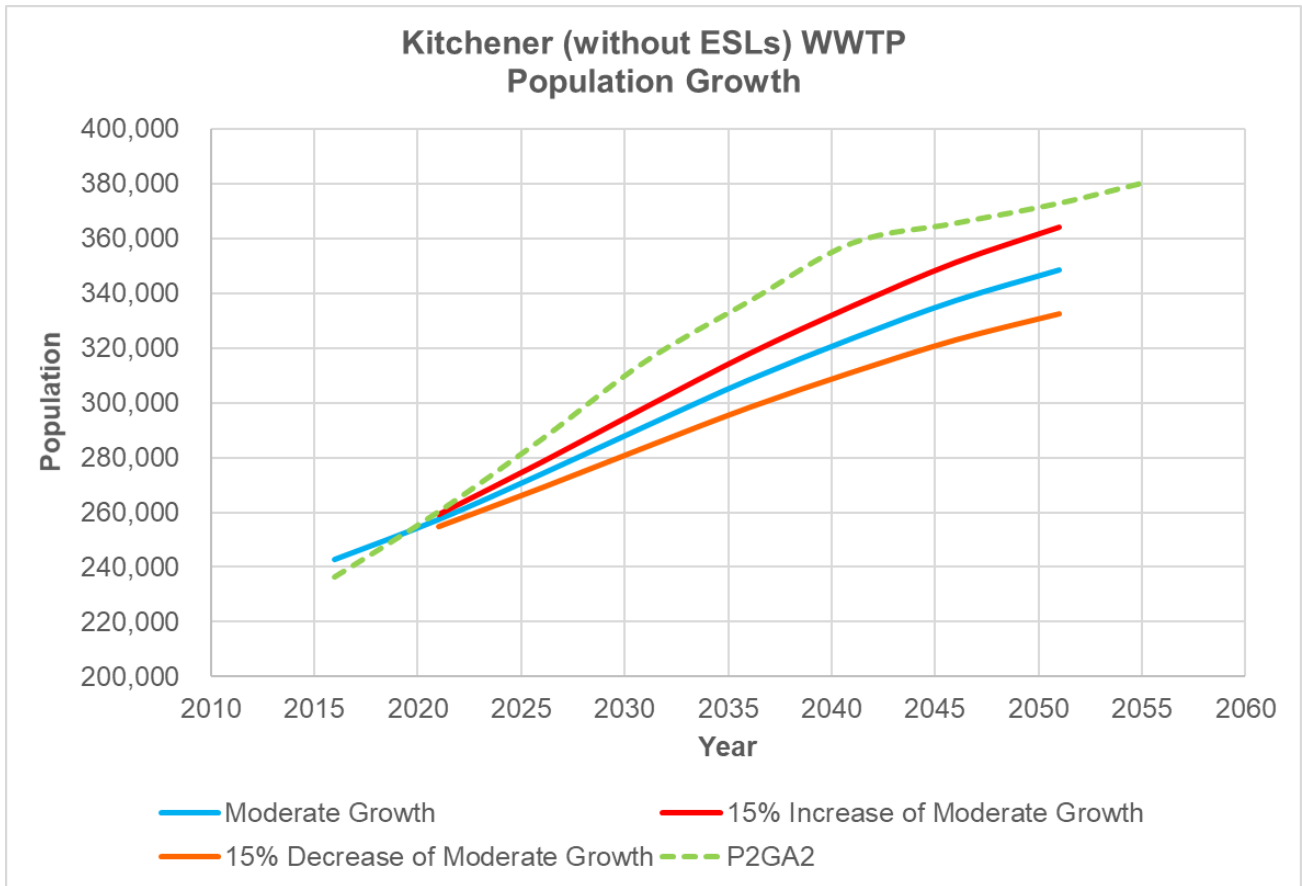


Figure 1 Population Projections for the Kitchener WWTP (without ESLs)

The projected ADFs to the Kitchener WWTP to 2051, not including flows that will be generated within the ESL growth area, based on population and a historic 5-year average PCF of 0.296 m³/cap/d during 2011 and 2015 derived from the Region’s 2016 WWWMR, are shown in Figure 2.

The projected ADF in 2051 is below the rated capacity for the Kitchener WWTP for all scenarios. The P2GA2 scenario and high growth scenarios are similar, with the plant reaching 85% of the rated capacity in 2039 and 2046, respectively. For the moderate growth and low growth scenarios, the plant will reach 85% of the rated capacity after 2051. This suggests that the plant will have sufficient capacity to handle the projected ADF over the next 33 years.

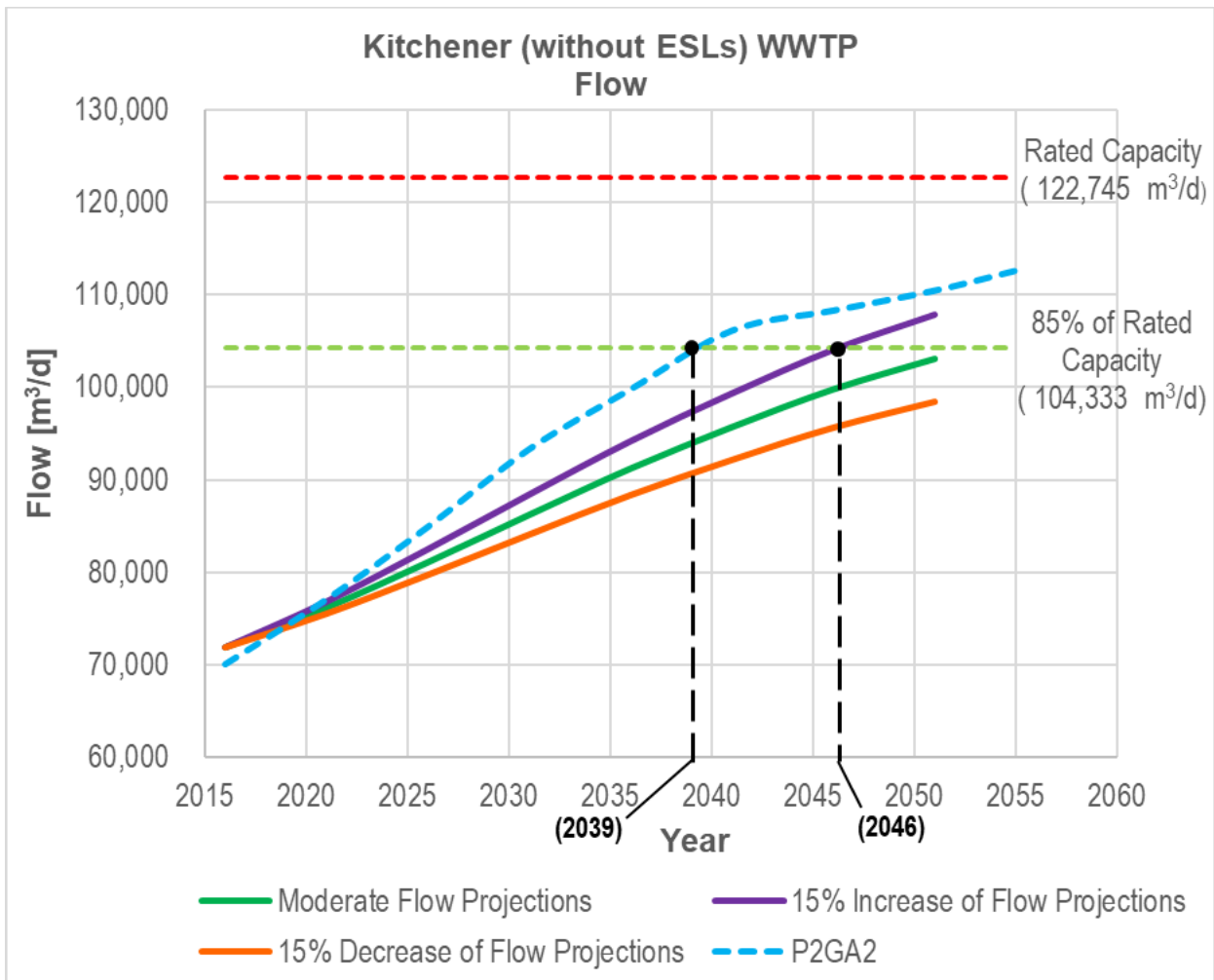


Figure 2 Flow Projections for the Kitchener WWTP (without ESLs)

3.1.2 Kitchener WWTP (with ESLs)

The proposed residential service population for the Kitchener WWTP to 2051, including the population within the ESL growth area, is shown in Figure 3.

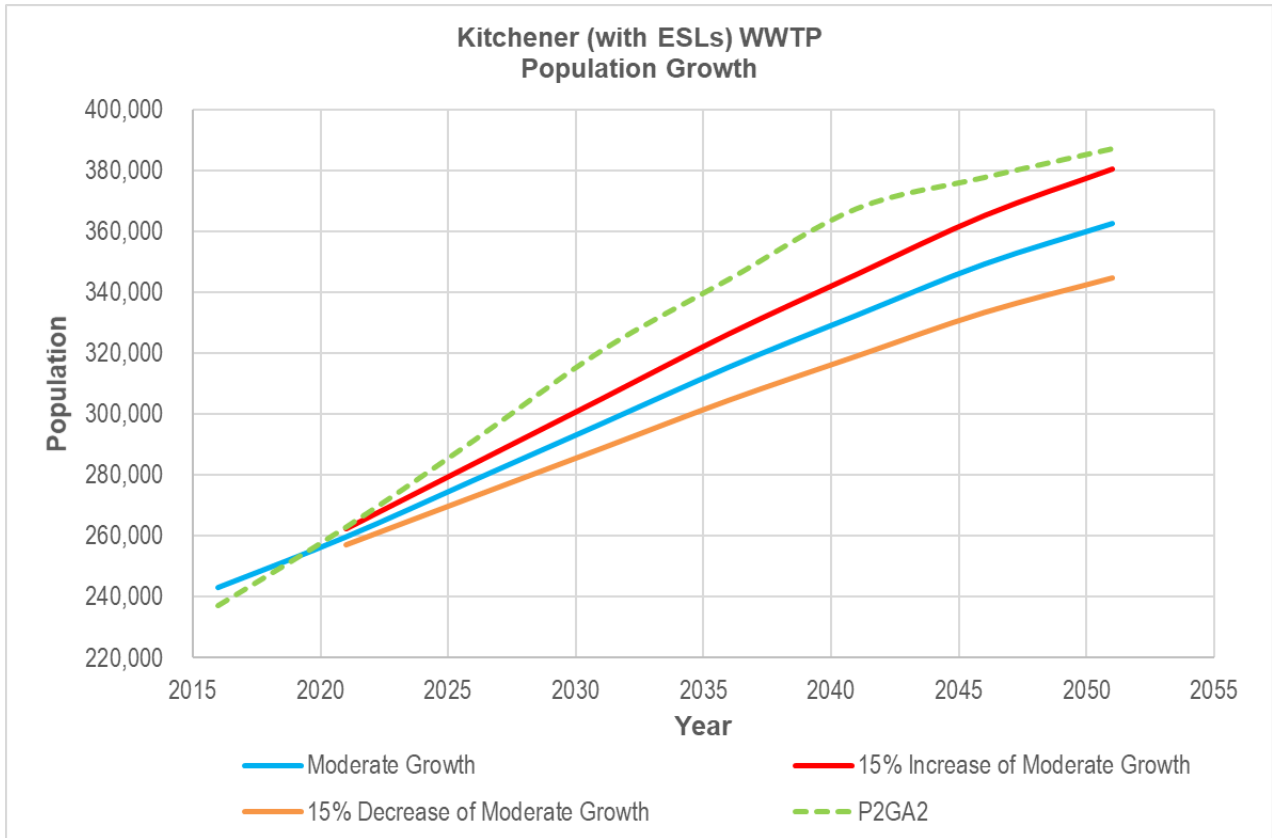


Figure 3 Population Projections for the Kitchener WWTP (with ESLs)

The projected ADF to the Kitchener WWTP to 2051, including the flows that will be generated within the ESL growth area, are shown in Figure 4. The ADFs are based on population and an average PCF of 0.296 m³/cap/d for the Kitchener WWTP service area derived from the Region’s 2016 WWWMR and an average PCF of 0.578 m³/cap/d for the ESL growth area derived from the equivalent residential population from the ESL Sanitary Servicing Class EA (AE, ongoing).

Figure 4 shows there is sufficient capacity at the Kitchener WWTP, including the forecasted ESL flows, to beyond the year 2051 in each of the growth sensitivity scenarios reviewed. Based on these values, an expansion will not be needed within the planning horizon for the WWTMP. A 15% higher growth rate will result in the Kitchener WWTP reaching 85% of its current rated capacity by 2040, the moderate

growth scenario by 2044, and the 15% lower growth rate scenario by 2049. For the P2GA2 scenario, the plant will reach 85% of the rated capacity in 2038, which is similar to the high growth scenario (2040). Accordingly, the population sensitivity shows minimal impact to the recommended capital timing other than potentially initiating a Schedule C Class EA for the expansion slightly sooner. However, this is still beyond the timing of the next WWTMP Update (typically updated every 5 to 10 years), which will provide an opportunity to review and update the growth projections.

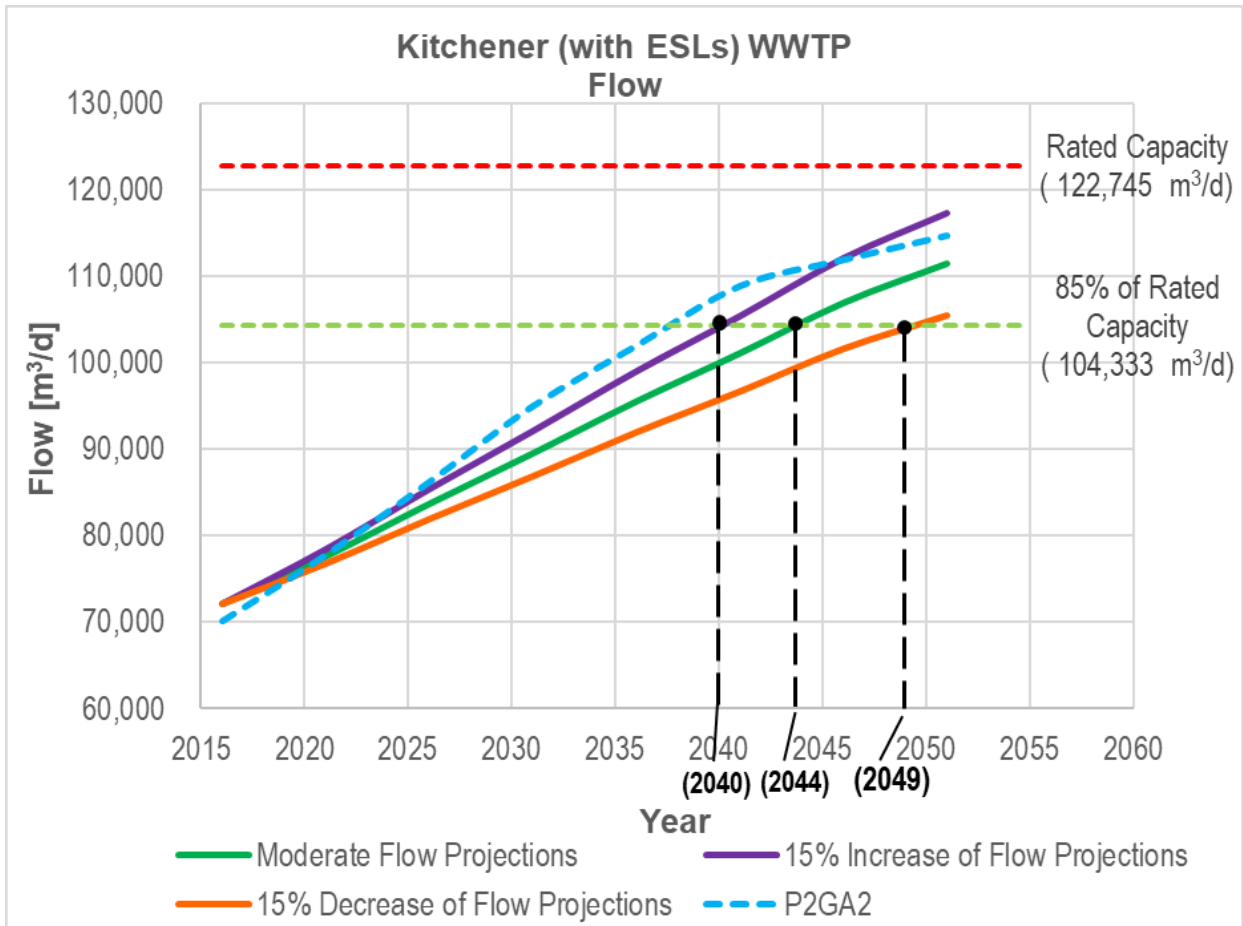


Figure 4 Flow Projections for the Kitchener WWTTP (with ESLs)

3.2 Waterloo WWTTP

The Waterloo WWTTP is a conventional activated sludge plant that provides treatment for wastewater generated in the City of Waterloo and a small portion from the City of Kitchener. The plant has an existing Environmental Compliance Approval (ECA)

approved hydraulic capacity of 72,730 m³/d, with a rated ADF treatment capacity of 57,500 m³/d.

The projected residential service population for the Waterloo WWTP to 2051 is shown in Figure 5.

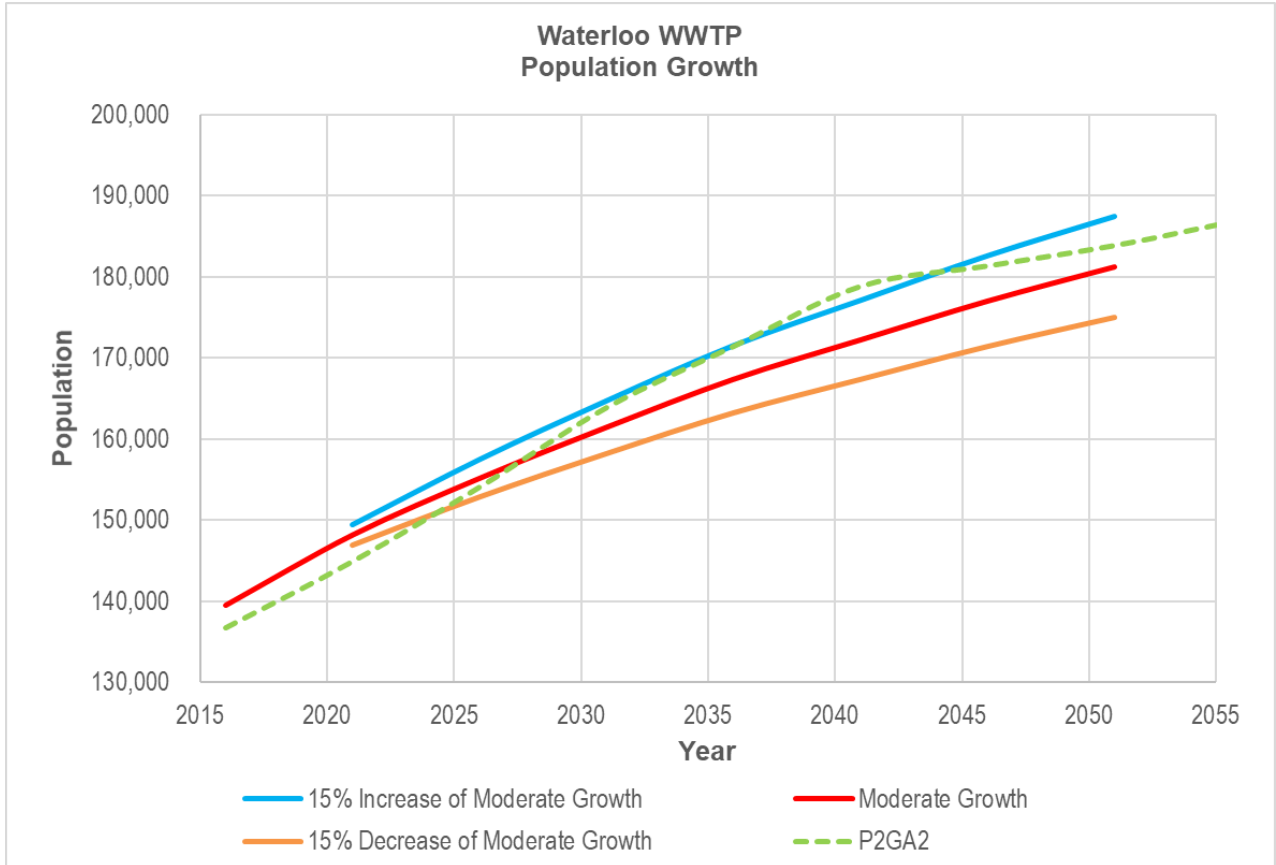


Figure 5 Population Projections for the Waterloo WWTP

The projected ADFs to the Waterloo WWTP to 2051, based on population and an average PCF of 0.334 m³/cap/d derived from the Region’s 2016 WWWMR, are shown in Figure 6. For a 15% higher growth rate scenario, a moderate growth scenario, and a 15% lower growth rate scenario, the impacts on timing to reach 85% of the plant’s rated capacity is minimal (+/- 1 year) and will be reached in 2019, 2020, and 2021, respectively. The growth rate scenarios will reach 100% of the plant’s rated capacity in 2036, 2041, and 2047, respectively, approximately 17 – 26 years later than 85% of the rated capacity. For the P2GA2 scenario, the plant will reach 85% of the rated capacity in 2022 and 100% of the rated capacity about 14 years later in 2036. It can

be noted that the timing for reaching 100% of the rated capacity in both the P2GA2 and high growth scenarios is the same (2036).

