2024 Watershed Overview of Wastewater Treatment Plant Performance

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Acronyms and Abbreviations

ADF	Average daily flow
cBOD	Carbonaceous 5-day biochemical oxygen demand
CCP	Composite Correction Program
ECA	Environmental Compliance Approval (formerly called Certificate of Approval)
EPA	US Environmental Protection Agency
GRCA	Grand River Conservation Authority
I/I	Inflow/Infiltration
MECP	Ontario Ministry of the Environment, Conservation and Parks
NDF	Nominal Design Flow (listed in plant's ECA)
OCWA	Ontario Clean Water Agency
PWQO	Provincial Water Quality Objectives
TAN	Total ammonia nitrogen
TBOD	Total 5-day biochemical oxygen demand
TKN	Total Kjeldahl nitrogen
TP	Total phosphorus
TSS	Total suspended solids
UIA	Un-ionized ammonia
WMP	Water Management Plan
WWOP	Watershed-wide Wastewater Optimization Program
WWTP	Wastewater treatment plant

Executive Summary

Since 2010, the Grand River Conservation Authority (GRCA) has been working collaboratively with local partners and the Ministry of the Environment, Conservation and Parks (MECP) to implement a Watershed-wide Wastewater Optimization Program (WWOP). A key program activity is the preparation of an annual report on effluent quality and plant loading for treatment facilities discharging in the Grand River watershed. The first annual report was produced for data collected in 2012. Year-to-year variations are used to evaluate the success of the program and track wastewater treatment plant (WWTP) impacts on the Grand River. Available performance and loading data for 28 of 30 public wastewater treatment plants were voluntarily reported for the 2024 operating year. This report summarizes treatment performance, data integrity, impacts on the Grand River, plant loading, and bypasses and overflows, and compares the results to previous years.

Plant Flows

Figure 1 shows the total average day flow (ADF) for all the reporting plants from 2012 to 2024. Additionally, the reported serviced population for each year is also shown on the secondary axis, represented by a green dashed line on the graph. From 2012 to 2024, the reported population increased by 21% (or approximately 1.7% per year), rising from about 805,200 in 2012 to 972,800 in 2024. Over the same period, total plant flows increased by 14% (or about 1.2% per year). In addition to community growth, total plant flow is also influenced by variations in precipitation.

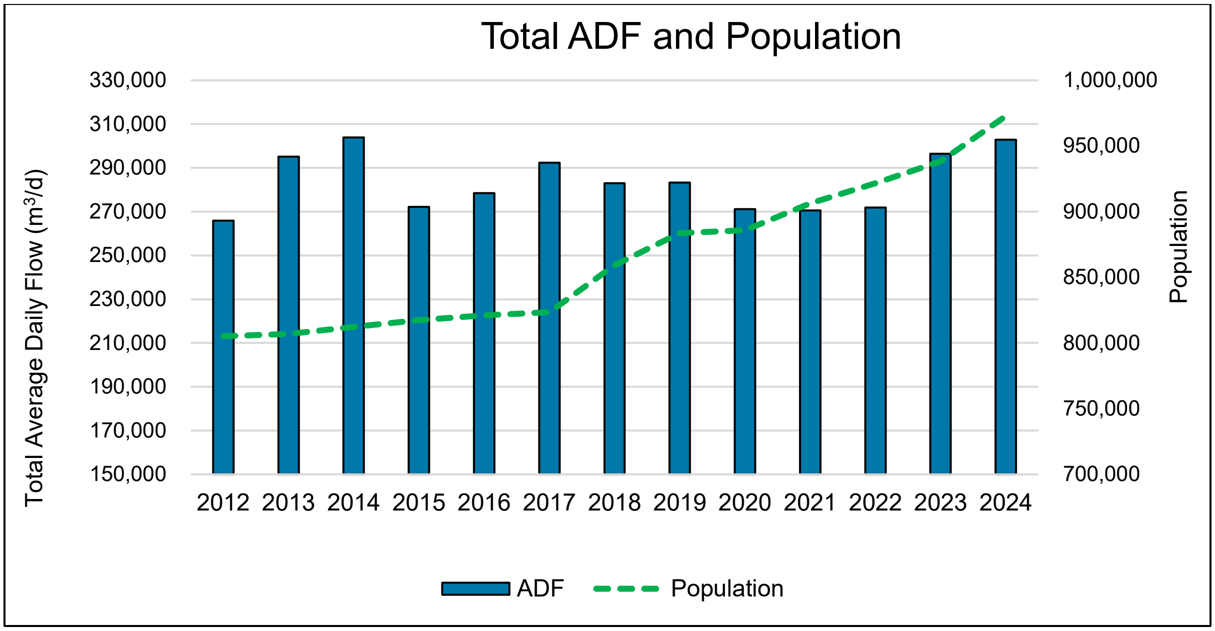


Figure 1: Total reported WWTP average daily flow and population from 2012-2024

Treatment Performance

Figure 2 and Figure 3 show the final effluent total phosphorus (TP) and total ammonia nitrogen (TAN) flow-weighted average concentrations and the total loading from 2012 to 2024. The dotted line in Figure 2 represents the watershed-wide flow-weighted concentration target for TP, which is calculated based on each plant's average daily flow (ADF) multiplied by the corresponding TP target and the sum of these values is divided by the total ADF. This target can change year over year as the annual ADF changes.

With respect to the TP concentrations and loads in Figure 2, the following observations can be made:

- From 2023 to 2024, the TP flow-weighted concentration decreased from 0.22 to 0.20 mg/L and the TP load decreased from 23.3 to 22.4 tonnes,
- From 2012 to 2024, the TP flow-weighted concentration decreased from 0.37 to 0.20 mg/L and the TP load from 36.0 to 22.4 tonnes,
- In 2024, for the first time since the program began summarizing data in 2012, the flow-weighted concentration fell below the watershed-wide target.

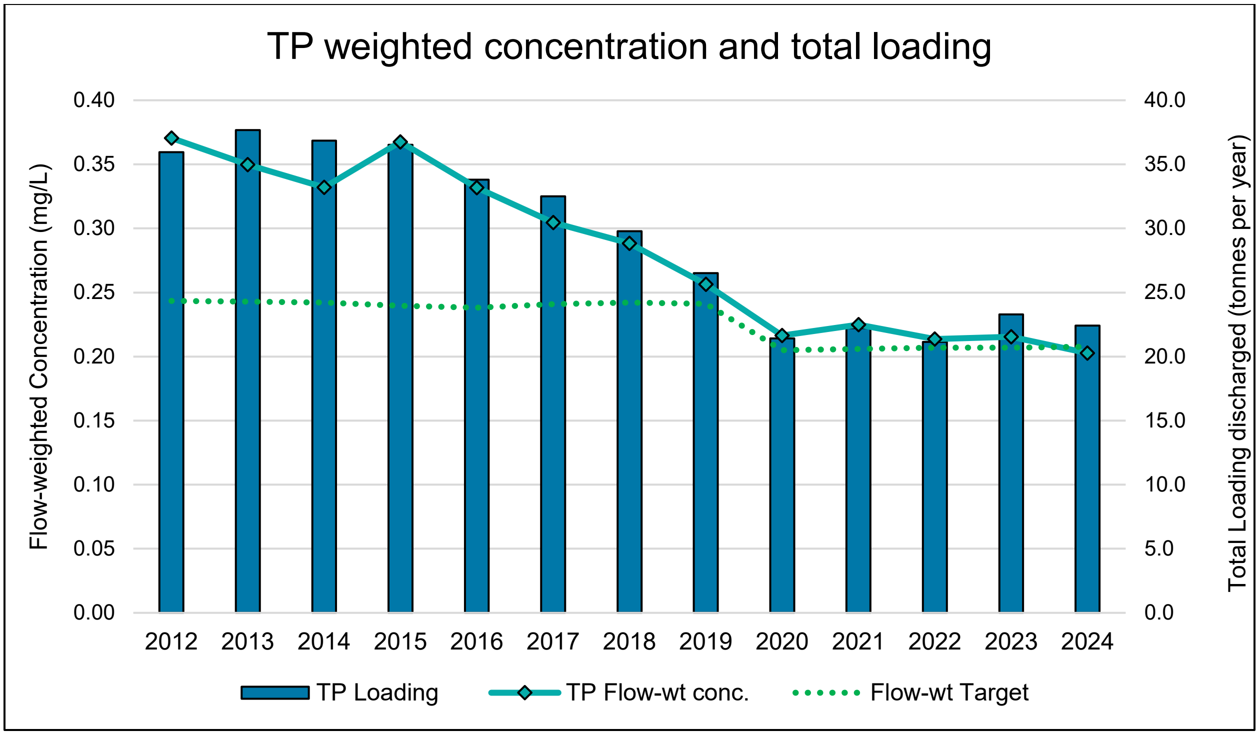


Figure 2: Flow-weighted effluent TP concentrations and total loading

With respect to Figure 3 showing the TAN loads and concentrations, the following notes are observed:

- From 2023 to 2024 the summer TAN flow-weighted concentration decreased from 0.6 to 0.3 mg/L and winter TAN flow-weighted concentration increased from 0.8 to 0.9 mg/L. TAN total loading decreased from 75 tonnes in the previous year to 69 tonnes.
- From 2012 to 2024, the overall total TAN flow-weighted concentration decreased from 9.8 to 0.6 mg/L and the total loading from 954 to 69 tonnes.