Based on the population sensitivity scenarios reviewed, the planning for an expansion for the Waterloo WWTP should begin in the short-term (approximately 2020).

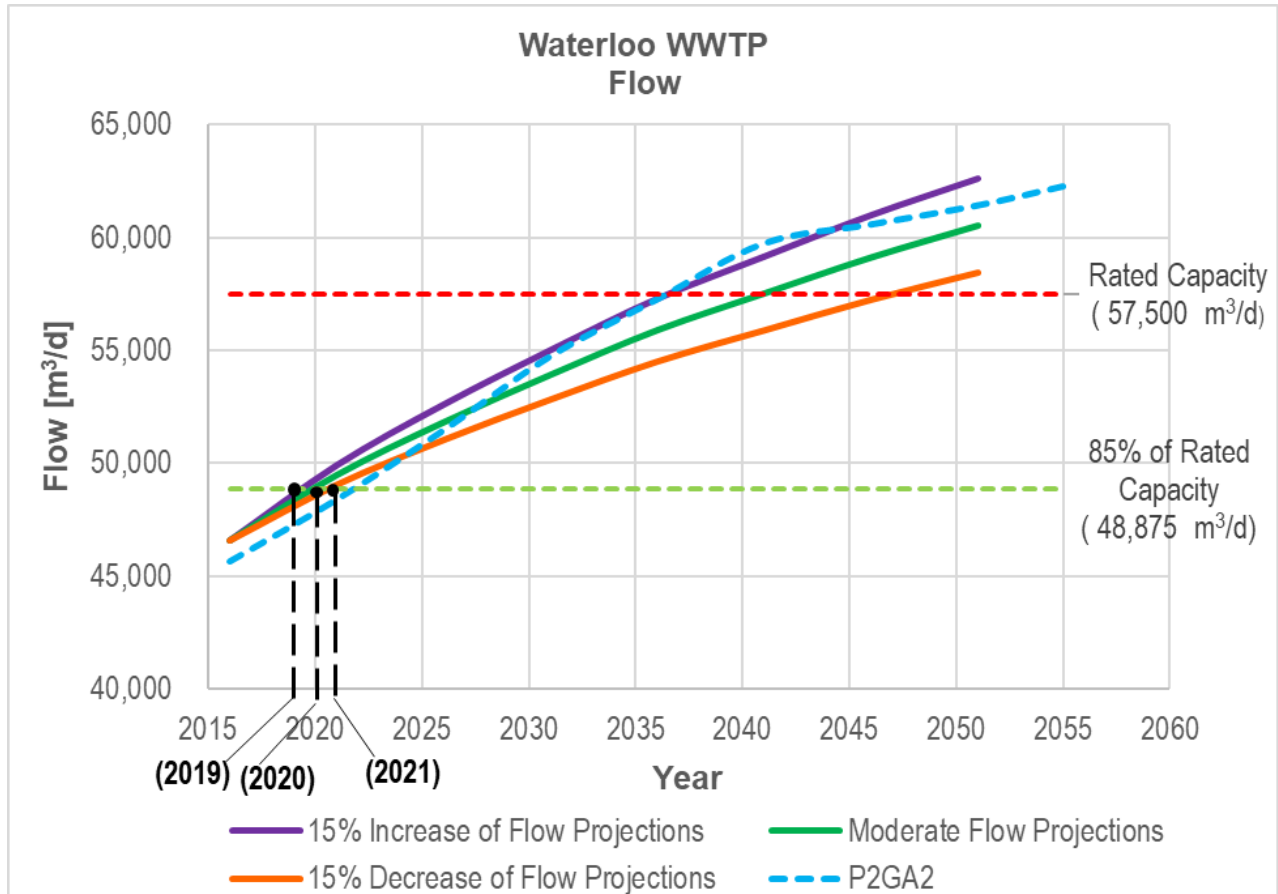


Figure 6 Flow Projections for the Waterloo WWTP

3.3 Galt WWTP

The Galt WWTP is a conventional activated sludge plant that provides treatment for wastewater generated from a portion of the City of Cambridge. The plant has an existing ECA approved Stage 1 rated ADF capacity of 56,800 m³/d.

The projected residential service population for the Galt WWTP to 2051 is shown in Figure 7.

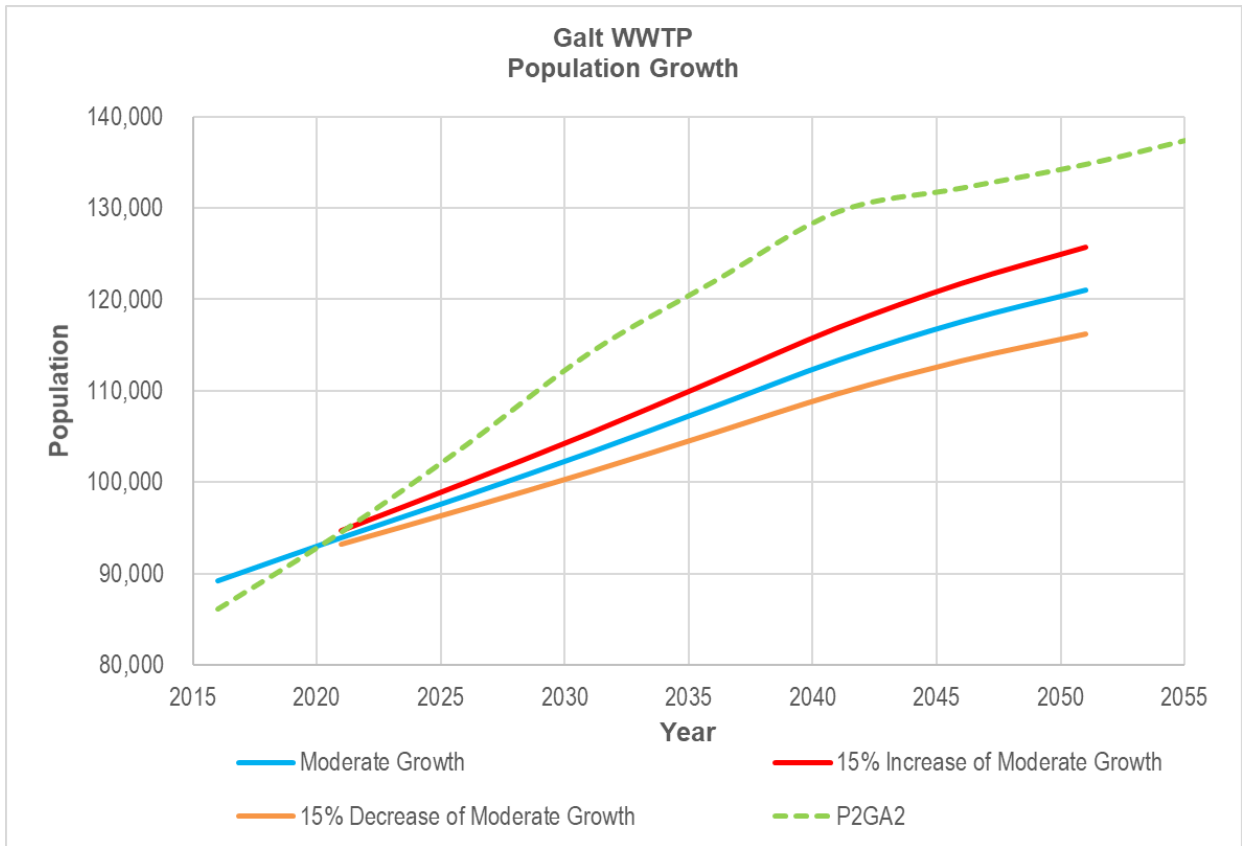


Figure 7 Population Projections for the Galt WWTP

The projected ADFs to the Galt WWTP to 2051, based on population and an average PCF of 0.405 m³/cap/d derived from the Region’s 2016 WWMR, are shown in Figure 8. The higher average PCF is attributed to higher industrial contributions within this service area, including the Industrial Road Service Area (IRSA).

For all scenarios, an expansion is not required before 2051. Similar to the Kitchener WWTP, higher growth rates will cause the plant to reach 85% of the rated capacity in 2043, approximately 5 years sooner than the moderate growth scenario (i.e., 2043 rather than 2048). For the P2GA2 scenario, the plant will reach 85% of the rated capacity in 2034. The P2GA2 projections were considered aggressive for the Galt WWTP; however, as noted above, an expansion is not required before 2051 even under the P2GA2 scenario. Accordingly, the population sensitivity shows minimal to no impact to the recommended capital timing other than potentially initiating a Schedule C Class EA for the expansion slightly sooner. Even under the P2GA2 scenario, the timing to initiate the Class EA would still be beyond the timing of the

next WWTMP Update (typically updated every 5 to 10 years), which will provide an opportunity to review and update the growth projections.

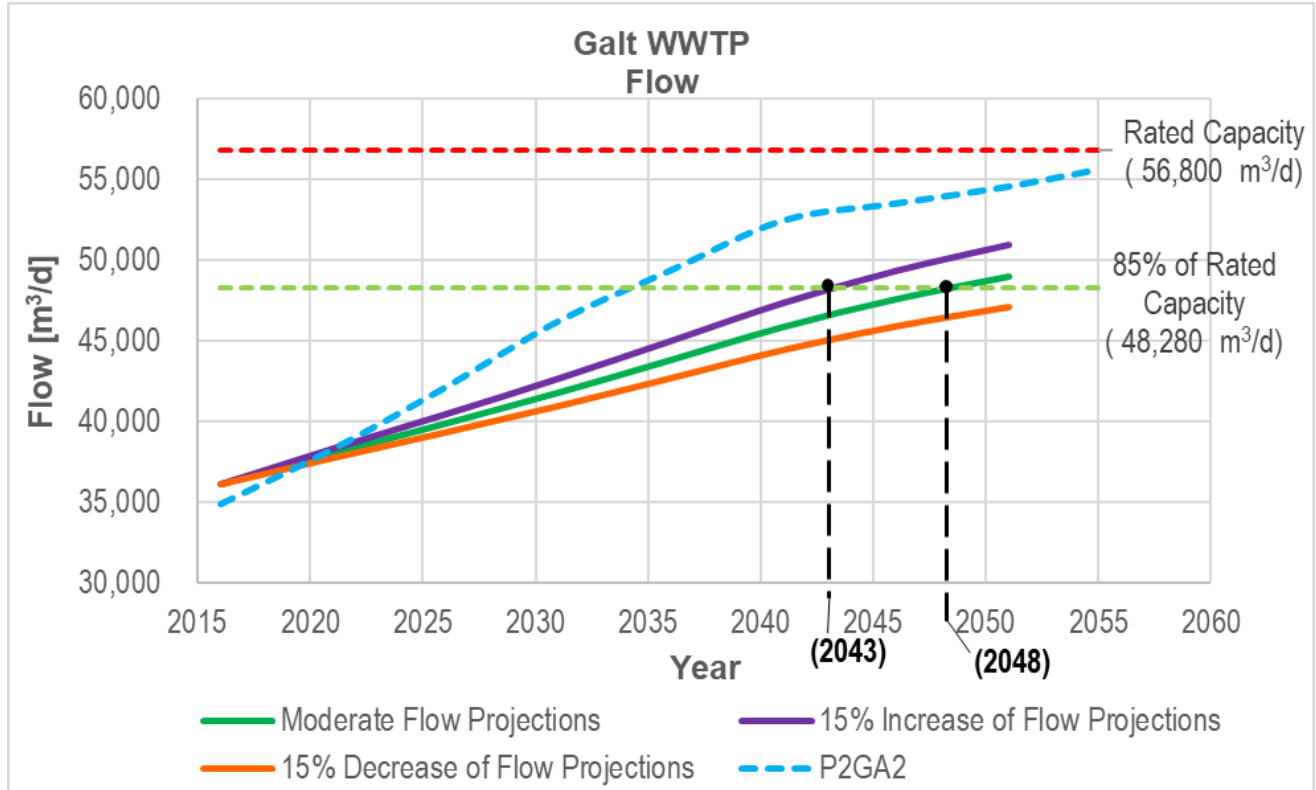


Figure 8 Flow Projections for the Galt WWTP

3.4 Preston WWTP

The Preston WWTP is a conventional activated sludge plant that provides treatment for wastewater generated from a portion of the City of Cambridge. The plant has a rated ADF capacity of 16,860 m³/d.

3.4.1 Preston WWTP (without ESLs)

The projected residential service population for the Preston WWTP to 2051, not including the population within the ESL growth area, is shown in Figure 9.

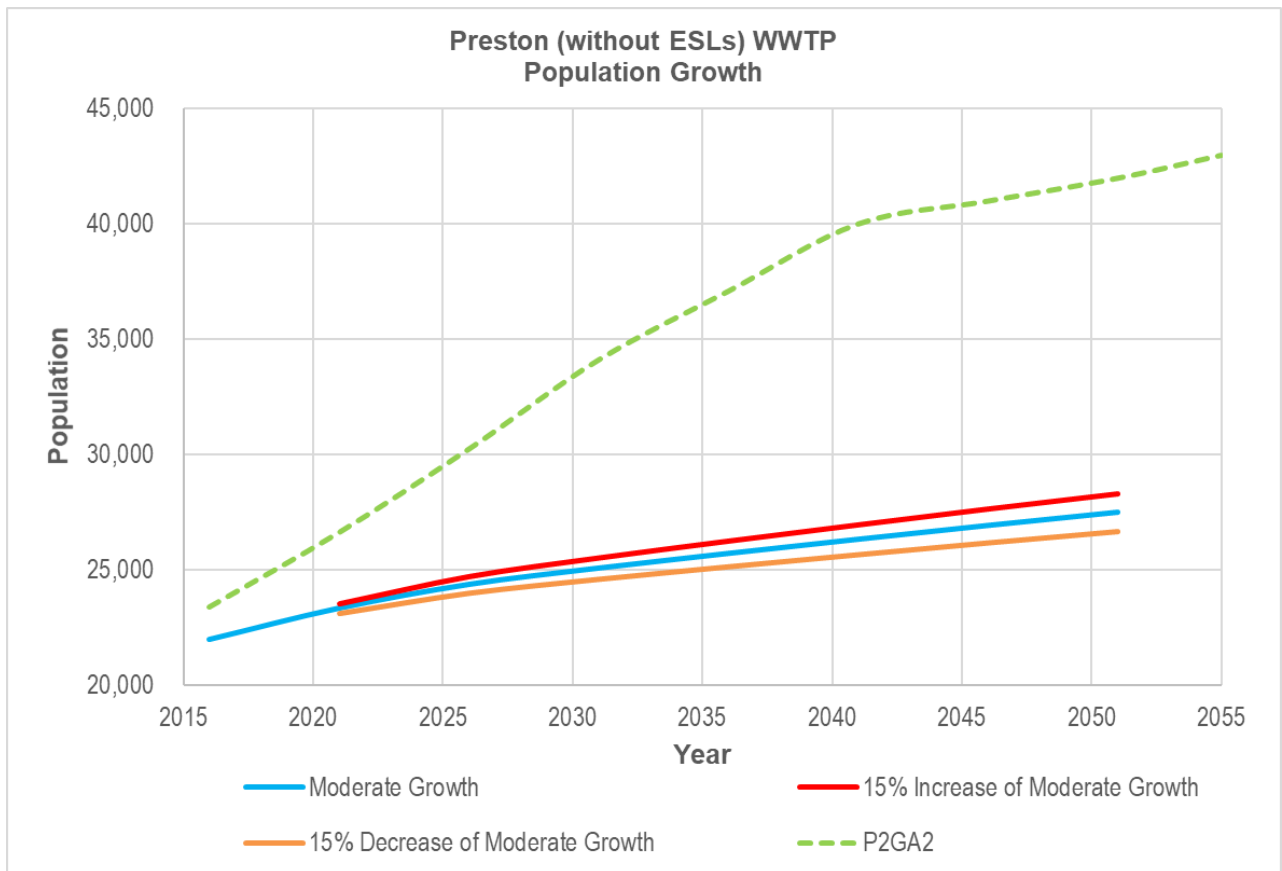


Figure 9 Population Projections for the Preston WWTP (without ESLs)

The projected ADFs to the Preston WWTP to 2051, not including flows that will be generated within the ESL growth area, based on population and an average PCF of 0.433 m³/cap/d derived from the Region’s 2016 WWWMR, are shown in Figure 10.

Under all scenarios, with the exception of P2GA2, all growth sensitivity scenarios remain well below the rated capacity of the Preston WWTP up to 2051. For the P2GA2 growth rate scenario, the plant will reach 85% of the rated capacity in 2030, and 100% of the rated capacity in 2039. P2GA2 projections were considered aggressive for the Preston WWTP and it is more appropriate to consider timing sensitivity relative to the high growth scenario (+15%). The high growth scenario indicates flows will remain below 85% of the rated capacity in 2051, confirming that planning for an expansion to the Preston WWTP is not expected within the planning horizon of the 2018 WWTMP Update. As such, high growth scenario has minimal impact to the recommended capital timing other than potentially initiating a Schedule

C Class EA for the expansion slightly sooner. However, this is still beyond the timing of the next WWTMP Update (typically updated every 5 to 10 years), which will provide an opportunity to review and update the growth projections.

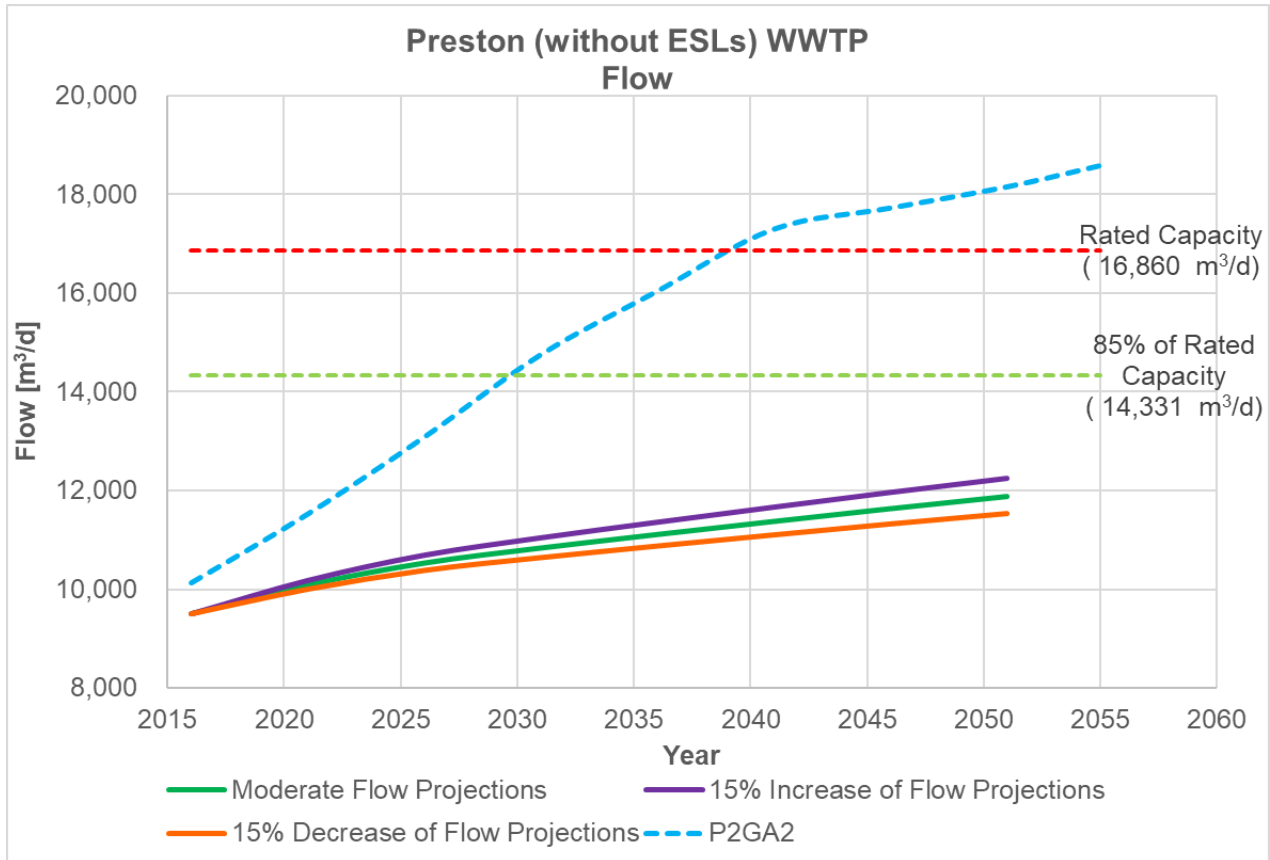


Figure 10 Flow Projections for the Preston WWTTP (without ESLs)

3.4.2 Preston WWTTP (with ESLs)

The projected residential service population for the Preston WWTTP to 2051, including the population within the ESL growth area, is shown in Figure 11.