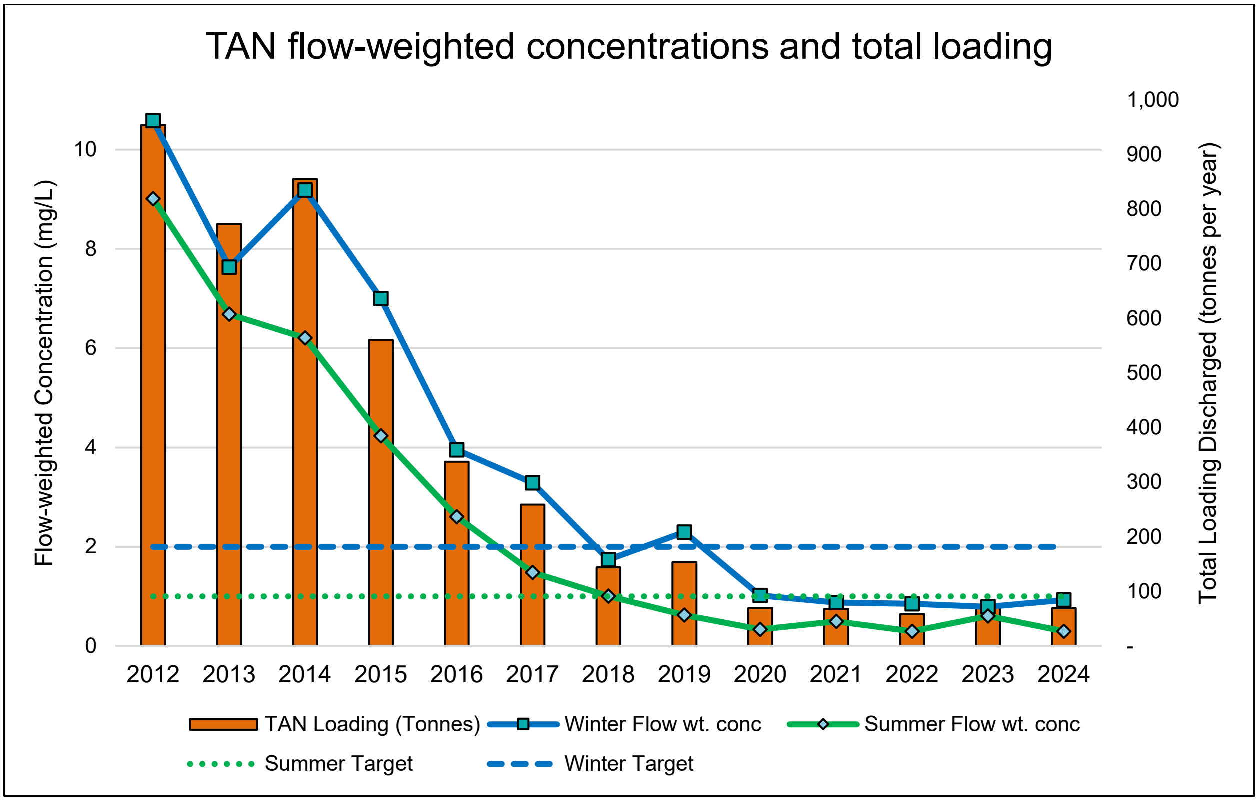


Figure 3: Flow-weighted summer and winter effluent TAN concentrations and total loading

Overall, both TP and TAN concentrations and loadings decreased steadily from 2012 to 2020 and have plateaued from 2020 to 2024.

Data Integrity Checks

A sludge accountability analysis compares the annual amount of sludge reported by a mechanical plant to the amount of sludge projected based on plant loadings and removal. Conducting this analysis can help to determine if monitoring is truly representative. In 2024, sludge accountability was reported for all 24 mechanical plants in the watershed. For 14 of the plants, the sludge accountability closed within ±15%.

A water balance analysis compares the annual amount of measured net precipitation on the surface area of a lagoon system to the annual amount of projected net precipitation using lagoon level measurements, total influent, and total effluent flows of a lagoon system. This analysis can help to determine if the flow measurement devices at a lagoon are accurate. In 2024, water balances were completed for all four lagoon systems in the watershed, with three closing within ±15%.

Grand River Impacts

Table 1 summarizes the impact of total annual average discharge of effluent from wastewater treatment plants on the total flow in the Grand River.

Table 1: WWTP Effluent flow as a percentage of Grand River total flow

Year	% Annual Average Flow	% August Average Flow
2012	6.8%	13.9%
2013	3.1%	5.4%
2014	2.6%	9.5%
2015	5.0%	11.5%
2016	4.7%	9.0%
2017	3.5%	7.3%
2018	3.7%	8.7%
2019	3.7%	10.3%
2020	4.5%	10.2%
2021	5.1%	12.6%
2022	5.5%	14.5%
2023	5.0%	7.1%
2024	5.3%	8.5%
Overall Average	4.5%	9.9%

The year-to-year variations in Table 1 are largely a function of precipitation and weather in the watershed in any given year. The percentage of flows in August is also shown, as flows in this month are typically the lowest and treated wastewater makes up a larger portion of river flow. Precipitation was above average in 2017, 2019, and 2023. In 2024, precipitation was above the long-term average from January to July and in December, resulting in wetter-than-normal conditions. In contrast, the period from August to November was generally drier than normal (Anderson, et al., 2024).