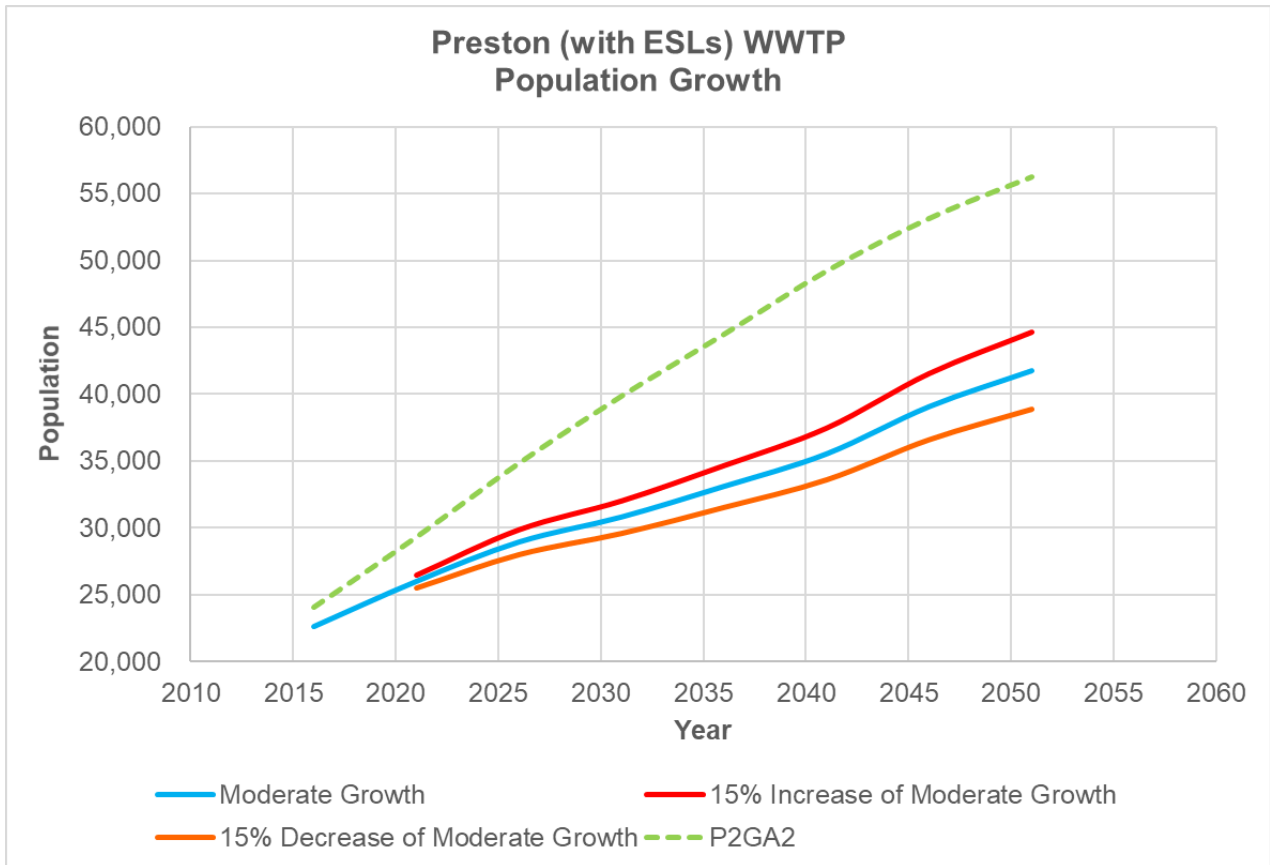


Figure 11 Population Projections for the Preston WWTP (with ESLs)

The projected ADFs to the Preston WWTP to 2051, including the flows that will be generated within the ESL growth area, are shown in Figure 12. The ADFs are based on population and an average PCF of 0.433 m³/cap/d for the Preston WWTP service area derived from the Region’s 2016 WWMR and an average PCF of 0.579 m³/cap/d for the ESL growth area derived from the equivalent residential population from the ESL Sanitary Servicing Class EA (AE, ongoing).

When this 85% trigger is reached including flows from the ESL, this would initiate works to allow the transfer of the ESL flow to the Kitchener WWTP. Higher growth rate, moderate growth and lower growth rate scenarios will reach 85% of the plant rated capacity in 2029, 2032, and 2035, approximately 9 years earlier than reaching 100% of the rated capacity in 2038, 2041 and 2044, respectively. For the P2GA2 scenario, 85% of the plant rated capacity will be reached in 2024 and 100% of the rated capacity will be reached in 2030. As noted for projections of the Preston WWTP without ESLs, the P2GA2 growth rates are considered aggressive for the Preston

WWTP. It is considered more appropriate to plan based on the higher growth scenario; however, the capacity of the Preston WWTP is reviewed annually through the WWWMR and will be monitored to confirm when the long-term servicing solution for the ESL should be implemented.

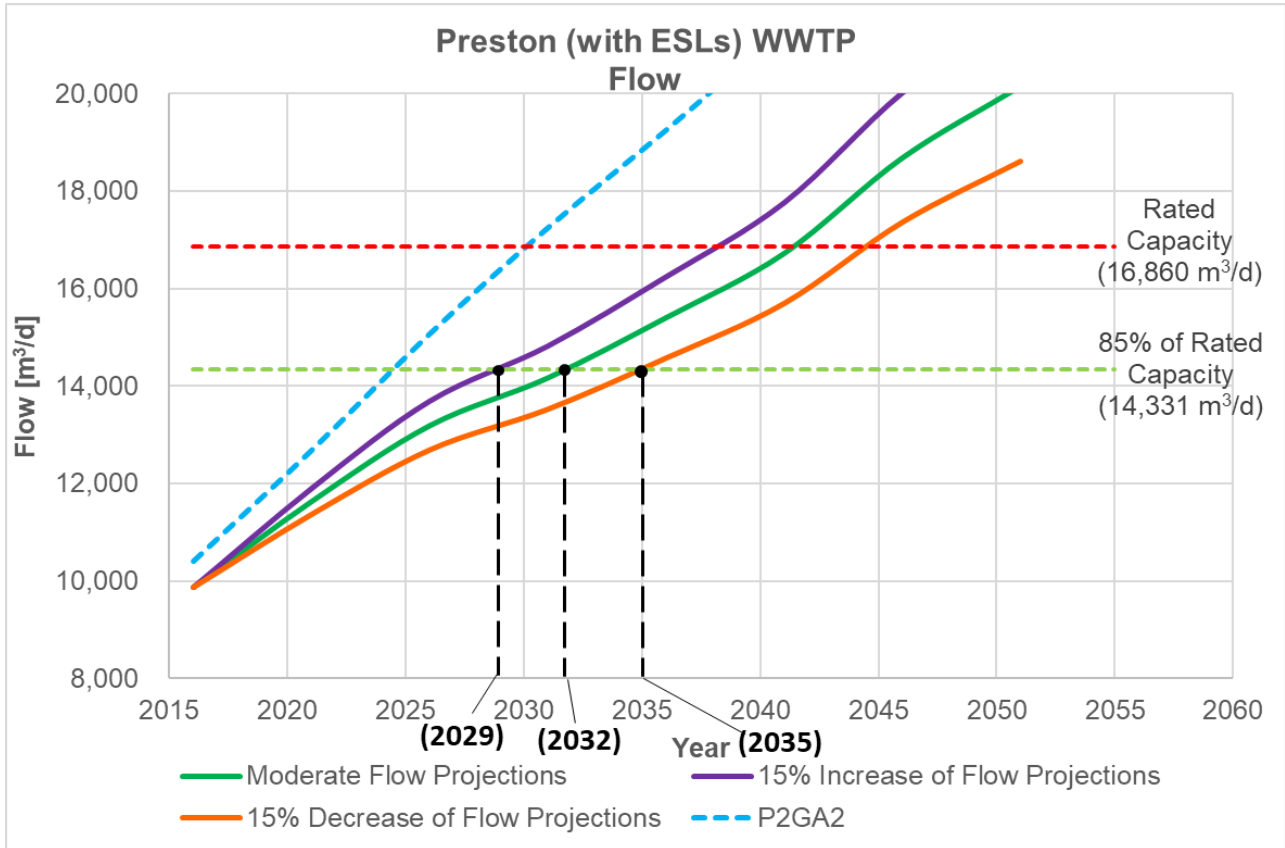


Figure 12 Flow Projections for the Preston WWTP (with ESLs)

3.5 Hespeler WWTP

The Hespeler WWTP is an extended aeration plant that provides treatment for wastewater generated from a portion of the City of Cambridge. The plant has a rated ADF capacity of 9,320 m³/d.

The projected residential service population for the Hespeler WWTP to 2051 is shown in Figure 13.

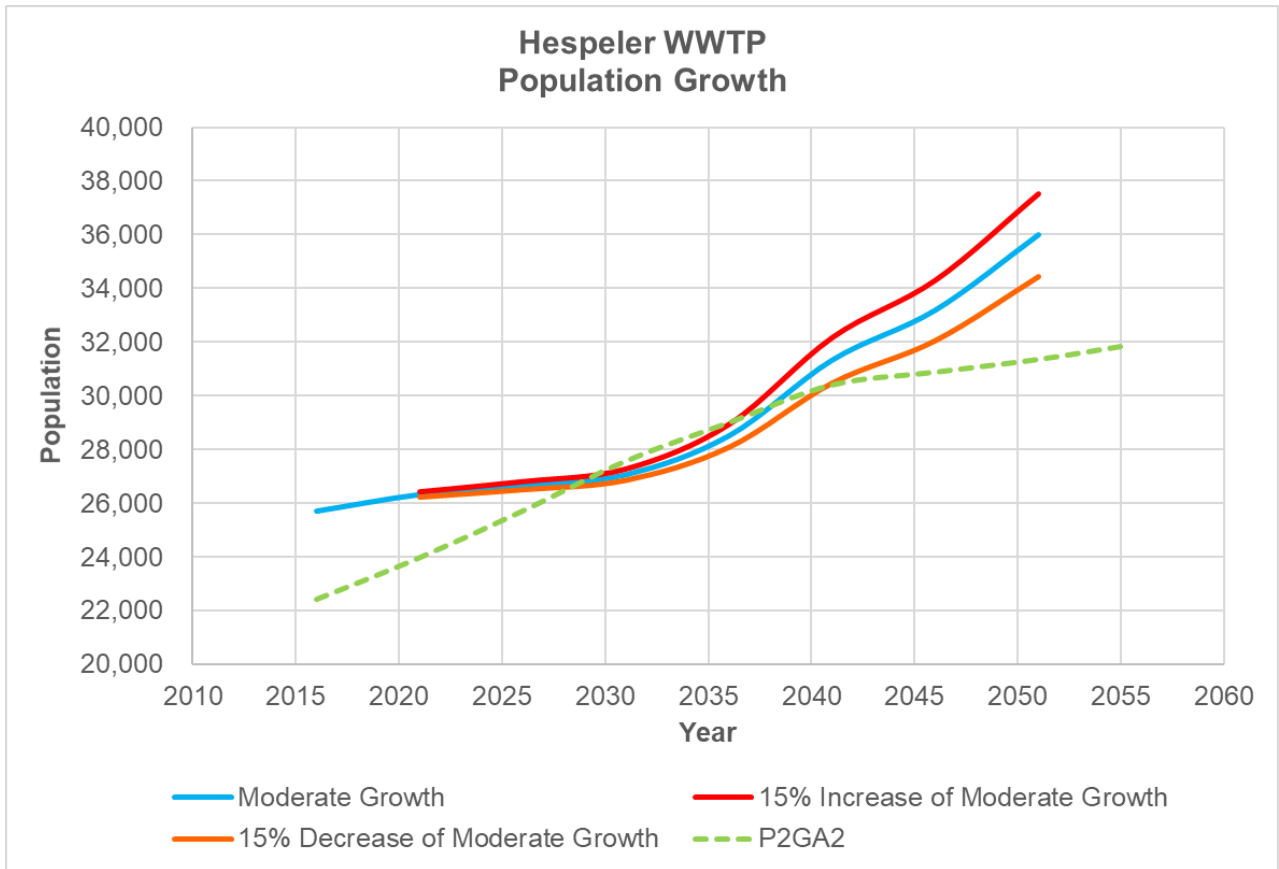


Figure 13 Population Projections for the Hespeler WWTP

The projected ADFs to the Hespeler WWTP to 2051, based on population and an average PCF of 0.275 m³/cap/d derived from the Region’s 2016 WWWWMR, are shown in Figure 14. The higher growth rate, moderate growth, and lower growth rate scenarios reach 85% of the plant rated capacity in 2035, 3036, and 2037, approximately 10 – 13 years earlier than reaching 100% of the rated capacity in 2045, 2047, and 2050, respectively. The projections are similar to those of the P2GA2 growth scenario until 2040 where 85% of the rated capacity will be reached in 2035, but 100% of the rated capacity will not be reached until after 2051. Accordingly, the planning for an expansion for the Hespeler WWTP should begin in the medium-term (approximately 2036) based on the population growth sensitivity scenarios reviewed.

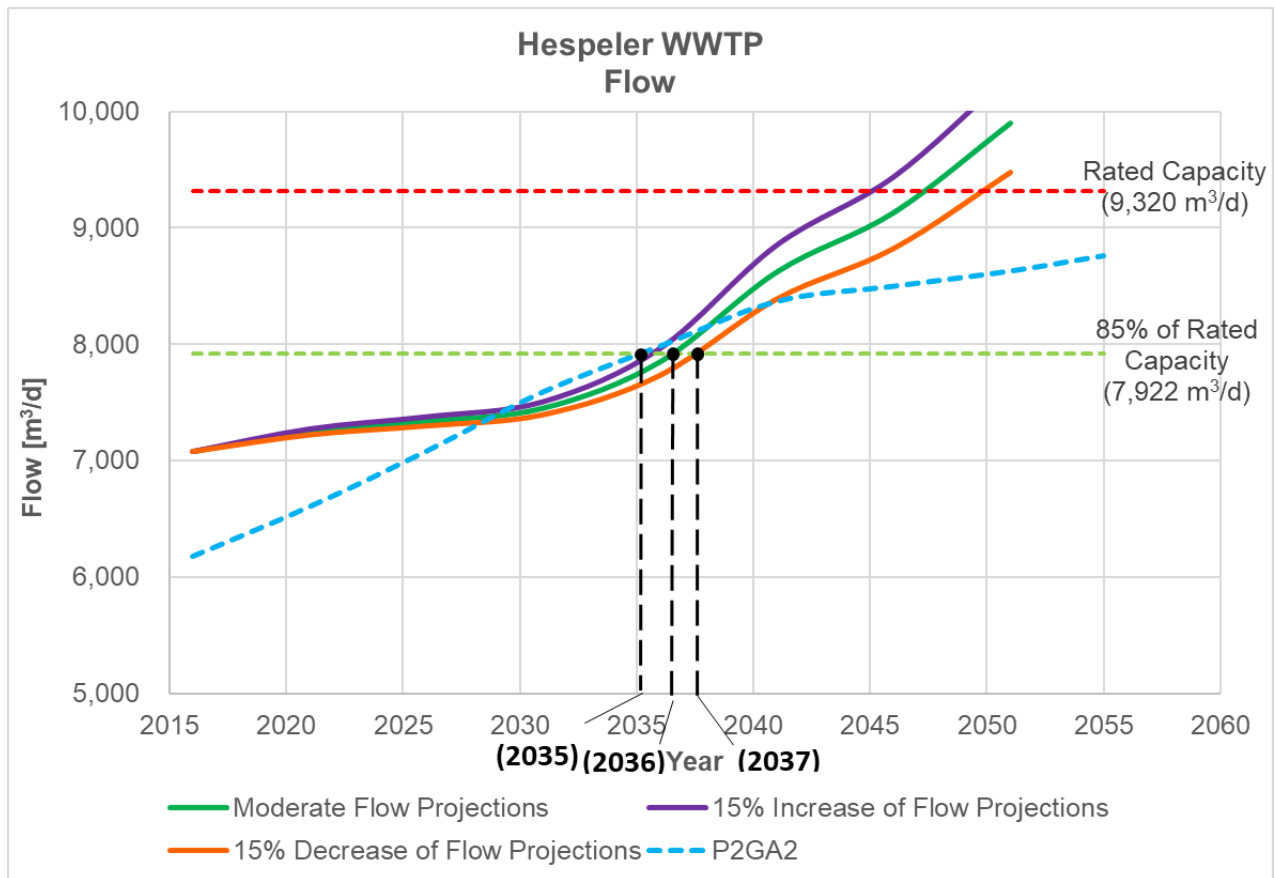


Figure 14 Flow Projections for the Hespeler WWTP

3.6 Ayr WWTP

The Ayr WWTP is an extended aeration package plant that provides treatment for wastewater generated in the Village of Ayr in the Township of North Dumfries. The plant has a rated ADF capacity of 3,000 m³/d.

The projected residential service population for the Ayr WWTP to 2051 is shown in Figure 15.

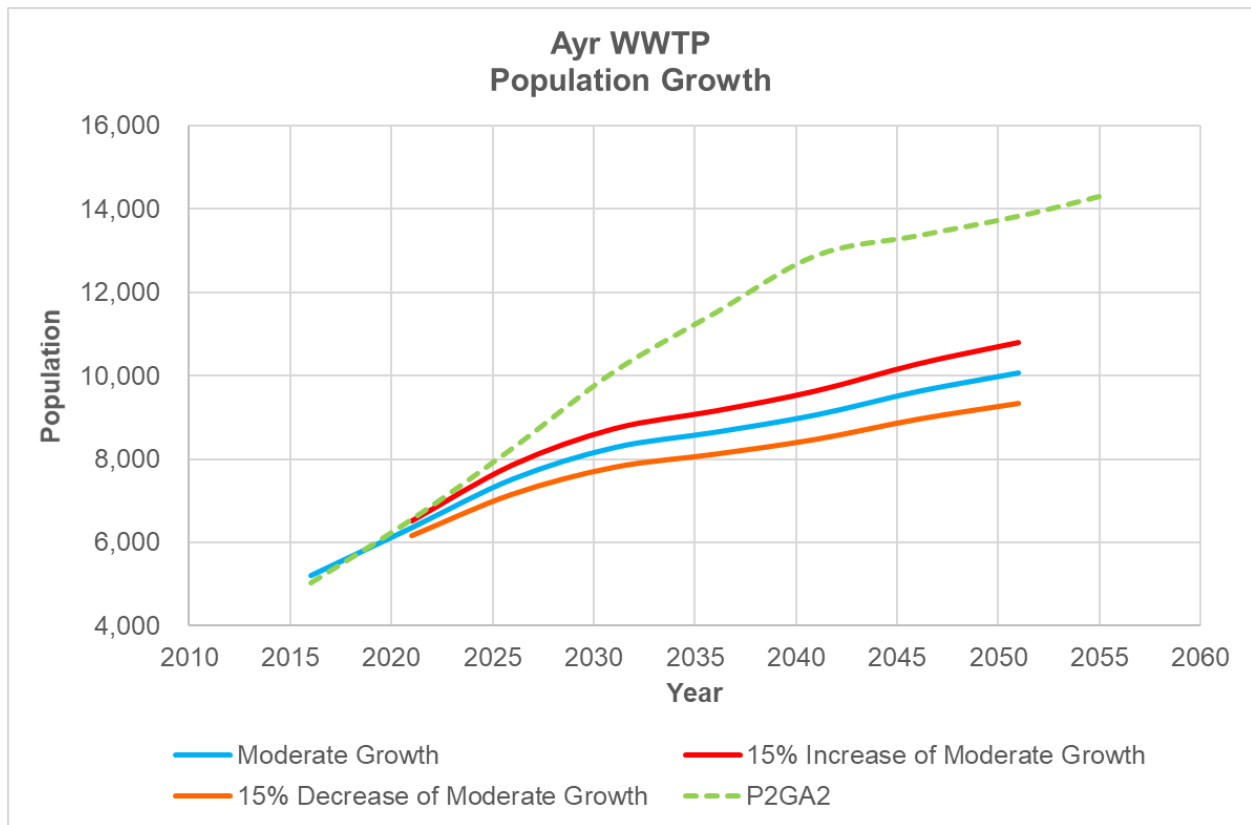


Figure 15 Population Projections for the Ayr WWTP

The projected ADF to the Ayr WWTP to 2051, based on population and an average PCF of 0.274 m³/cap/d derived from the Region’s 2016 WWWWMR, are shown in Figure 16.

Under all scenarios, with the exception of P2GA2, the Ayr WWTP has adequate rated capacity to 2051. Projections for P2GA2 indicate 85% of the rated capacity would be reached in 2029 and 100% of the rated capacity would be reached in 2034. P2GA2 projections were considered aggressive for the Ayr WWTP and it is more appropriate to consider timing sensitivity relative to the high growth scenario (+15%). The high growth scenario will reach 85% capacity in approximately 2037 and the rated capacity beyond 2051. As such, high growth scenario has minimal impact to the recommended capital timing other than potentially initiating a Schedule C Class EA for the expansion slightly sooner. However, this is still beyond the timing of the next WWTMP Update (typically updated every 5 to 10 years), which will provide an opportunity to review and update the growth projections.