As shown in Table 1, treated effluent accounts for 2.6% to 6.8% of total river flow on an annual average basis. During summer low-flow conditions in August, this proportion increases to 5.4% to 14.5%. This highlights how the influence of WWTP effluent on the river varies from year to year, depending on precipitation.

Recent upgrades and optimization efforts at wastewater treatment plants (WWTPs) have contributed to improvements in some parameters in the Grand River. Notably, the 2019 upgrades at the Kitchener and Waterloo WWTPs enabled nitrification, resulting in reduced concentrations of TAN, UIA, and nitrite in the river. However, a 2024 surface water chemistry study by LGL found elevated levels of TP and TAN downstream of the Region's four major WWTPs compared to upstream, during winter, summer, and fall (LGL Limited, 2025).

Plant Loading

Table 2 summarizes the 2024 median in comparison to 2012-2023 ranges and typical values for raw influent concentrations for Total 5-day biochemical oxygen demand (TBOD), total suspended solids (TSS), TP and total Kjeldahl nitrogen (TKN). These data give an estimate of typical concentrations for the plants in the Grand River watershed as sometimes poor estimates of population play into the per capita loadings. Table 3 summarizes key process loading metrics for 2024 as well as typical values and the range of median reported values from 2012 to 2023. Per capita loadings are influenced by sampling, proportion of industry to residential loading and population estimates. The results in the tables enable plant owners and operators to compare loadings at their facilities to those at other plants in the watershed, to determine the impact of industrial discharges and highlight concerns with unrepresentative sampling of raw influent.

Table 2: Summary of 2012 to 2024 watershed WWTP raw influent concentrations

Raw Influent concentrations	**Watershed Median** 2012-2023 (min-max)	**Watershed Median** 2024	Range of typical concentrations*
TBOD (mg/L)	193-251	**225**	120-380
TSS (mg/L)	204-264	**248**	120-370
TP (mg/L)	5-6	**5**	4-12
TKN (mg/L)	38-47	**47**	20-45

* (Metcalf & Eddy, 2003)

Table 3: Summary of 2012 to 2024 watershed WWTP loading metrics

Loading Measure	**Watershed Median** 2012-2023 (min-max)	**Watershed Median** 2024	**Typical Value****
Per capita flow (L/person/day)	280 - 351	**295**	350 - 500
ADF as % of Nominal Design	55% - 61%	**62%**	N/A
Peak day: Annual average flow	2.25 – 3.54	**2.20**	2.5 – 4.0
Per capita TBOD* loading (g/person/day)	63 - 77	**66.6**	80
Per capita TSS loading (g/person/day)	69 - 93	**75.1**	90
Per capita TKN loading (g/person/day)	13 - 14	**13.2**	13
Per Capita TP loading (g/person/day)	1.6 – 2.0	**1.7**	2.1
Raw TSS:TBOD ratio	1.01 - 1.25	**1.09**	0.8 - 1.2
Raw TKN:TBOD ratio	0.17 - 0.23	**0.20**	0.1 - 0.2

*Some previously reported data was based on cBOD and may be less reliable. Research indicates that cBOD measurements of raw wastewater underestimate organic loading by 20 to 40%.

** (US EPA, 1989)

Year-to-year variations in per capita flow, the average day flow as a percentage of the design flow, and the ratio of the peak day to average day flow from Table 3 are largely due to differences in inflow and infiltration (I/I) related to precipitation.

Bypasses and Overflows

Bypasses and overflows are terms used to describe events that result in untreated or partially treated sewage reaching natural water bodies (Grand River Municipal Water Managers Working Group, 2009). Bypasses occur when parts of a treatment process are bypassed and partially treated wastewater discharges to the environment via the WWTP effluent outfall. Overflows occur when sewage enters the environment at a location other than the effluent outfall. Bypasses/overflows can be classified as low, moderate, or high risk according to the level of risk to downstream users. Overall, the total number of bypasses and overflows was 46 in 2024, a substantial decrease from 66 events recorded in the previous year. In terms of the volume of bypasses recorded in 2024 compared to the previous year, there is an increase from 88,053 to 471,096 cubic metres. Several low and moderate risk bypasses in 2024 occurred in January and April and were related to weather conditions generating high peak day flows to the WWTP.

Effluent quality in the Grand River watershed has improved significantly since 2012, driven by facility upgrades and ongoing optimization. These efforts have led to major reductions in total phosphorus (TP) and total ammonia nitrogen (TAN) discharged to the river.

While the Grand River watershed population has continued to grow, treatment performance has steadily improved. Although 2023 saw a rise in both TP and TAN loadings, 2024 showed a return to lower flow-weighted concentrations and loadings. Between 2012 and 2024, flow-weighted TP concentrations fell from 0.37 to 0.20 mg/L, and TAN from 9.8 to 0.6 mg/L.