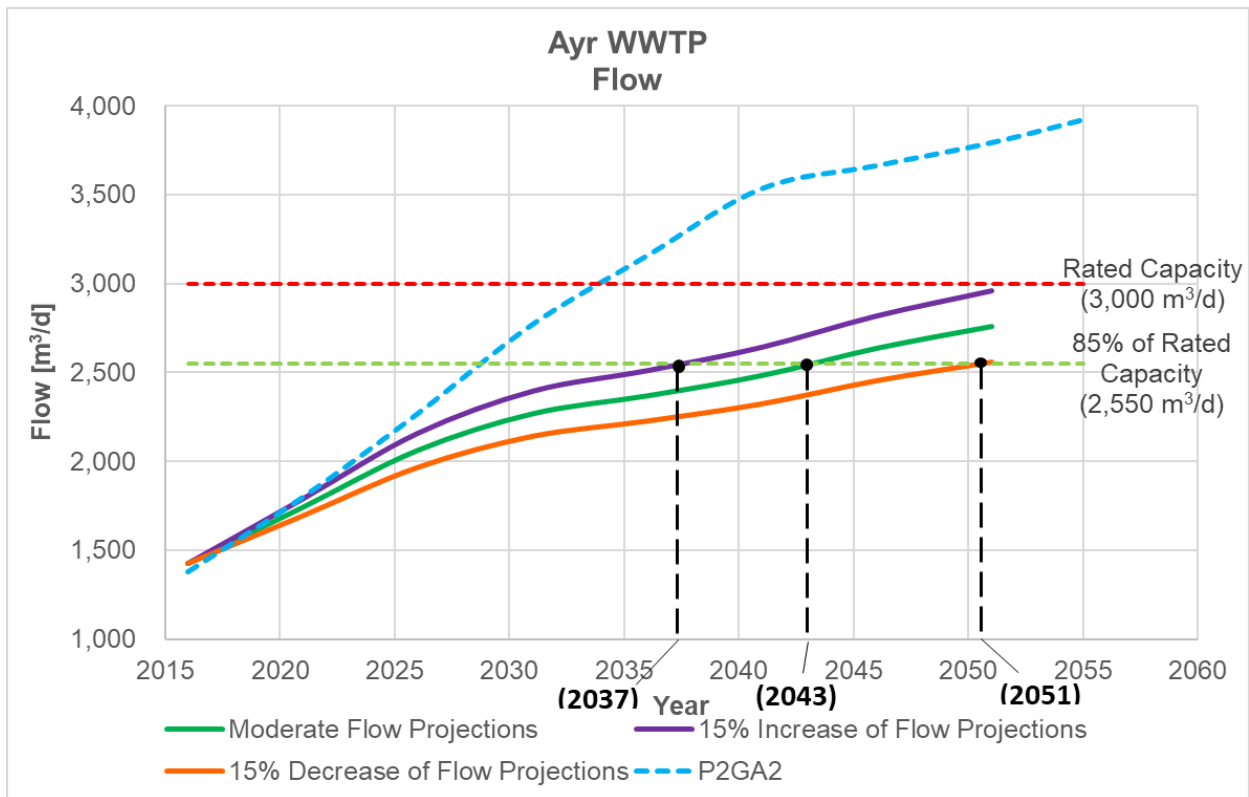


Figure 16 Flow Projections for the Ayr WWTP

3.7 New Hamburg WWTP

The New Hamburg WWTP is a sequencing batch reactor (SBR) activated sludge facility that provides treatment for wastewater generated in the communities of Baden and New Hamburg in the Township of Wilmot. Currently, the Region is completing detailed design for the Phase 2 expansion, which will increase the existing rated capacity from 5,200 m³/d to 6,900 m³/d. For the purpose of this Master Plan Update, plant capacity is based on the Phase 2 upgraded plant, as these upgrades will be constructed within the next 3 years.

The projected residential service population for the New Hamburg WWTP to 2051 is shown in Figure 17.

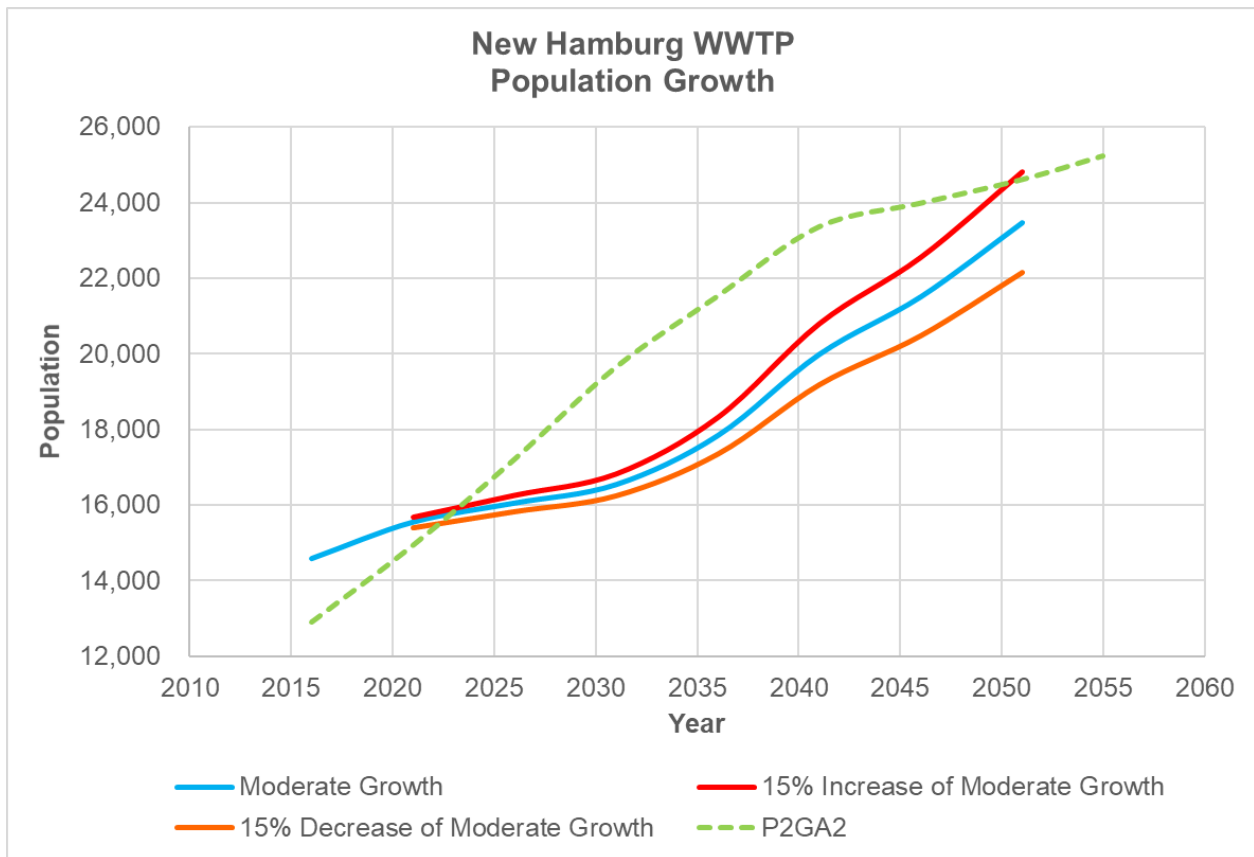


Figure 17 Population Projections for the New Hamburg WWTP

The projected ADFs to the New Hamburg WWTP to 2051, based on population and an average PCF of 0.293 m³/cap/d derived from the Region’s 2016 WWWMR, are shown in Figure 18.

The P2GA2 growth scenario will reach 85% of the plant rated capacity in 2032 and 100% of the capacity in 2043. P2GA2 projections were considered aggressive for the New Hamburg WWTP and it is more appropriate to consider timing sensitivity relative to the high growth scenario (+15%). The high growth scenario will reach the plant rated capacity very close to 2051, with 85% of the capacity being reached 2 years sooner (2039) than the moderate growth scenario. The moderate and lower growth scenarios will not reach 100% of the plant rated capacity until after 2051. Accordingly, with the exception of the P2GA2 growth scenario, the population sensitivity shows minimal impact to the recommended capital timing other than potentially initiating a Schedule C Class EA for the expansion slightly sooner. However, this is beyond the

timing of the next WWTMP Update (typically updated every 5 to 10 years), which will provide an opportunity to review and update the growth projections.

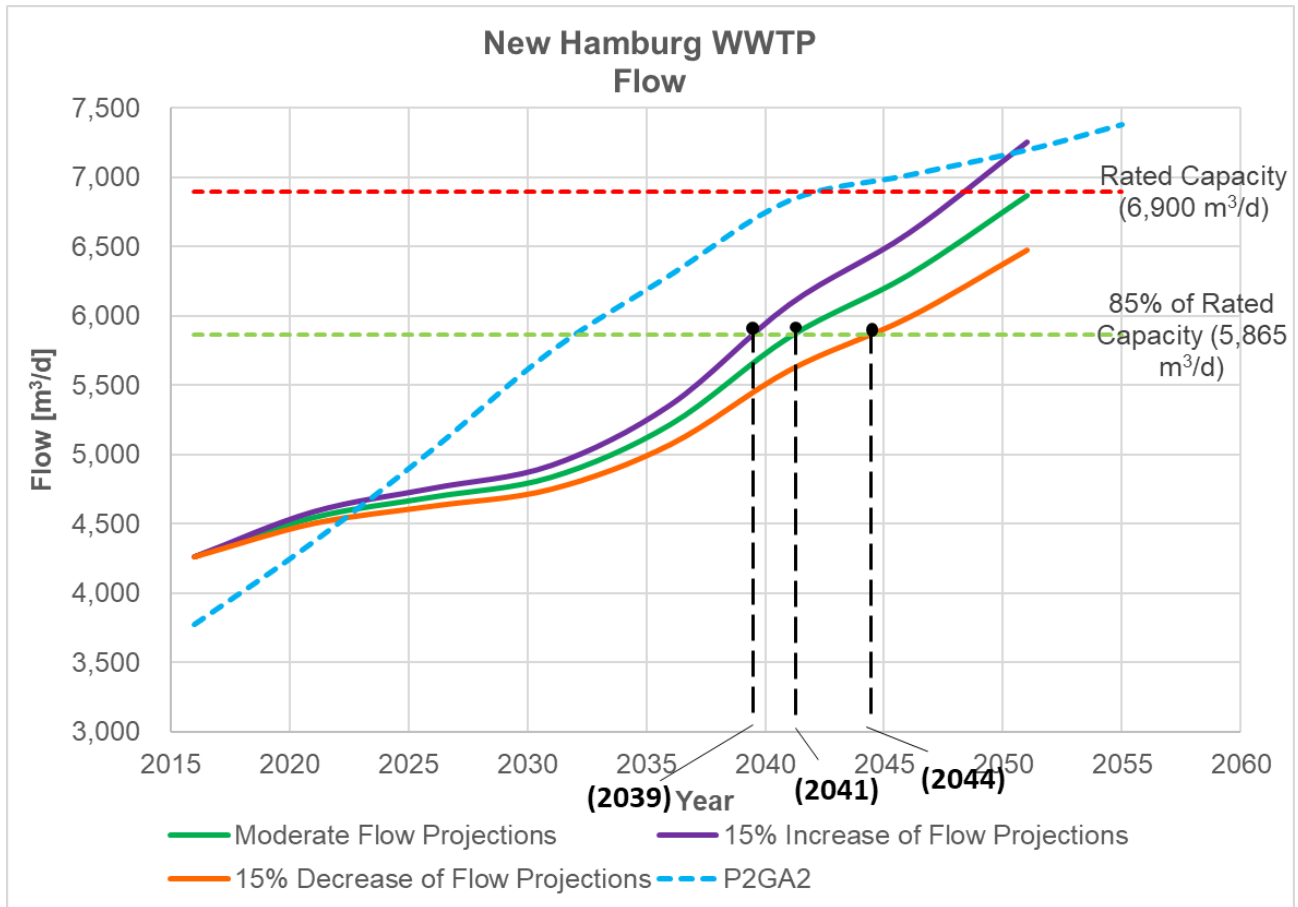


Figure 18 Flow Projections for the New Hamburg WWTP

3.8 Wellesley WWTP

The Wellesley WWTP is an extended aeration package plant that provides treatment for wastewater generated in the Township of Wellesley. The plant has a rated ADF capacity of 1,100 m³/d.

The projected residential service population for the Wellesley WWTP to 2051 is shown in Figure 19.

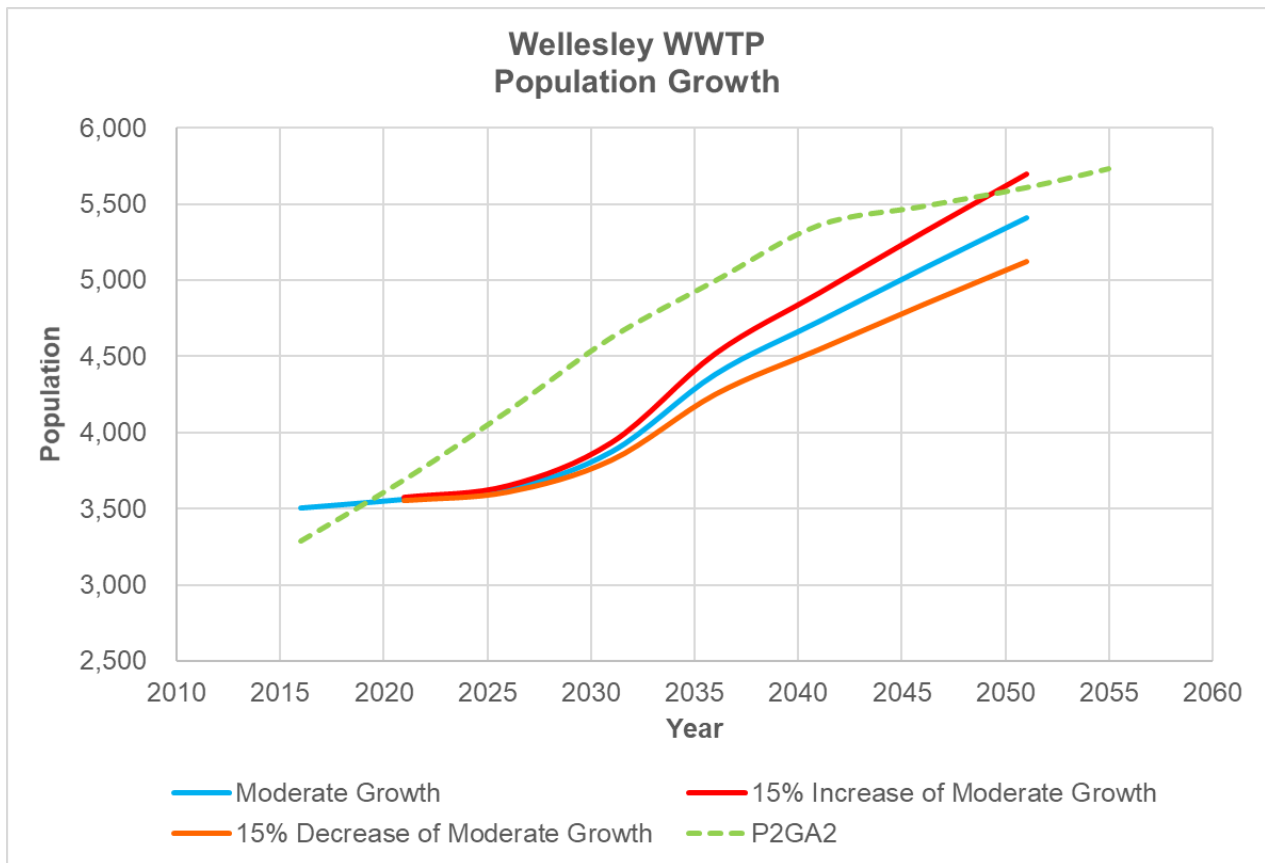


Figure 19 Population Projections for the Wellesley WWTP

The projected ADF the Wellesley WWTP to 2051, based on population and an average PCF of 0.233 m³/cap/d derived from the Region’s 2016 WWWMR, are shown in Figure 20. The P2GA2 growth scenario will reach 85% of the rated capacity in 2024 and 100% of the rated capacity in 2032. P2GA2 projections were considered aggressive for the Wellesley WWTP and it is more appropriate to consider timing sensitivity relative to the high growth scenario (+15%). The high growth scenario has negligible impact on the overall timing to reach 85% of the plant rated capacity (approximately 2032 for both the moderate and high growth scenarios). The high, moderate and low growth rate scenarios will reach 100% of the capacity in 2038, 2041, and 2044, respectively, approximately 6 – 11 years later. Based on the population growth sensitivity scenarios reviewed, initiating the planning in the medium term (approximately 2032) for an expansion of the Wellesley WWTP was considered appropriate.

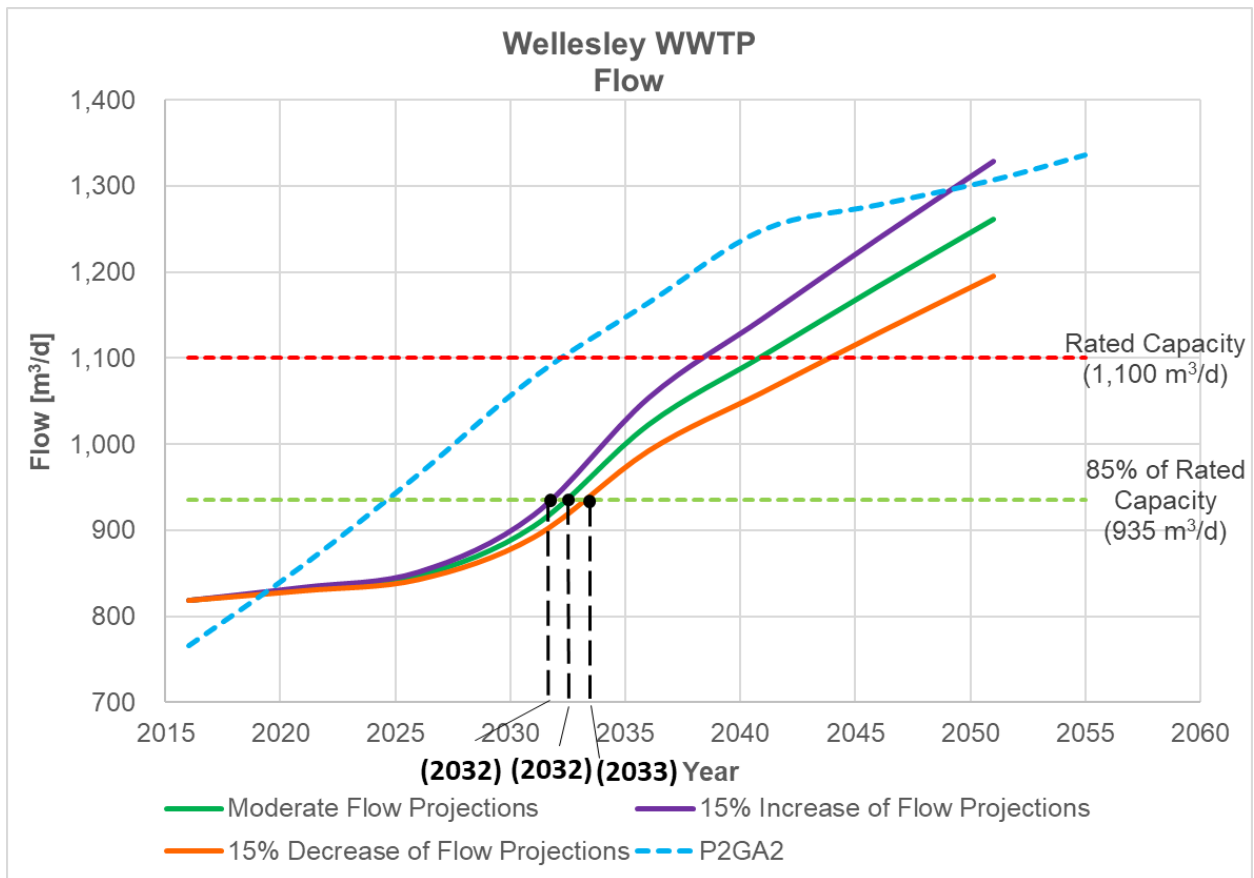


Figure 20 Flow Projections for the Wellesley WWTP

3.9 St Jacobs WWTP

The St Jacobs WWTP is an oxidation ditch extended aeration plant that provides treatment for wastewater generated in the Town of St Jacobs located in the Township of Woolwich. The St Jacobs WWTP has a rated ADF capacity of 1,450 m³/d.

The projected residential service population for the St Jacobs WWTP to 2051 is shown in Figure 21.