Annual reporting has been key to the success of the watershed-wide wastewater optimization program. Tools such as per capita flows, sludge accountability, and flow-weighted averaging, highlighted in this report, may benefit other organizations managing multiple treatment plants.

The program’s success relies on the voluntary engagement of operators and managers. WWOP remains committed to supporting this community through knowledge sharing and collaboration, helping ensure a healthy, sustainable watershed for future generations.

INTRODUCTION

The Grand River watershed has a population close to 1 million that is expected to reach 1.5 million by 2051 (GRCA, 2024). Based on data reported to the Grand River Conservation Authority (GRCA), wastewater from a total population of about 972,800 is treated by municipal and First Nations-owned facilities in the watershed while the remainder of the population is serviced by other means such as private septic systems. Significant population growth will result in more wastewater treatment plant (WWTP) effluent being discharged into the Grand River and its tributaries. There are 30 municipal and First Nations-operated wastewater treatment facilities that discharge their treated effluent into rivers in the watershed, as shown in Figure 4.

The organizations listed below are responsible for their operation:

- Township of Southgate
- Town of Grand Valley
- Township of Mapleton
- Township of Wellington North
- Township of Centre Wellington
- Region of Waterloo
- City of Guelph
- Oxford County
- County of Brant
- City of Brantford
- Haldimand County
- Six Nations of the Grand River
- Mississaugas of the Credit First Nation

The following report describes the background and objectives of the Grand River Watershed-wide Wastewater Optimization Program (WWOP) and provides a summary of performance data from 2012 to 2024 voluntarily reported by the program participants.