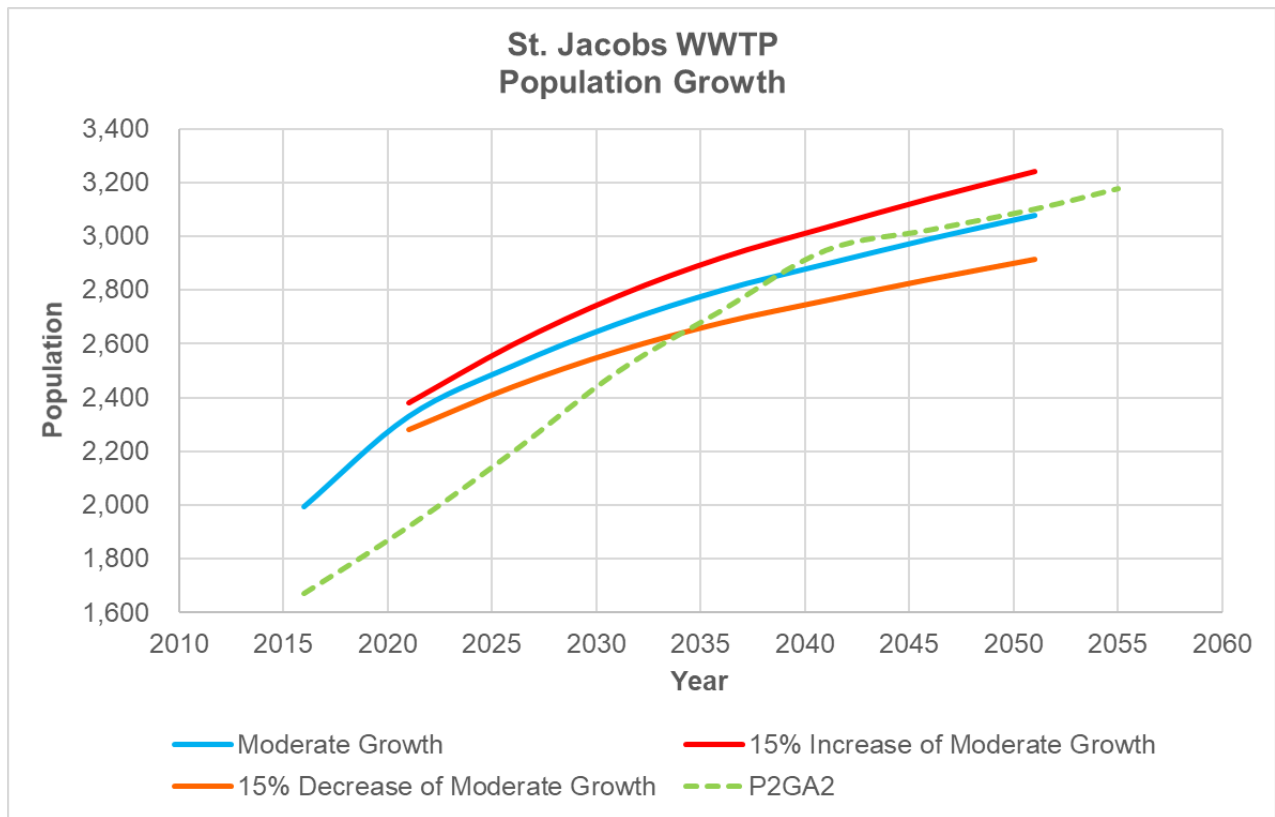


Figure 21 Population Projections for the St Jacobs WWTP

The projected ADF to the St Jacobs WWTP to 2051, based on population and an average PCF of 0.497 m³/cap/d derived from the Region’s 2016 WWWMR, are shown in Figure 22. The higher PCF is attributed to the historical I/I issues within the service area.

The high growth scenario causes the plant to exceed the rated capacity in approximately 2036 compared to approximately 2042 with the moderate growth scenario. The timing for reaching the trigger of 85% of the rated capacity is only influenced by approximately 2 years compared to the moderate growth scenario (2025 versus 2023). For P2GA2, the projections are lower than the moderate growth scenario until approximately 2038, after which they remain between the moderate and higher growth scenarios. P2GA2 projections indicate 85% of the plant rated capacity will be reached in 2031 and 100% of the rated capacity will be reached in 2040.

Based on the population growth sensitivity scenarios reviewed, the planning for an expansion for the St Jacobs WWTP should begin in the short-term (approximately 2025).

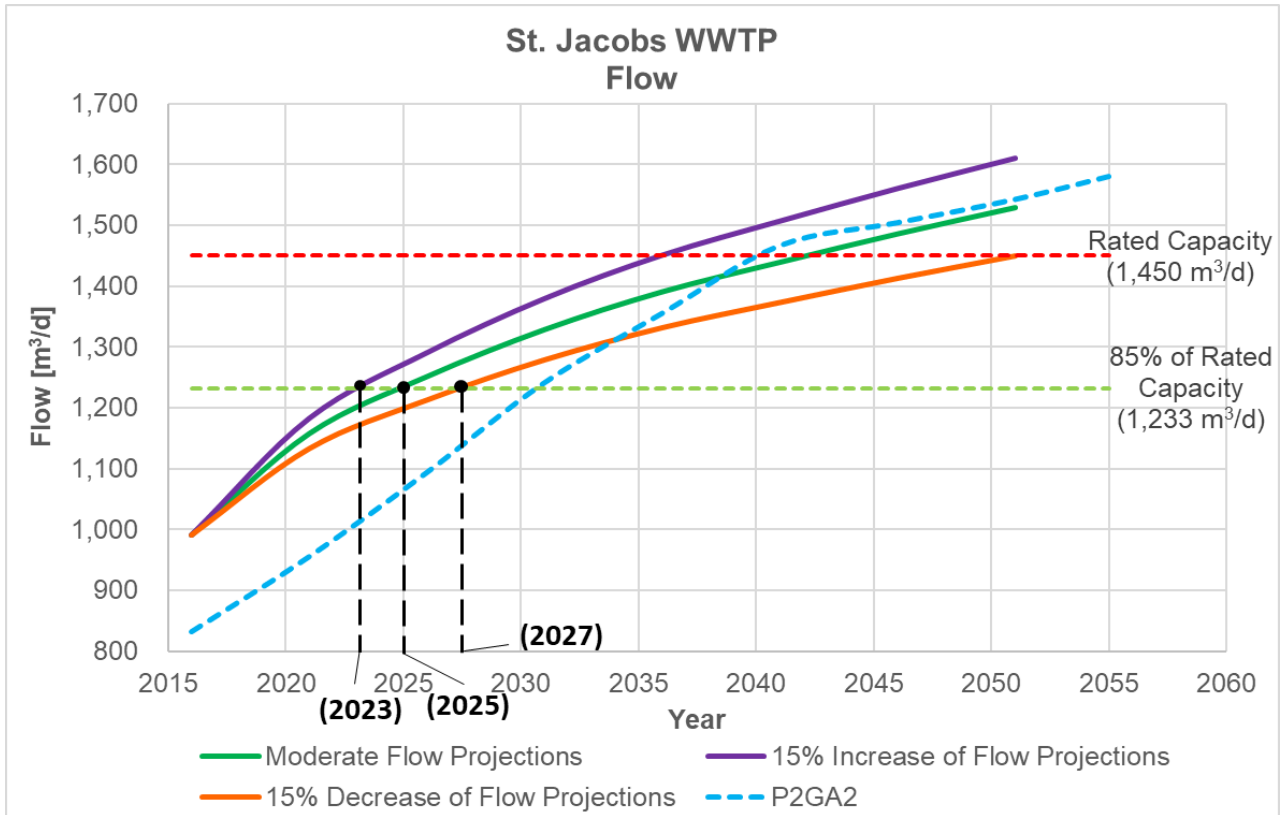


Figure 22 Flow Projections for the St Jacobs WWTP

3.10 Elmira WWTP

The Elmira WWTP is a biological nutrient removal (BNR) plant that provides treatment for wastewater generated in the Town of Elmira located in the Township of Woolwich. The Elmira WWTP has a rated ADF capacity of 7,800 m³/d.

The projected residential service population for the Elmira WWTP to 2051 is shown in Figure 23.

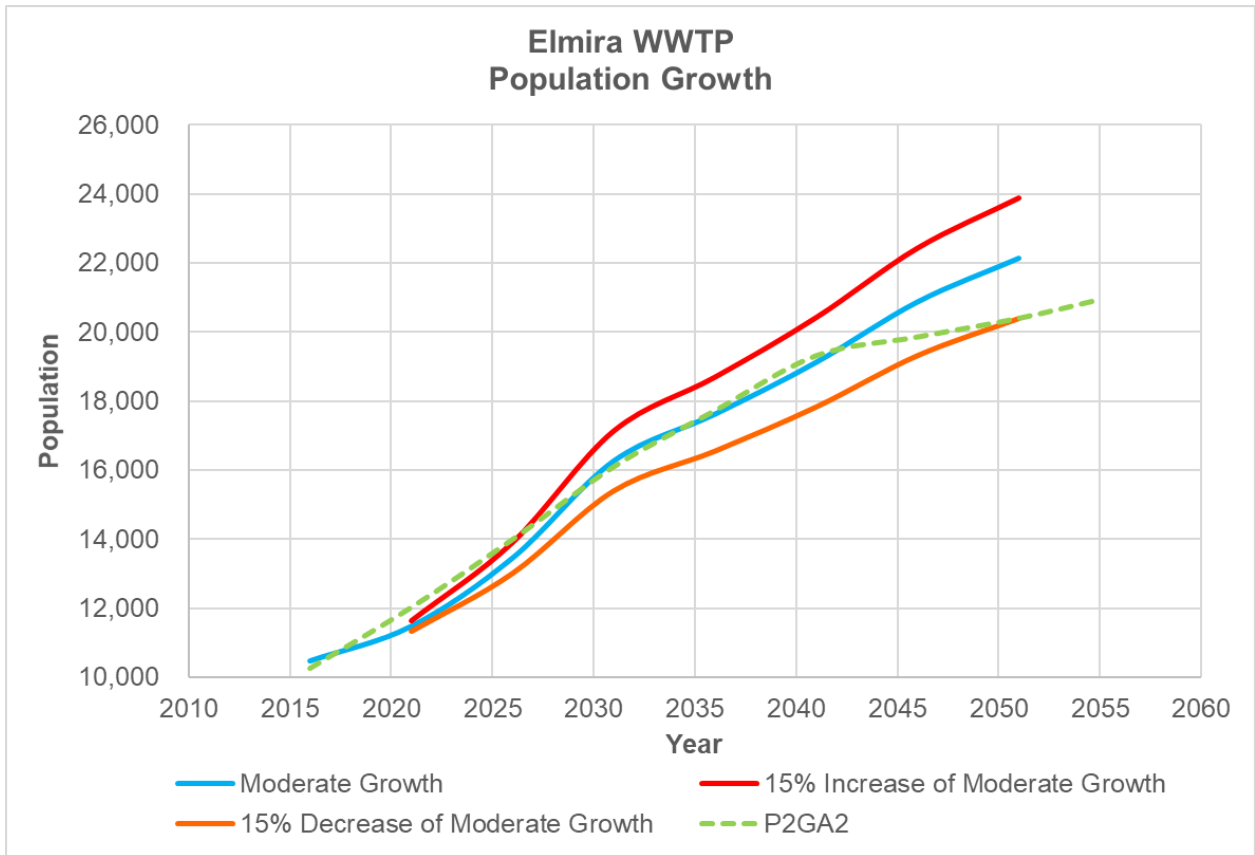


Figure 23 Population Projections for the Elmira WWTP

The projected ADF to the Elmira WWTP to 2051, based on population and an average PCF of 0.427 m³/cap/d derived from the Region’s 2016 WWMR, are shown in Figure 24. The higher average PCF is attributed to additional contribution from industrial areas and historical I/I issues within the service area.

The high growth scenario causes the plant to exceed the rated capacity in approximately 2034, compared to approximately 2038 for the moderate growth scenario. The timing for reaching the trigger of 85% of the rated capacity is only influenced by approximately 2 years compared to the moderate growth scenario (2028 versus 2030). P2GA2 projections are similar to the moderate growth scenario until approximately 2043. After 2043, the rate of increase for the P2GA2 scenario decreases and the projected flows are more aligned with the lower population growth scenario. Based on the population growth sensitivity scenarios reviewed, the planning for an expansion for the Elmira WWTP should begin in the medium-term (approximately 2030).

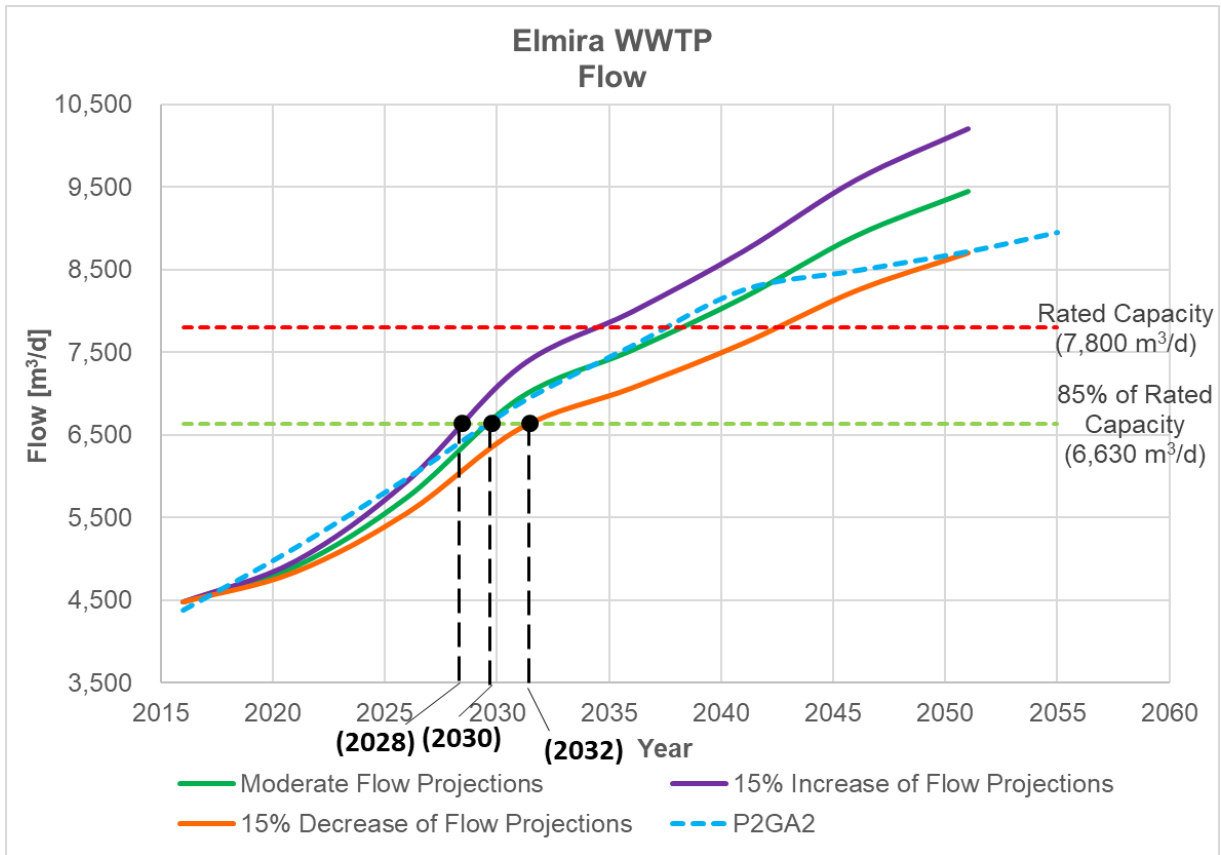


Figure 24 Flow Projections for the Elmira WWTP

4. Per Capita Flow Sensitivity

Per capita sensitivity was completed for plants that require expansion within the 2051 timeframe based on the moderate growth scenario including:

- + Waterloo WWTP
- + Hespeler WWTP
- + Wellesley WWTP
- + St Jacobs WWTP
- + Elmira WWTP

4.1 Waterloo WWTP

Figure 25 and Figure 26 summarize the PCF sensitivity for the Waterloo WWTP. Based on the moderate growth scenario, Waterloo WWTP will reach 85% of the rated capacity in 2020. Similar to the high growth scenario (refer to Section 3.2, Figure 6), higher PCF flow projection only accelerates the moderate growth timeline, as shown in. As the planning for an expansion to the Waterloo WWTP is already triggered in the short-term based on the moderate growth forecast, consideration of the higher PCF does not impact the recommended next steps.

Lower PCF flow projections may defer expansion timing in terms of the plant rated capacity; however, upgrades may still be required to address capacity limitations in key unit processes (e.g., loading limited processes).

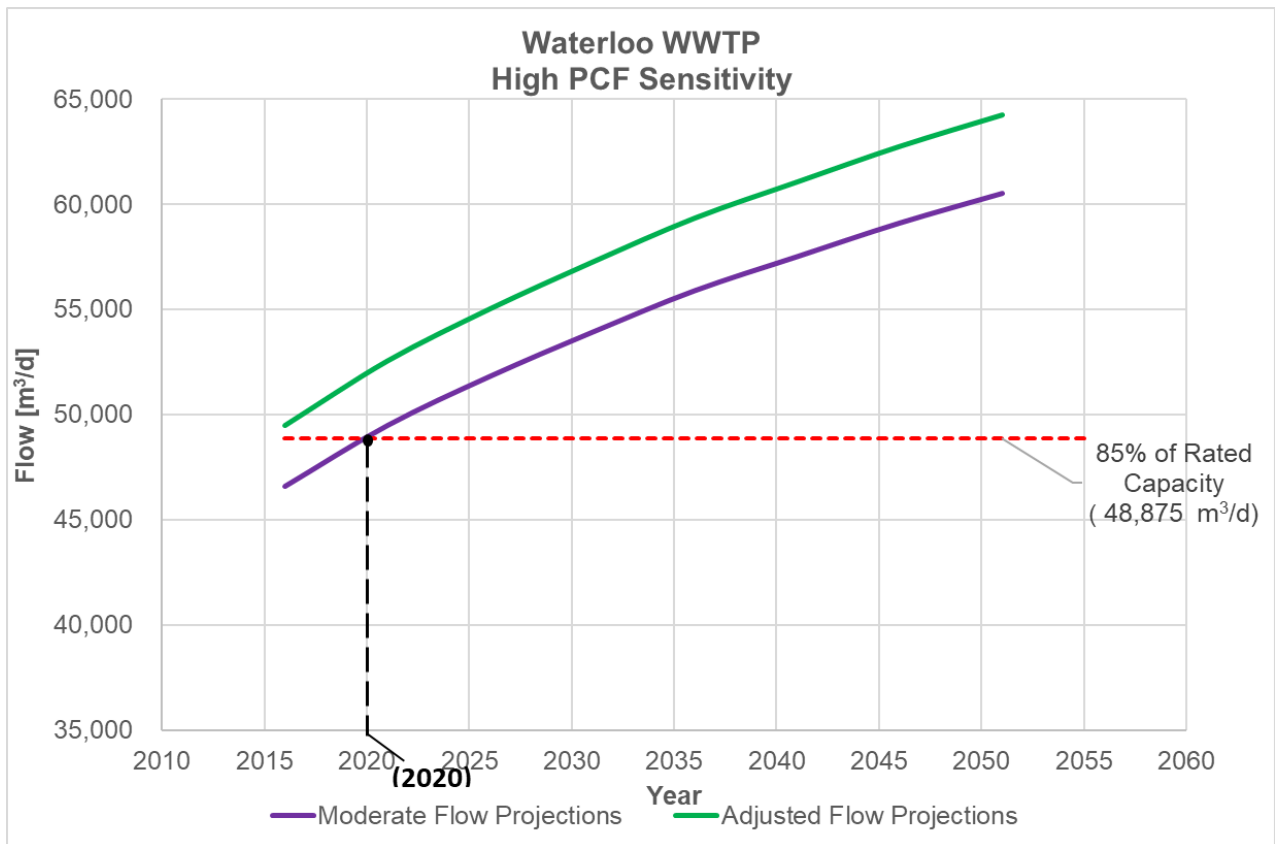


Figure 25 High PCF Projections (Adjusted Flow) for the Waterloo WWTP

The loading limited process at the plant is the aeration tanks. As discussed in Section 2.2, when considering changes to per capita flows, the overall loadings of key wastewater constituents (e.g., BOD₅, TSS, etc.) will remain unchanged since loadings are directly proportional to population. Overall, higher PCFs will result in a more dilute, lower concentration wastewater influent, while lower PCFs will result in a more concentrated wastewater influent. As a result, for the WWTPs where the capacity limiting processes are governed by loadings rather than hydraulic throughput (e.g. aeration tankage, oxygenation system, secondary clarifier SLR, and digestion), there would be no impact on timing of major works based on per capita flow sensitivity. The timing for aeration tank expansion planning at the Waterloo WWTP is the same for the high, moderate and low PCF scenarios, as illustrated below (using the lower PCFs scenario as an example):

- ✦ At moderate PCFs, the aeration tank capacity is limited to 11,610 kg/d BOD₅ (i.e. historic BOD₅ concentration of 200 mg/L x aeration tank equivalent ADF capacity)

of 58,050 m³/d), which is equivalent to a flow capacity of 58,050 m³/d (refer to Tech Memo No. 2 – Existing Conditions). The plant would reach 85% of this capacity in 2021.

- ✦ At lower PCFs, the BOD₅ loading to the aeration tanks remains unchanged at 11,610 kg/d. However, due to the concentrating effects of a 15% reduction in PCF, the aeration tank capacity is reduced by 15% (i.e. 0.85 x 58,050 m³/d) which is equivalent to a flow capacity of 49,340 m³/d. Overall, the plant would still reach 85% of this capacity in 2021, as shown in Figure 26.

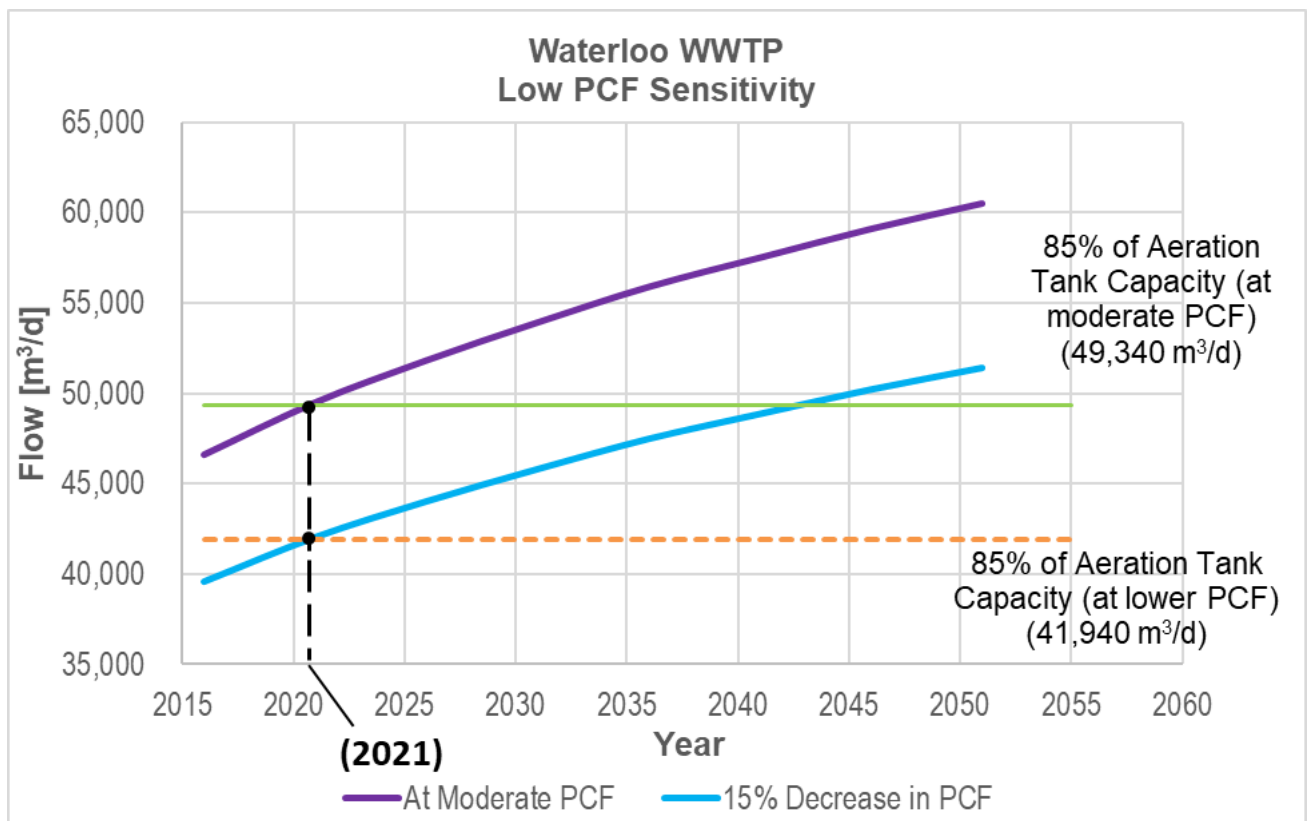


Figure 26 Low PCF Projections for the Waterloo WWTP

Overall, changes of PCFs have minimal impact to the expansion planning timelines (2021 versus 2020) in terms of the aeration tank capacity at the Waterloo WWTP, compared to the expansion timelines in terms of the plant rated capacity under the baseline moderate growth scenario (refer to Section 3.2, Figure 6).

4.2 Hespeler WWTP

The PCF sensitivity to expansion or upgrades at the Hespeler WWTP is summarized in Figure 27 and Figure 28. The adjusted flow and the moderate flow projection for the Hespeler WWTP are very similar, as shown in Figure 27. It can also be noted that the adjusted flow projections are similar to the high growth scenario (refer to Section 3.5, Figure 14), with 85% of the plant rated capacity being reached in 2036 versus 2035.

Lower PCF projections may defer expansion timing in terms of the plant rated capacity; however, upgrades may still be required to address capacity limitations in key unit processes (e.g., loading limited processes).

Following the ongoing upgrades at the Hespeler WWTP, the capacity limiting process will be aeration tankage for nitrification. As a result, as discussed in Section 4.1, there would be no impact on timing of major works in terms of aeration tank capacity based on per capita flow sensitivity, as illustrated below (using the lower PCFs scenario as an example):

- + At moderate growth PCFs, the aeration tank capacity is limited to 1,430 kg/d BOD₅ (i.e. historic BOD₅ concentration of 150 mg/L BOD₅ x aeration tank equivalent ADF capacity of 9,540 m³/d), which is equivalent to a flow capacity of 9,540 m³/d (refer to Tech Memo No. 2 – Existing Conditions). The plant would reach 85% of this capacity in 2038.
- + At lower PCFs, the BOD₅ loading capacity of the aeration tanks remains unchanged at 1,430 kg/d. However, due to the concentrating effects of a 15% reduction in PCFs, the aeration tank capacity is reduced by 15% (i.e. 0.85 x 9,540 m³/d) which is equivalent to a flow capacity of 8,110 m³/d. Overall, the plant would still reach 85% of this capacity in 2038, as shown in Figure 28.

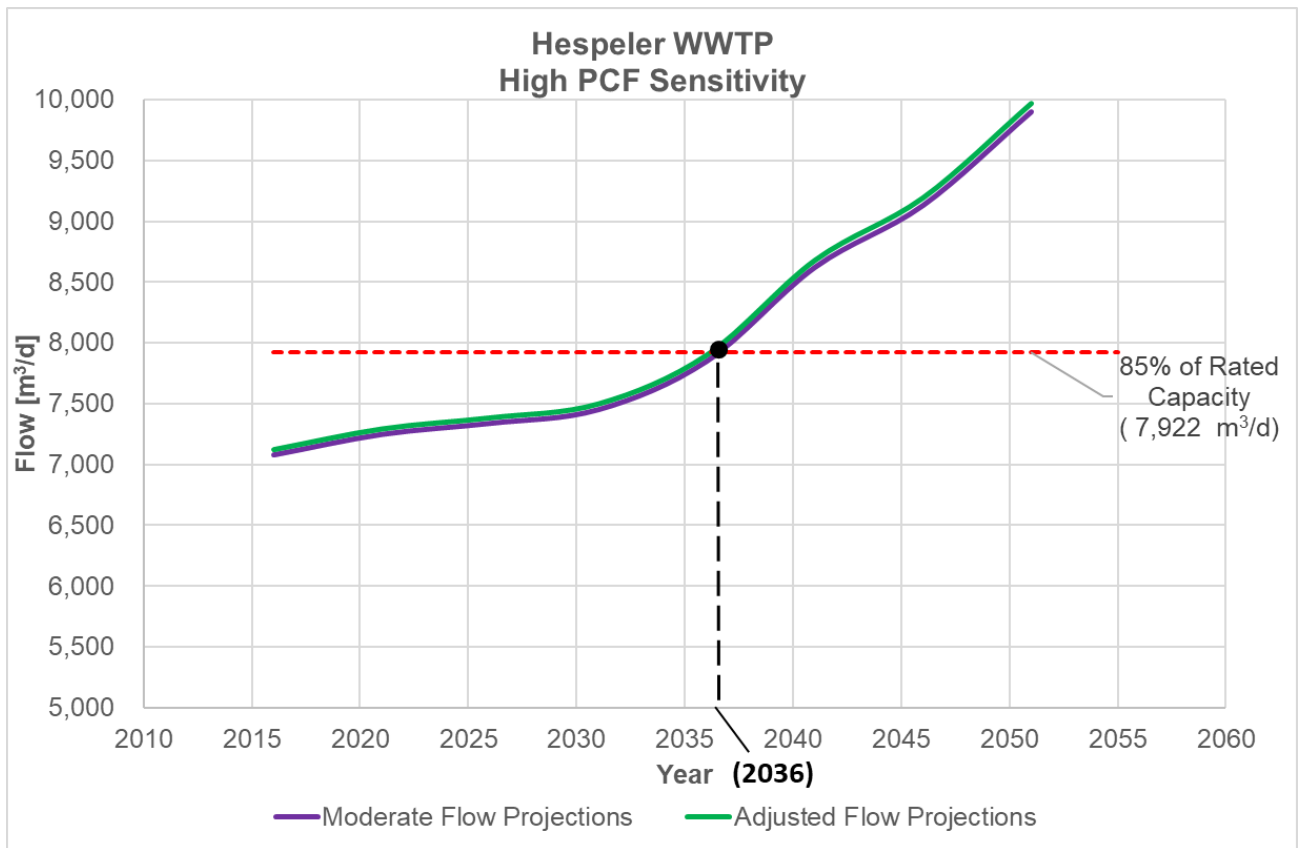


Figure 27 High PCF Projections (Adjusted Flow) for the Hespeler WWTP

Overall, changes of PCFs have minimal impact to the expansion planning timelines (2038 versus 2036) in terms of the aeration tank capacity at the Hespeler WWTP, compared to the expansion planning timelines in terms of the plant rated capacity under the baseline moderate growth scenario (refer to Section 3.5, Figure 14).

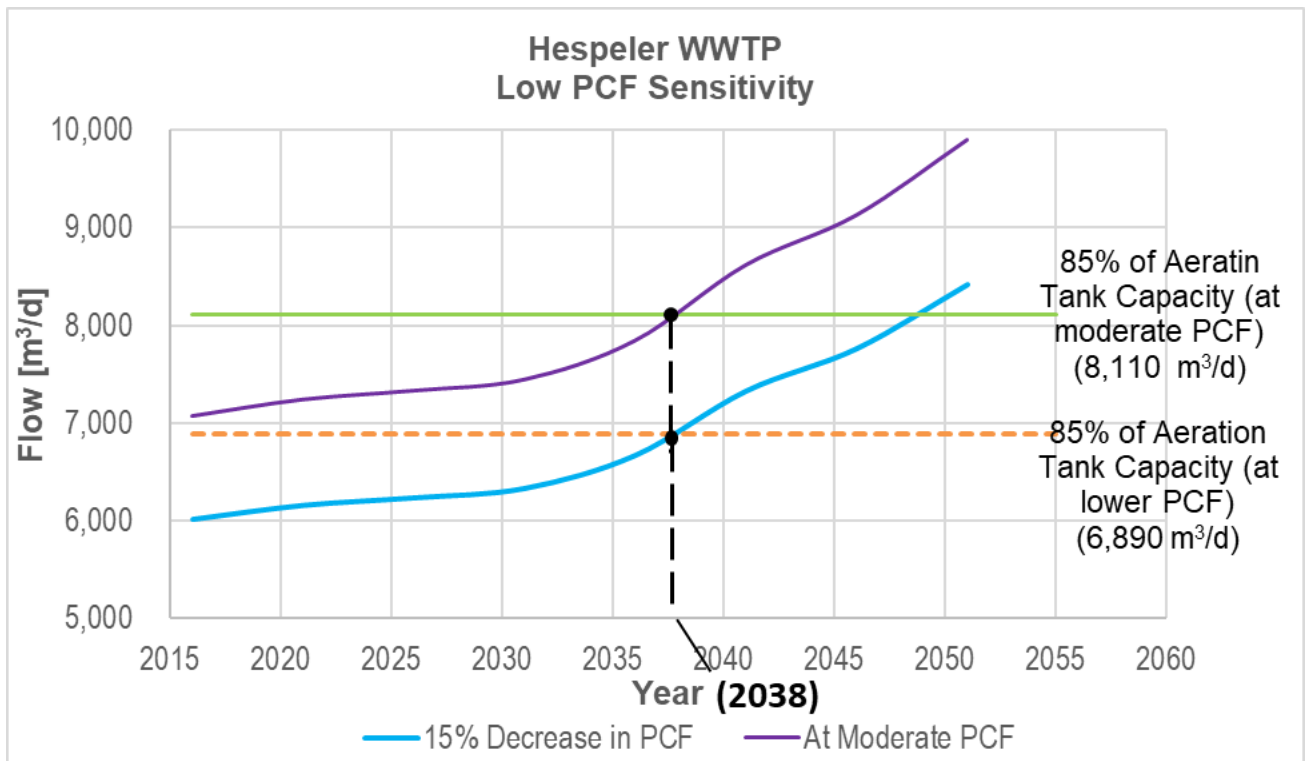


Figure 28 Low PCF Projections for the Hespeler WWTP

4.3 Wellesley WWTP

The PCF sensitivity to expansion or upgrades at the Wellesley WWTP is summarized in Figure 29 and Figure 30. Adjusted flows shift timing for expansion planning forward by approximately 5 years compared to the moderate flow scenario (2027 versus 2032), as shown in Figure 29. The adjusted flow scenario indicates a larger impact on the timing for expansion planning than the high growth scenario (refer to Section 3.8, Figure 20), which showed the 85% capacity being reached at the same time as the moderate growth scenario (2032).

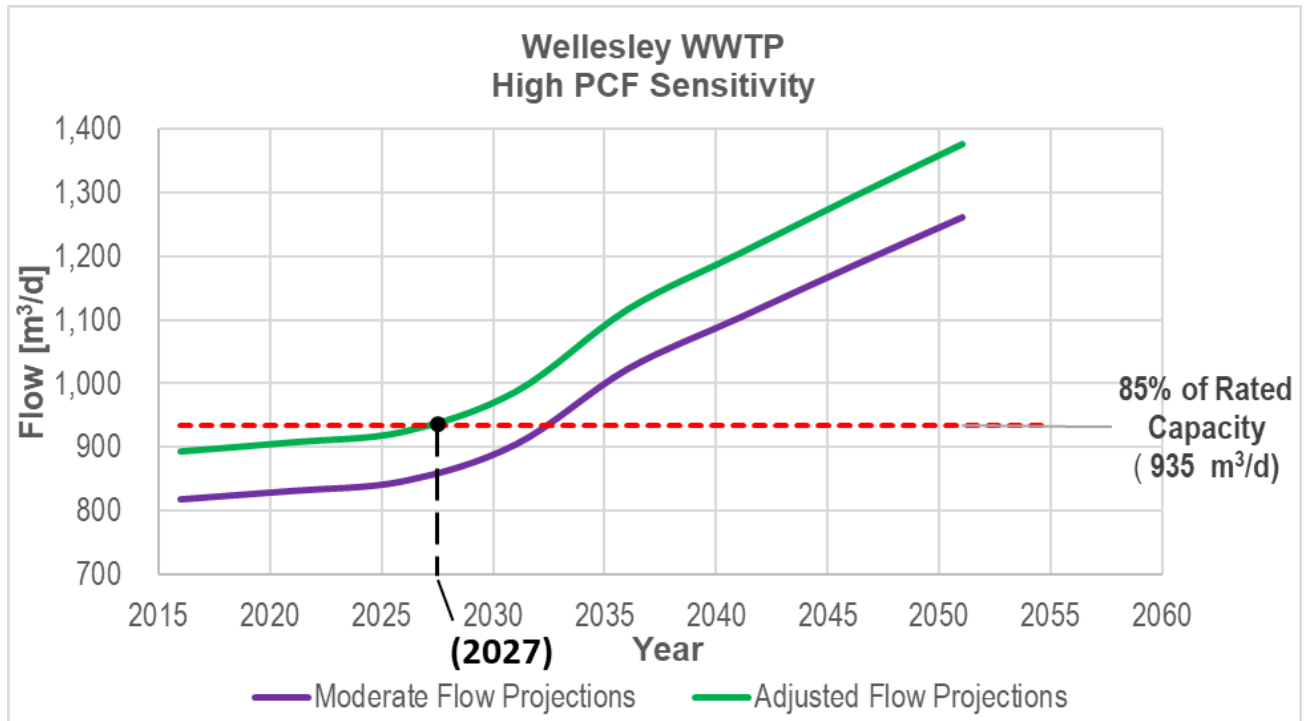


Figure 29 High PCF Projections (Adjusted Flow) for the Wellesley WWTP

The capacity limiting process at the Wellesley WWTP is secondary clarifier SOR, which are positively impacted by lower PCF projections. Lower PCFs flow projections may defer expansion timing in terms of the plant rated capacity; however, upgrades may still be required to address capacity limitations in loading limited processes.

The loading limited process at the plant is the aeration tanks. As a result, as discussed in Section 4.1, there would be no impact on timing of major works in terms of aeration tank capacity based on per capita flow sensitivity, as illustrated below (using the lower PCFs scenario as an example):

- + At moderate PCFs, the aeration tank capacity is limited to 180 kg/d BOD₅ (i.e. historic BOD₅ concentration of 160 mg/L x aeration tank equivalent ADF capacity 1,130 m³/d), which is equivalent to a flow capacity of 1,130 m³/d (refer to Tech Memo No. 2 – Existing Conditions). The plant would reach 85% of this capacity in 2033.
- + At lower PCFs, the BOD₅ loading capacity of the aeration tanks remains unchanged at 180 kg/d. However, due to the concentrating effects of a 15% reduction in PCFs, the aeration tank capacity is reduced by 15% (i.e. 0.85 x 1,130

m³/d) which is equivalent to a flow capacity of 960 m³/d. The plant would still reach 85% of this capacity in 2033, as shown in Figure 30.

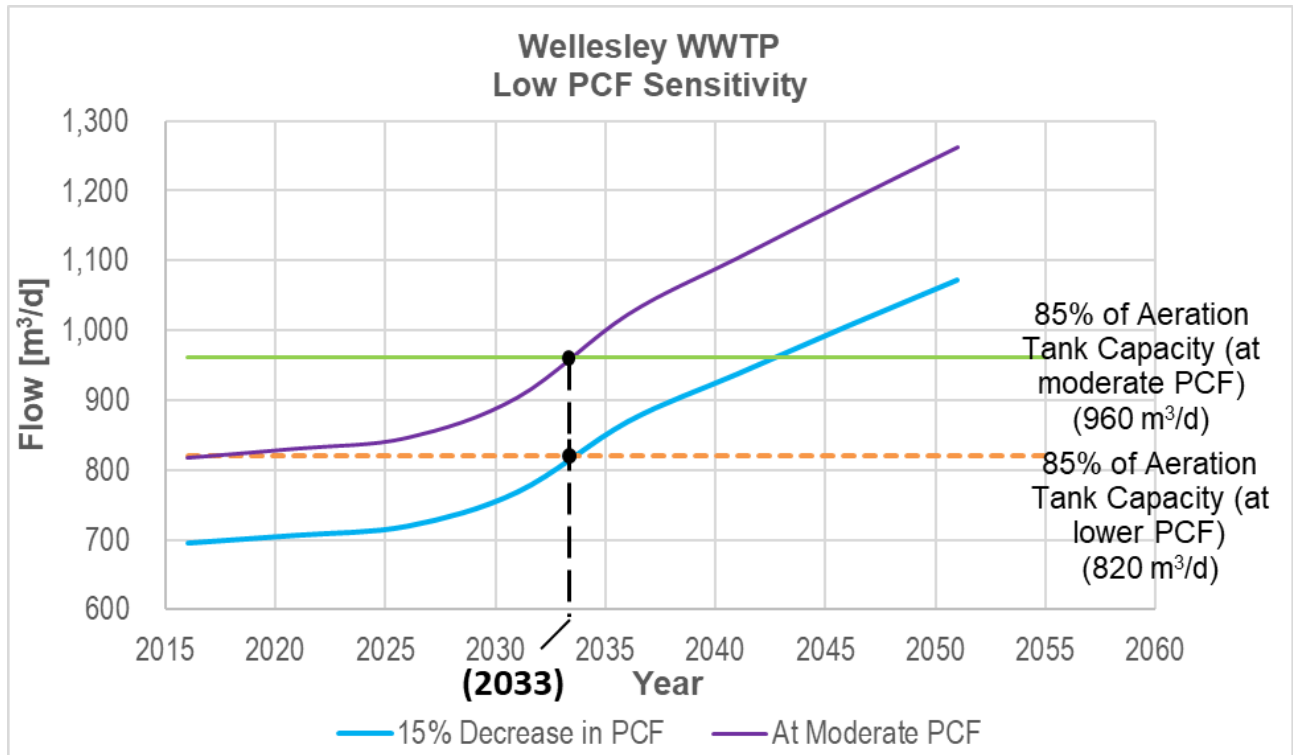


Figure 30 Low PCF Projections for the Wellesley WWTP

As a result, the changes of PCFs result in a similar expansion planning timeline (2033 versus 2032) in terms of the aeration tank capacity, compared to the expansion planning timeline in terms of the plant rated capacity under the baseline moderate growth scenario (refer to Section 3.8, Figure 20).

4.4 St Jacobs WWTP

The PCF sensitivity to expansion or upgrades at the St Jacobs WWTP is summarized in Figure 31 and Figure 32. Adjusted flows move the expansion planning timing for the St Jacobs WWTP forward by approximately 4 years to 2021, as shown in Figure 31. The adjusted flow scenario indicates a larger impact on the timing for expansion planning than the high growth scenario (refer to Section 3.9, Figure 22), which showed the 85% capacity being reached approximately 2 years in advance of the moderate growth scenario (2023 versus 2025).

The capacity limiting processes at the St Jacobs WWTP are governed by hydraulic throughput, which are positively impacted by lower PCF projections. Lower PCF projections may defer expansion timing in terms of the plant rated capacity, however, upgrades may still be required to address capacity limitations in loading limited processes.