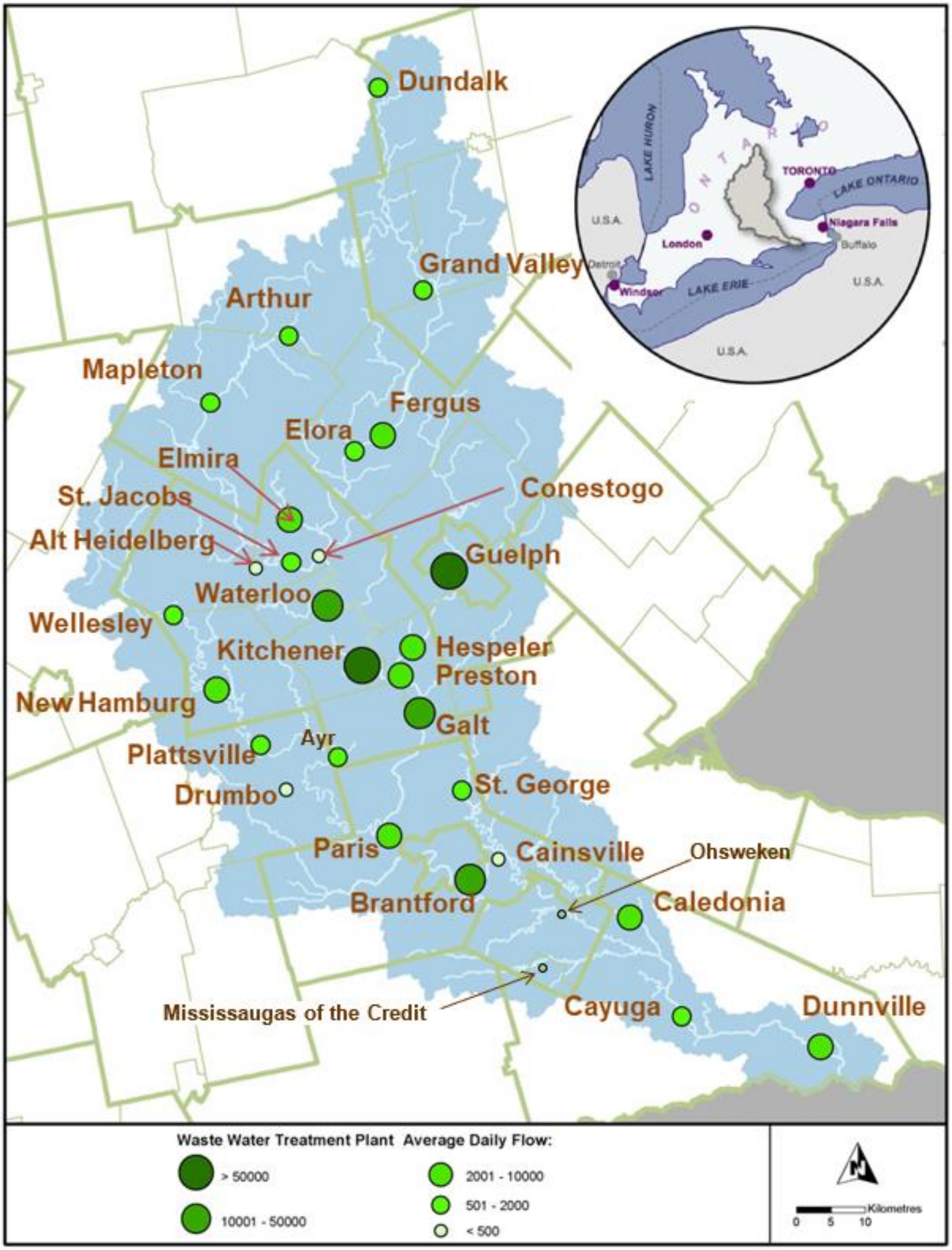


Figure 4: Map showing locations of WWTPs in the watershed

Background

The Grand River, located in southwestern Ontario, traverses approximately 310 km from its source near Dundalk to its point of discharge into Lake Erie at Port Maitland. The river and its tributaries serve as drinking water supply for four communities in the watershed in addition to providing other uses including a world-renowned brown trout tail-water fishery, active and passive recreation opportunities and productive agricultural lands (Anderson, et al., 2011). Because of its cultural heritage and outstanding recreational opportunities, the Grand River and its major tributaries (Nith, Conestogo, Speed and Eramosa) were designated as a Canadian Heritage River in 1994 (Canadian Heritage Rivers System, 2017). 30 wastewater treatment facilities discharge treated effluent to the Grand or its tributaries.

Since 2010, GRCA has been working collaboratively with municipal and First Nations partners and the Ministry of the Environment, Conservation and Parks (MECP) to develop a Watershed-wide Wastewater Optimization Program (WWOP). The WWOP supports maintaining and improving water quality in the Grand River, as identified in the Grand River Water Management Plan (WMP) (GRCA WMP Project Team, 2014). The WWOP is a voluntary program focused on skills development, knowledge transfer and capacity building within the watershed. The objectives of the program are to:

- Improve water quality in the Grand River and its tributaries as a direct result of improving wastewater treatment performance,
- Improve the water quality of Lake Erie,
- Tap the full potential of existing wastewater infrastructure and promote excellence in infrastructure management,
- Reduce vulnerability to climate change,
- Build and strengthen partnerships for wastewater optimization,
- Enhance partner capability and motivation,
- Leverage and learn from existing area-wide optimization programs in the United States (US), and
- Demonstrate strategies that can serve as a model for other areas of Ontario.

WWOP promotes optimization across the watershed by encouraging the adoption of the Composite Correction Program (CCP). The US Environmental Protection Agency (EPA) developed the CCP as a structured approach to identify and systematically address performance limitations to achieve a desired effluent quality (US EPA, 1989). The CCP was adapted for Ontario and documented in the handbook, “The Ontario Composite Correction Program Manual for Optimization of Sewage Treatment Plants” (PAI & WTC, 1996).

Additionally, the WMP suggests that adopting the CCP will help to reduce the overall loading of total phosphorus (TP) to the Grand River and, ultimately, to Lake Erie.

The CCP is based on the model shown in Figure 5. Good administration, design, and maintenance establish a “capable plant” and, by applying good process control, operators achieve a “good, economical” effluent.