The loading limited process at the St Jacobs WWTP is the oxidation ditch. As a result, as discussed in Section 4.1, there would be no impact on timing of major works in terms of the oxidation ditch capacity based on per capita flow sensitivity, as illustrated below (using the lower PCFs scenario as an example):

- + At moderate PCFs, the oxidation ditch capacity is limited to 174 kg/d BOD₅ (i.e. . historic BOD₅ concentration of 120 mg/L x oxidation ditch equivalent ADF capacity of 1,450 m³/d), which is equivalent to a flow capacity of 1,450 m³/d (refer to Tech Memo No. 2 – Existing Conditions). The plant would reach 85% of this capacity in 2025.
- + At lower PCFs, the BOD₅ loading capacity of the ATs remains unchanged at 174 kg/d. However, due to the concentrating effects of a 15% reduction in PCFs, the AT capacity is reduced by 15% (i.e. 0.85 x 1,450 m³/d) which is equivalent to a flow capacity of 1,230 m³/d. Overall, the plant would still reach 85% of this capacity in 2025, as shown in Figure 32.

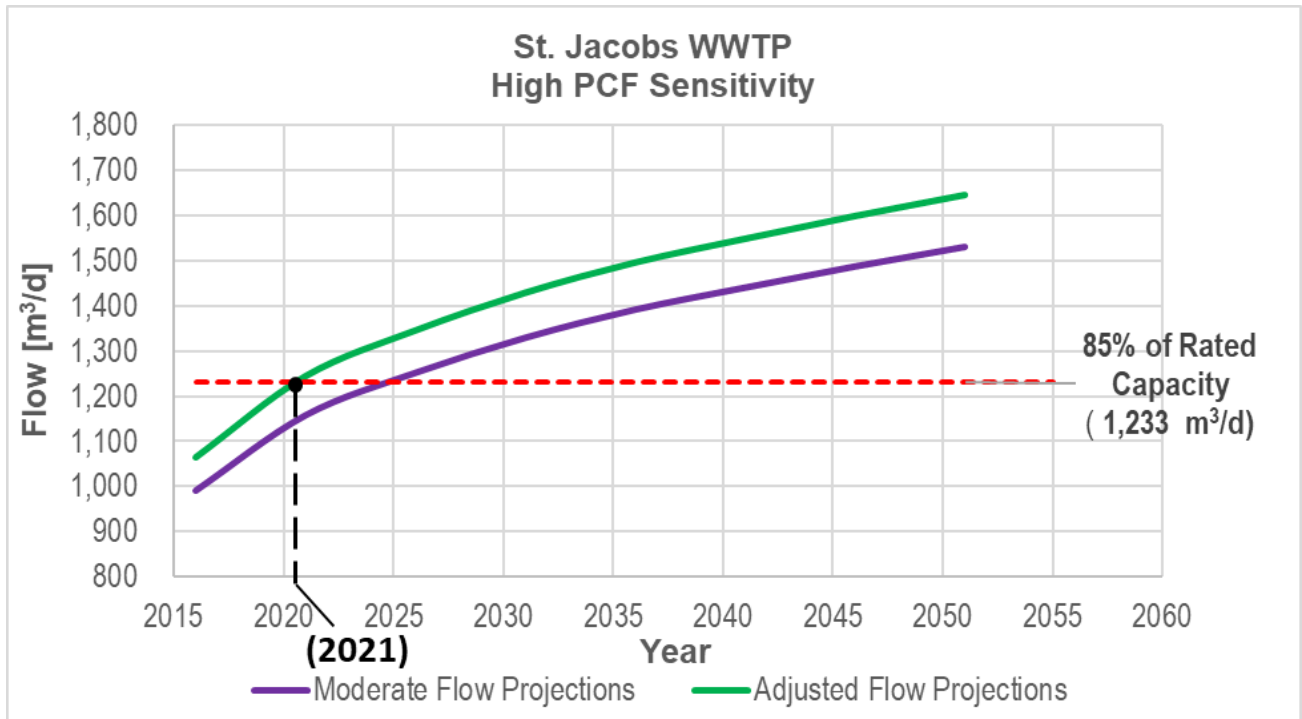


Figure 31 High PCF Projections (Adjusted Flow) for the St Jacobs WWTP

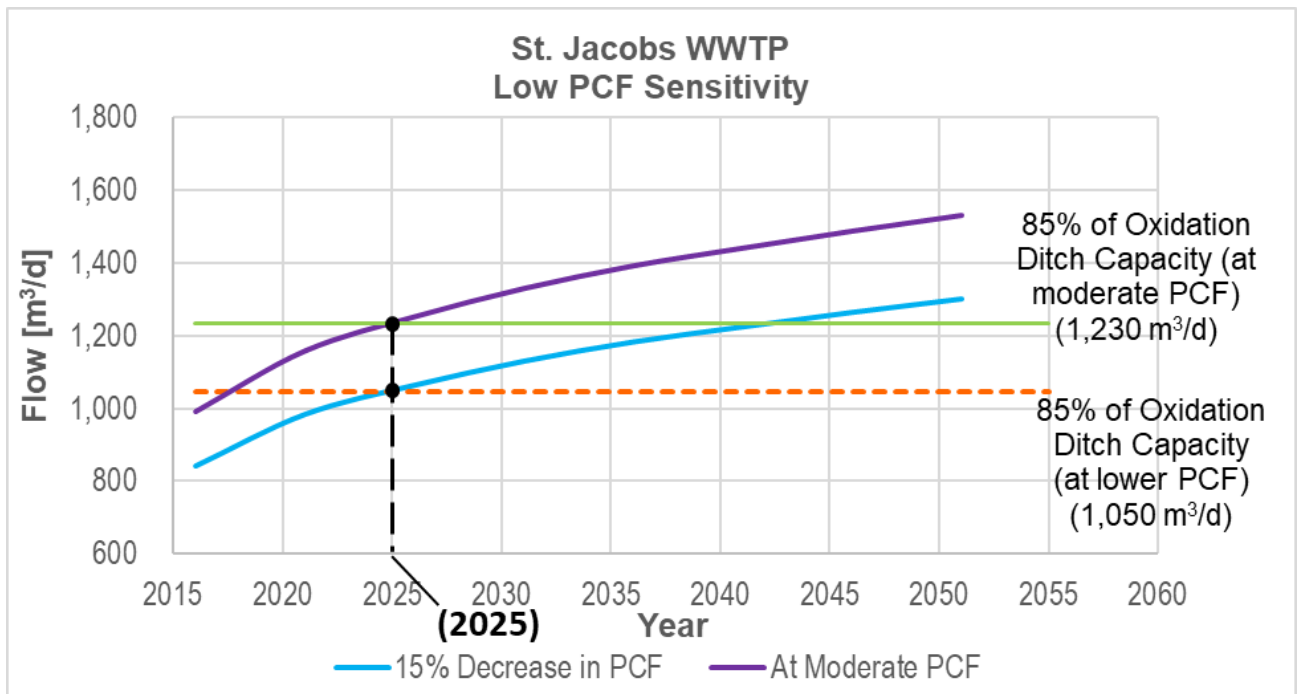


Figure 32 Low PCF Projections for the St Jacobs WWTP

Overall, changes of PCFs have minimal to no impact to the expansion planning timelines (both 2025) in terms of the oxidation ditch capacity at the St Jacobs WWTP, compared to the expansion planning timeline in terms of the plant rated capacity under the baseline moderate growth scenario (refer to Section 3.9, Figure 22).

4.5 Elmira WWTP

The PCF sensitivity to expansion or upgrades at the Elmira WWTP is summarized in Figure 33 and Figure 34. Adjusted flows move expansion timing forward by approximately 3 years to 2027, as shown in Figure 33. The adjusted flow scenario indicates a greater impact on the timing for expansion planning than the high growth scenario (refer to Section 3.10, Figure 24), which showed the 85% capacity being reached approximately 2 years in advance of the moderate growth scenario (2028 versus 2030).

Lower PCF projections may defer expansion timing in terms of the plant rated capacity, however, upgrades may still be required to address capacity limitations in key unit processes (e.g., loading limited processes).

The capacity limiting processes at the Elmira WWTP are aeration tank and oxygenation capacity. As a result, as discussed in Section 4.1, there would be no impact on timing of major works in terms of the aeration and oxygenation capacity based on per capita flow sensitivity, as illustrated below (using the lower PCFs scenario as an example):

- + At moderate PCFs, the aeration tank capacity is limited to 1,480 kg/d BOD₅ (i.e. historic BOD₅ concentration of 260 mg/L x aeration tank equivalent ADF capacity of 5,700 m³/d), which is equivalent to a flow capacity of 5,700 m³/d (refer to Tech Memo No. 2 – Existing Conditions). The plant would reach 85% of this capacity in 2021.
- + The BOD₅ loading capacity of the aeration tanks remains unchanged at 1,480 kg/d. However, due to the concentrating effects of a 15% reduction in PCFs, the aeration tank capacity is reduced by 15% (i.e. 0.85 x 5,700 m³/d), which is equivalent to a flow capacity of 4,845 m³/d. Overall, the plant would still reach 85% of this capacity in 2021.

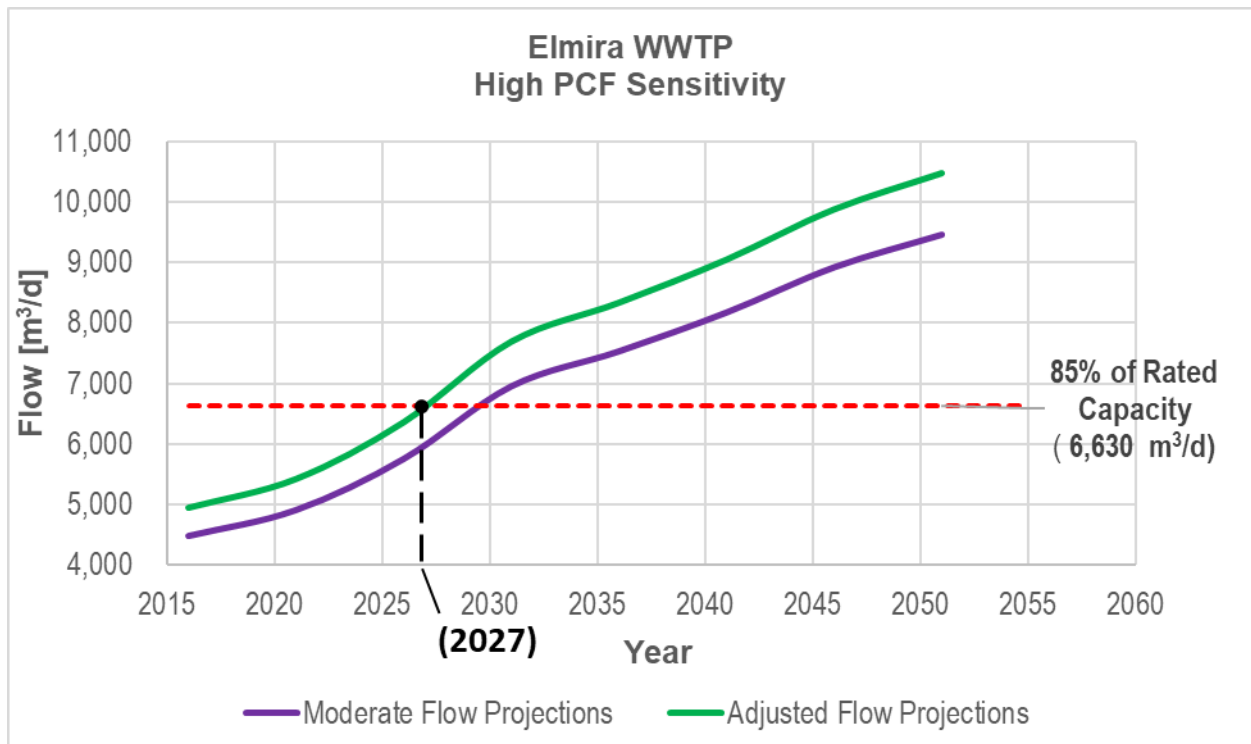


Figure 33 High PCF Projections (Adjusted Flow) for the Elmira WWTP

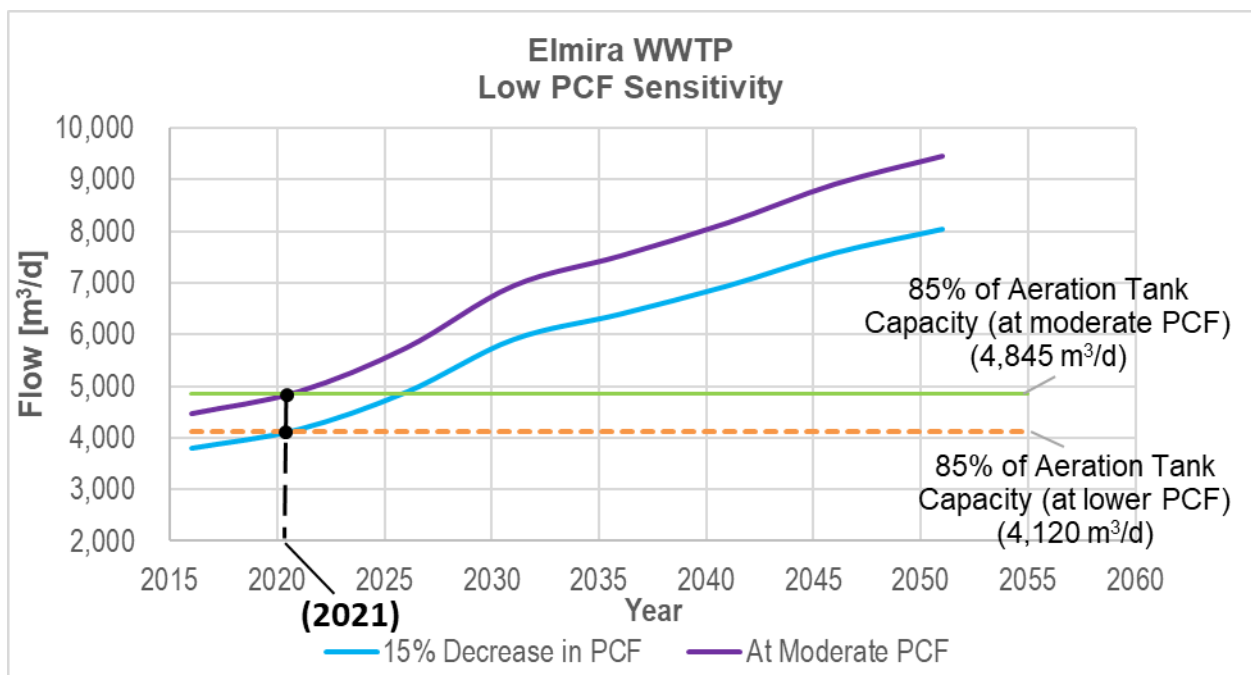


Figure 34 Low PCF Projections for the Elmira WWTP

While moderate flow projections identify a need to plan for capacity expansion by approximately 2030 (refer to Section 3.10, Figure 24), the aeration tank and oxygenation capacity will be reached much sooner. As a result, an early project to address aeration tank and oxygenation deficiencies is recommended ahead of when a plant expansion would be required based on flow considerations alone. In addition to these processes, there are also solids processing bottlenecks that should be addressed along similar timelines.

5. Inflow/Infiltration Sensitivity

The Wellesley, St Jacobs and Elmira WWTPs each have treatment processes that are constrained based on historical peak flows that are higher than the design peak flows. If the I/I issues within the WWTP service areas are addressed, there may be opportunity to defer upgrades and/or expansions.

5.1 Wellesley WWTP

The treatment processes of the Wellesley WWTP and the corresponding rated capacities are shown in Figure 35. The capacity limiting process during high flows at the Wellesley WWTP is the secondary clarifier SOR. With a peak factor of 4.0 based on the peak flow identified in the ECA and Operations Manual, the secondary clarifier SOR is limited to approximately 950 m³/d. By reducing the peak factor to 3.4 (approximately 15% reduction) through a reduction in I/I, the available capacity of the secondary clarifiers would increase to the rated capacity of the plant (1,100 m³/day).

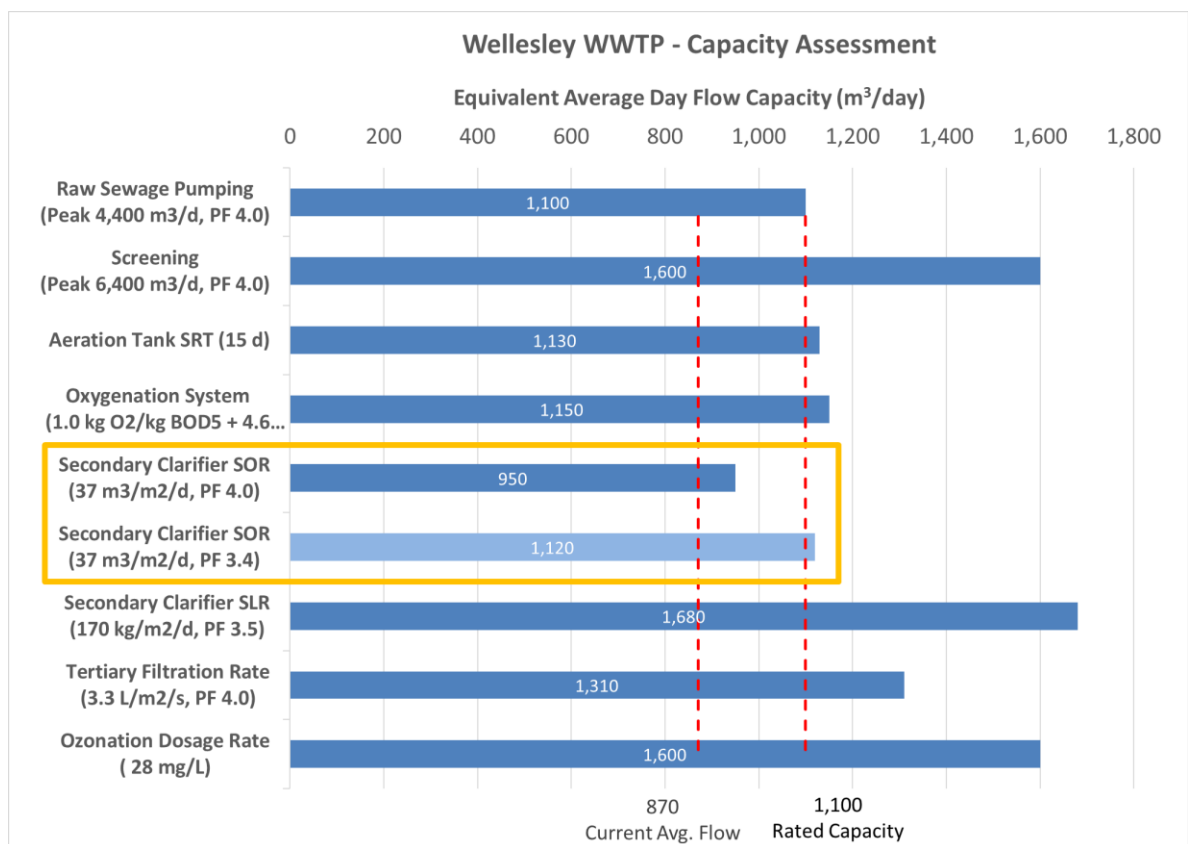


Figure 35 Treatment Processes and Rated Capacities of the Wellesley WWTP

Figure 36 provides the overall timelines for upgrades based on current I/I to provide a consistent estimate of implementation timing. Overall, the existing clarifier capacity based on current peak flows is similar to 85% of the existing rated capacity. As a result, without a reduction in I/I to the plant, planning for the expansion (Schedule C Class EA) should begin sooner than average day plant flows would suggest (i.e., 2030 rather than 2033). This should allow for time to implement upgrades to address clarifier capacity that are fully compatible with a planned future expansion.