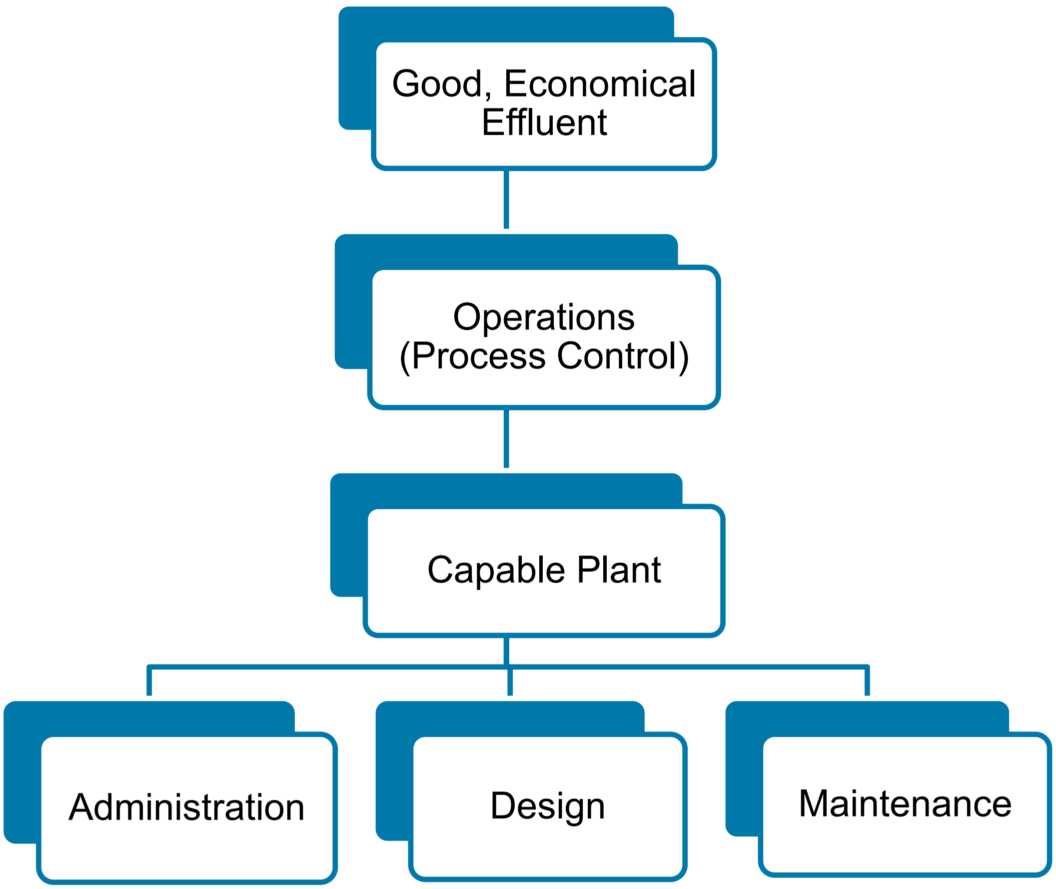


Figure 5: Composite Correction Program Performance Pyramid

The CCP is a two-step approach. The first step, a Comprehensive Performance Evaluation, evaluates and identifies performance limiting factors in the areas of administration, design, maintenance and operations of a wastewater treatment plant. If applicable, in Step 2 (Comprehensive Technical Assistance) a facilitator works with plant operators and managers to address and resolve any factors identified in Step 1. The watershed municipalities of Guelph, Haldimand County and Brantford have applied the CCP approach and have demonstrated its benefits, including improved effluent quality and re-rated capacity.

This approach has proven to be successful but is resource intensive when applied on a plant-by-plant basis. To address this challenge, an area-wide approach (as shown in Figure 6) was adopted based on the successful strategy for optimizing drinking water treatment systems in the US. Major components include Status, Targeted Performance Improvement, and Maintenance. The model utilizes a proactive, continuous improvement approach to improve effluent quality.

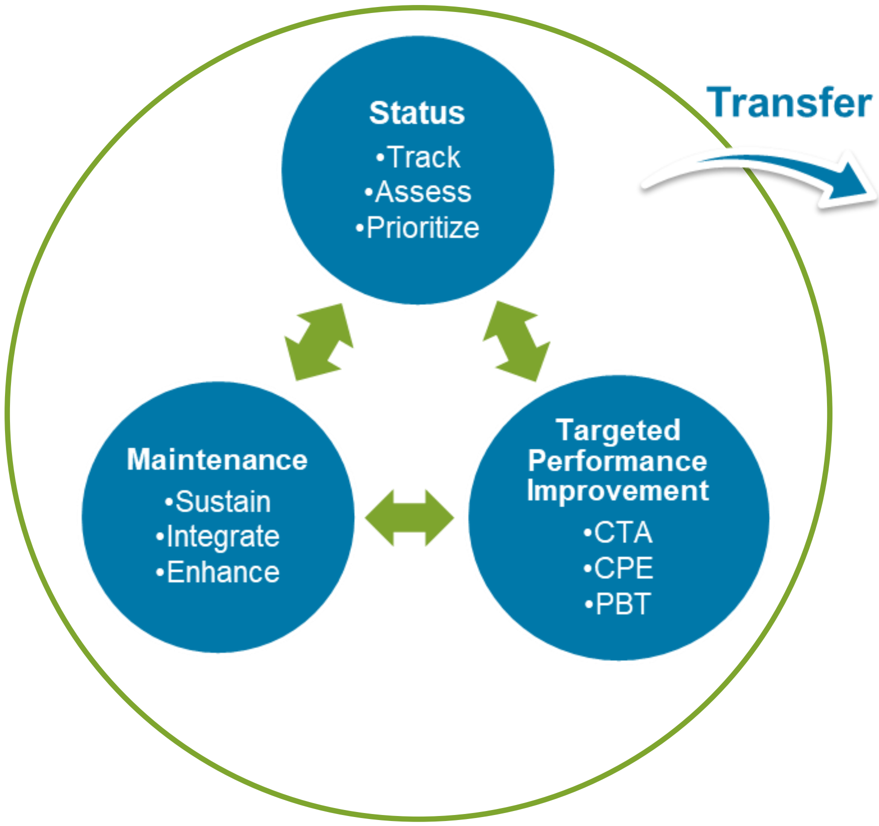


Figure 6: Area-Wide Optimization Model

Lake Erie Action Plan

Wastewater treatment plant optimization and area-wide optimization programs are highlighted as actions in the Canada-Ontario Lake Erie Action Plan to reduce phosphorous loadings. (Canada-Ontario Agreement Partners, 2018)