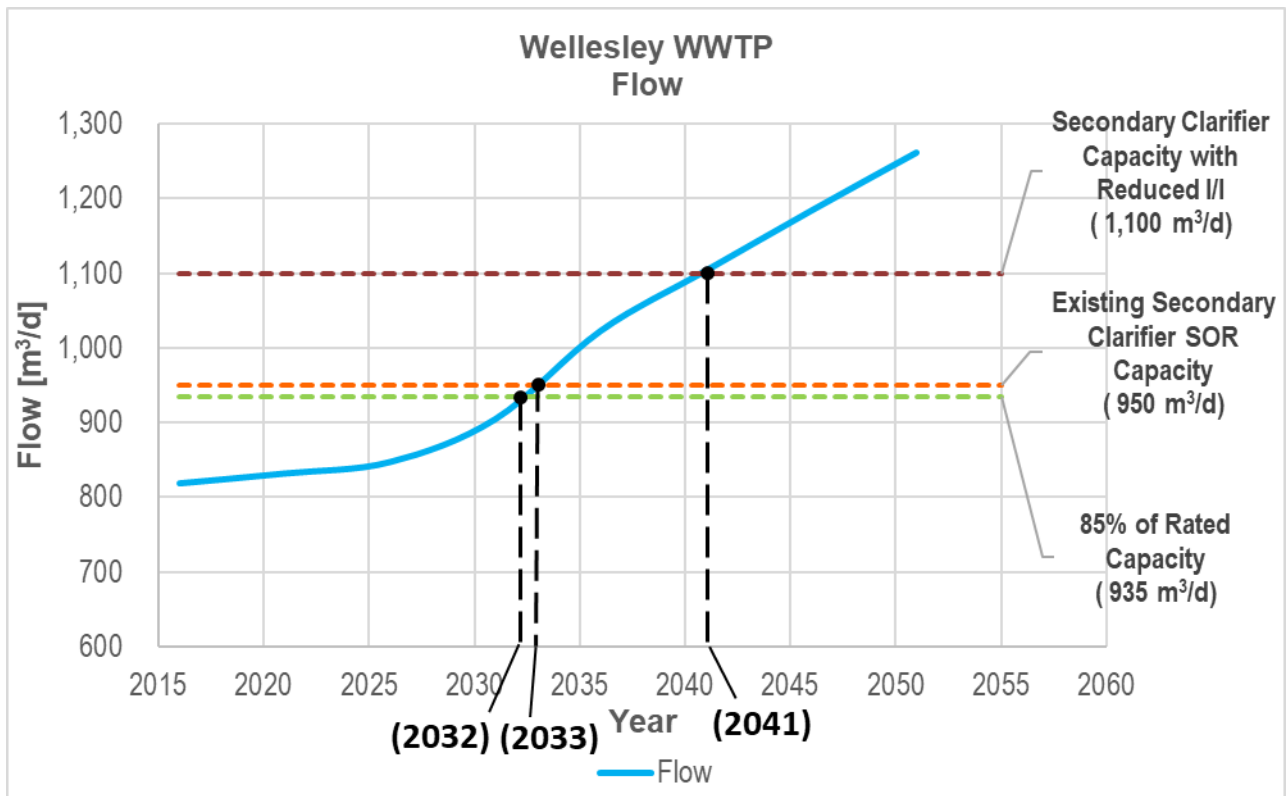


Figure 36 Impacts of Reduced I/I on Upgrade and/or Expansion at the Wellesley WWTP

5.2 St Jacobs WWTP

The treatment processes of the St Jacobs WWTP and the corresponding rated capacities are shown in Figure 37. The limiting processes during high flows at the St Jacobs WWTP are the capacities of tertiary filtration and UV disinfection. The peak factor would need to be reduced from 3.3 to 2.5, to allow these processes to meet the current rated plant capacity. This is almost a 25% reduction in peak flows to the facility and would require a dedicated long-term action plan. Although a 25%

reduction is needed to reduce the peaking factor to 2.5, any reductions achieved in peak flows would be of benefit to the plant.

Figure 38 summarizes the timing of works based on reduced I/I levels. Overall, since tertiary filtration and UV disinfection capacity is already operating near capacity, there is insufficient time to implement and realize the benefits of an I/I program to defer expansion. As a result, an early project to ensure the plant will continue to have adequate hydraulic capacity for the full range of flows is recommended.

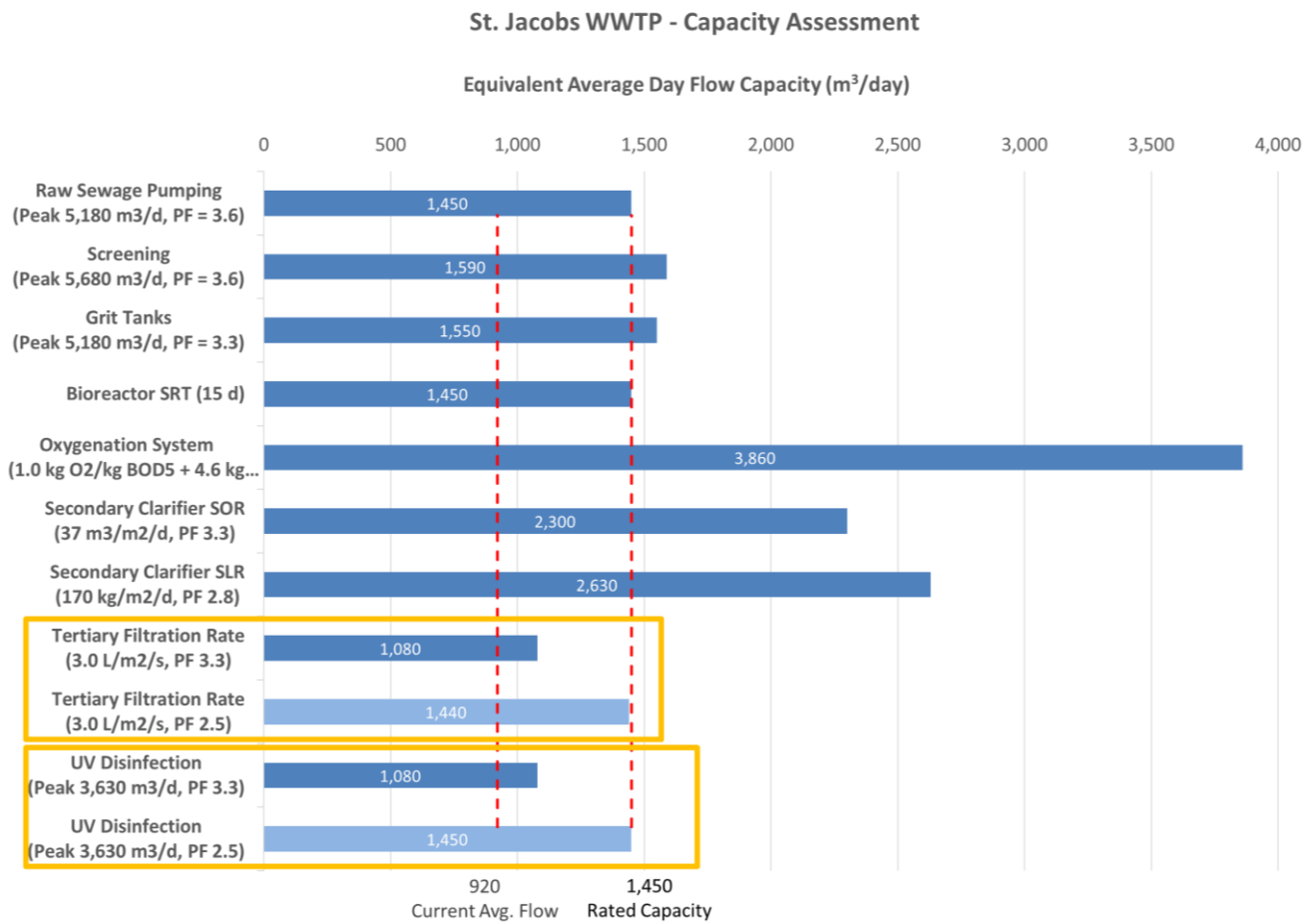


Figure 37 Treatment Processes and Rated Capacities of the St Jacobs WWTP

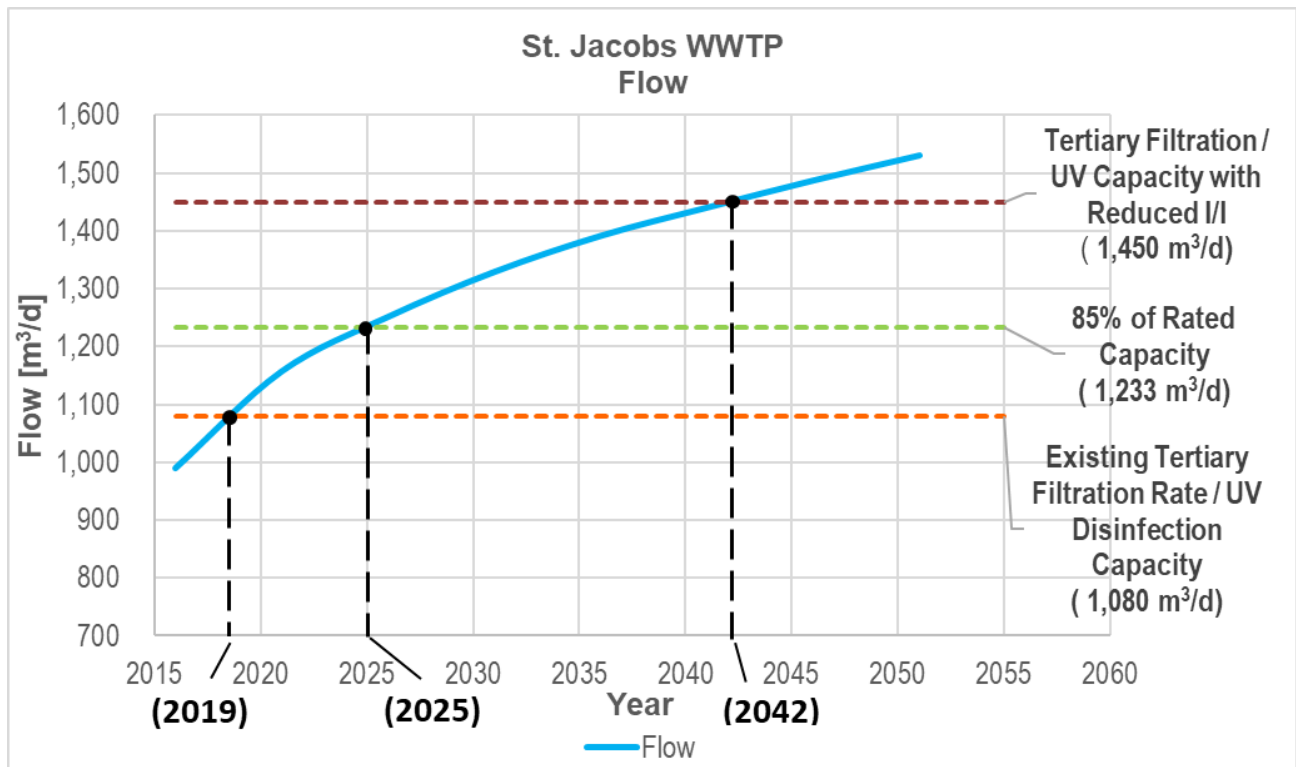


Figure 38 Impacts of Reduced I/I on Upgrade and/or Expansion at the St Jacobs WWTP

5.3 Elmira WWTP

The treatment processes of the Elmira WWTP and the corresponding rated capacities are shown in Figure 39. The capacity limiting process during high flows at the Elmira WWTP is primary clarifier SOR. The peak factor at the plant would need to be reduced from 3.2 to 2.4 to increase clarifier capacity up to the rated capacity. This is almost a 25% reduction in peak flows to the facility and would require a dedicated long-term action plan. Although a 25% reduction is needed to reduce the peaking factor to 2.4, any reductions achieved in peak flows would be of benefit to the plant.

Figure 40 summarizes the timing of works based on reduced I/I levels. Due to both higher peak flows and loadings than the original plant design, significant upgrades will need to be considered in advance of the planning for the Elmira WWTP expansion in 2030. This timing is consistent with the findings of the sensitivity analysis with respect to per capita loadings.

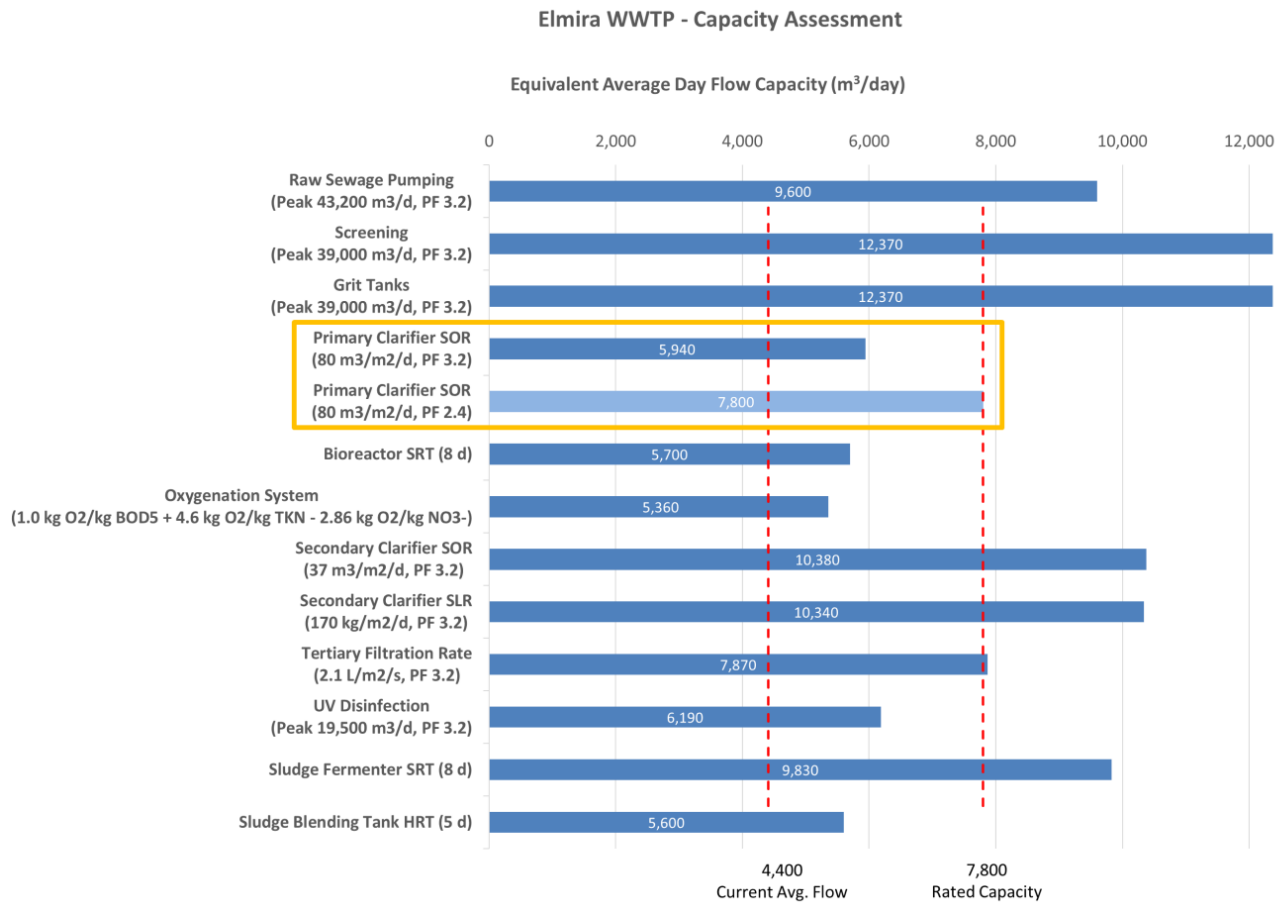


Figure 39 Treatment Processes and Rated Capacities of the Elmira WWTP

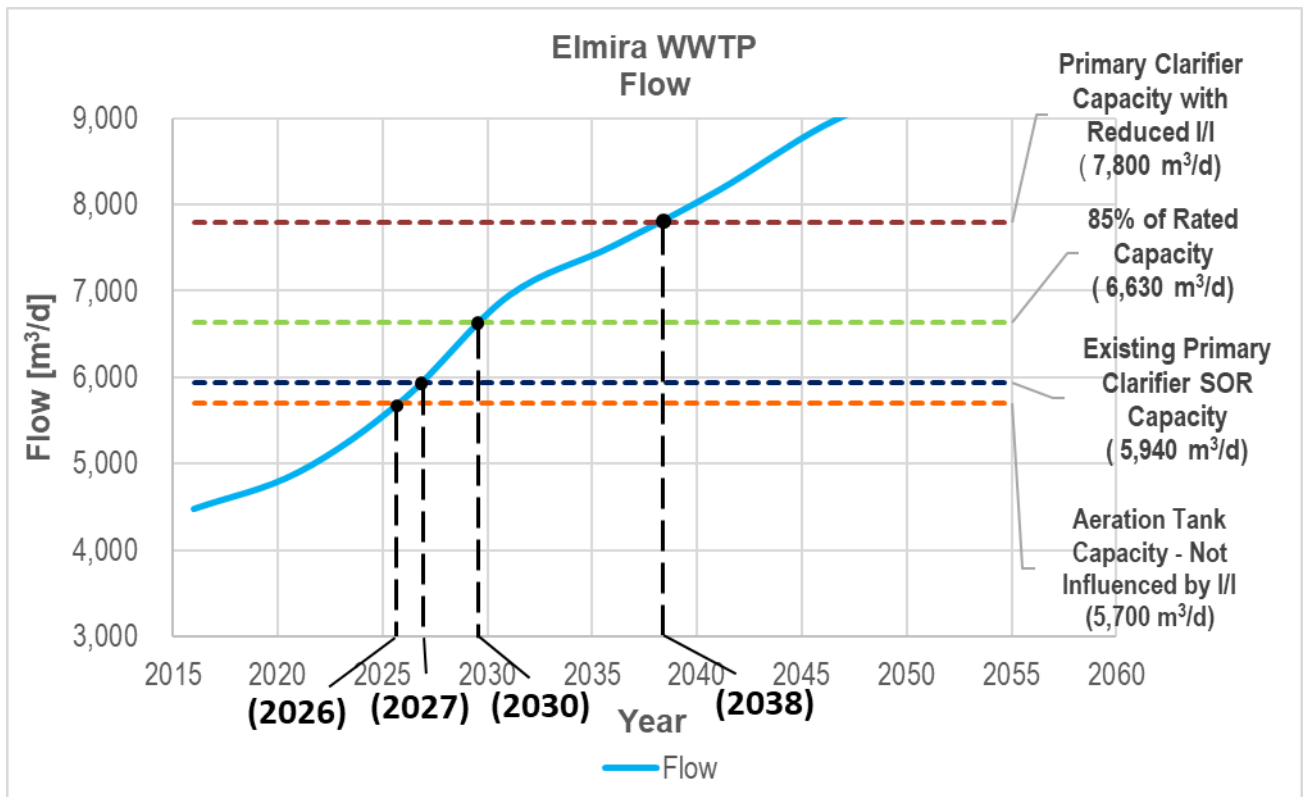


Figure 40 Impacts of Reduced I/I on Upgrade and/or Expansion at the Elmira WWTP

6. Summary

The impact of the sensitivity scenarios varies for individual plants based on specific growth forecasts, plant capacity, and unit process constraints. Table 2 summarizes the sensitivity scenarios for plants that are expected to require an expansion within the planning horizon to 2051.

Implementation timelines are presented to identify where early budgeting for projects may be considered to mitigate overall risks. Recommendations for the implementation timelines were developed with considerations for the following:

- + Waterloo WWTP expansion planning is deferred by two years (2021) compared to the high growth sensitivity scenario to allow completion of the optimization study, which will be a key input to the Class EA.
- + Hespeler WWTP expansion planning recommended to begin in 2036, as identified in the moderate growth scenario, as the sensitivity scenarios reviewed indicated very minor impacts.
- + Wellesley WWTP expansion planning is deferred to 2030 compared to 2024 for the P2GA2 scenario and 2027 for the high PCF sensitivity scenario based on the following:
 - The P2GA2 projection was considered to be aggressive for the Wellesley WWTP and presents a risk of initiating an expansion too far in advance of needing the infrastructure. Monitoring through the annual WWWMR will allow the opportunity re-assess the timing of an expansion if necessary based on the actual flows realized.
 - The trigger for initiating an expansion at 85% capacity is an estimate to allow time for planning, detailed design, and construction in advance of reaching the full rated capacity of a plant. The actual duration between 85% and 100% capacity of plant is dependent on factors such as the rate of flow increase and the size of the plant. When reviewing the projections specific to the Wellesley WWTP, initiating the planning for an expansion in 2030 still provides sufficient time to complete planning and expansion construction ahead of the plant reaching rated capacity based on the high PCF scenario (approximately 2035).

- ✦ For St Jacobs and Elmira WWTPs, early projects are recommended to address unit process capacity limitations, which are reached well in advance of the expansion planning timelines.

Table 2 Sensitivity Analysis Timeline Summary for Plants Expected to Require an Expansion by 2051

WWTP	Year to Reach 85% of Rated Capacity						
	Moderate Growth (Baseline) (1)	Population Sensitivity			Per Capita Sensitivity	I/I Sensitivity	Recommended Timeline
		-15% Pop. Growth ⁽²⁾	+15% Pop. Growth ⁽³⁾	P2GA2 Sensitivity ⁽⁴⁾			
Waterloo	2020	2021	2019	2022	2021 ⁽⁵⁾	-	Begin Expansion Planning in 2021
Hespeler	2036	2037	2035	2035	2036 ⁽⁵⁾	-	Begin Expansion Planning in 2036
Wellesley	2032	2033	2032	2024	2027 ⁽⁶⁾	2033 ⁽⁷⁾	Begin Expansion Planning in 2030
St Jacobs	2025	2027	2023	2031	2021 ⁽⁶⁾	2019 ⁽⁸⁾	Filter/Disinfection Upgrades in 2020
Elmira	2030	2032	2028	2030	2021 ⁽⁹⁾	2027 ⁽¹⁰⁾	Bioreactor Upgrades Assessment in 2020

Notes:

1. Timing to reach 85% of rated capacity based on moderate growth (baseline) scenario.
2. Timing to reach 85% of rated capacity based on 15% decrease of moderate growth scenario.
3. Timing to reach 85% of rated capacity based on 15% increase of moderate growth scenario.
4. Timing to reach 85% of rated capacity based on P2GA2 scenario.
5. Timing for 85% confidence level PCFs flows to reach 85% of aeration tank/oxygenation system capacity.
6. Timing for 85% confidence level PCFs flows to reach 85% of rated capacity.
7. Secondary clarifier SOR limitations without I/I reduction.
8. Filtration and UV disinfection capacity without I/I reduction.
9. Capacity limited by loadings to bioreactors and oxygenation capacity.
10. Primary clarifier SOR limitations without I/I reduction.