A key activity under the Status Component is plant performance monitoring, used to demonstrate the success of the program, track changes over time and identify plants for further optimization work. Targeted Performance Improvement establishes voluntary performance targets and applies tools for achieving them. This component can include performance-based training, technical assistance, and other activities to develop and transfer skills. The purpose of the Maintenance component is to sustain and grow the program. As part of the maintenance component, a recognition program was developed to encourage participation and to acknowledge plants that:

- Participate in the WWOP,
- Apply CCP concepts,
- Meet all the effluent compliance limits stated in their Environmental Compliance Approval (ECA),
- Adopt and achieve voluntary effluent quality performance targets,
- Participate in enhanced annual reporting (per capita loading, sludge accountability, etc.) and,
- Conduct annual sludge accountability analysis or water balance for lagoon systems.

The recognition awards based on 2024 plant data will be presented in the fall of 2025.

Additionally, the WWOP area-wide model includes a Transfer element to share and encourage other jurisdictions to adopt this approach.

Data Collection Methodology

Voluntary performance reporting across the watershed was initiated through several workshops that were held in 2010 and 2011 that brought wastewater operators, supervisors and managers together from communities within the watershed. These workshops provided information on optimization using the CCP and training on some of the tools used to evaluate WWTP performance. Workshop participants, with the assistance of peer facilitators, were encouraged to carry out the following performance calculations using their own plant data for 2012:

- Annual Average Daily Flow (ADF) as a percentage of Nominal Design Flow (NDF),
- Per capita influent flow,
- Ratio of peak day flow to ADF,
- Per capita TBOD, total suspended solids (TSS), and total Kjeldahl nitrogen (TKN) loading to the plant, and
- The ratios of TSS to TBOD and TKN to TBOD in the raw influent.

Additional workshops were held throughout 2012-2024 to review these performance metrics. Participants across the watershed were encouraged to calculate these metrics on an annual basis, report the information back to the GRCA, as well as include them in performance reports to the MECP.

In addition to the metrics listed above, plant staff voluntarily submitted plant performance data including effluent TP and TAN concentrations. An Excel spreadsheet template was provided to plant owners and operators for data submission.

This report summarizes 2024 plant data and compares it to 2012-2023 data.

Wastewater Treatment Plant Reporting and Performance

Data Reporting

For 2024, 28 of the 30 WWTPs voluntarily reported data to the GRCA using an Excel spreadsheet template. In presenting summaries of the data in the following sections, the plants are ranked from largest to smallest in terms of flow treated.

Final Effluent Quality

Total Phosphorus (TP)

TP is being targeted for improvement in the WWOP since “a high concentration of phosphorus in most rivers and streams in the Grand River watershed has long been recognized as an issue as it is the primary nutrient that promotes nuisance growth of aquatic plants and algae in the rivers” (GRCA WMP Project Team, 2014). Over the past decade, zones of low oxygen, as a result of excessive algal growth, have been increasing in Lake Erie causing significant impact on the lake’s environment and Canadian economy (Canada-Ontario Agreement Partners, 2018). In early 2018, the Canada-Ontario Lake Erie Action Plan on achieving phosphorus loading reductions in Lake Erie from Canadian sources was finalized. According to 2003-2013 data, “Canadian sources contribute 54 percent of the total phosphorus load to the eastern basin, with the majority of this coming from one tributary - the Grand River” (Canada-Ontario Agreement Partners, 2018). This is another important reason to reduce phosphorous levels in the Grand River and its tributaries.

Total Ammonia Nitrogen (TAN)

Nitrate and ammonia can have direct toxic effects on aquatic life at high concentrations and TAN acts as an oxygen scavenger that reduces the dissolved oxygen (DO) concentration in water. TAN is being targeted under the WWOP since “high levels of un-ionized ammonia occur in the Grand River watershed in reaches downstream of wastewater treatment plants” (GRCA WMP Project Team, 2014). Un-ionized ammonia is the toxic component of total ammonia nitrogen. As the pH and temperature increase, the amount of un-ionized ammonia increases as well.

Voluntary Effluent Quality Performance Targets

The Grand River Water Management Plan recommends that “watershed municipalities who own WWTPs adopt voluntary effluent quality performance targets that go beyond the compliance objectives as stated in ECAs” to achieve the goal of improved water quality in the watershed (GRCA WMP Project Team, 2014). The proposed voluntary effluent targets are set out in Table 4. The TP targets were established based on demonstrated performance across the province and within the watershed for various levels of treatment (e.g., separate targets were established for secondary and tertiary treatment). Since nitrification is less effective in colder temperatures, there are different targets for TAN in “summer” (May to October) and “winter” (November to April) periods.

Table 4: Voluntary effluent quality performance targets for TP and TAN

Treatment Type	TP Target (monthly average mg/L)	Summer[1] TAN Target (monthly average mg-N/L)	Winter[1] TAN Target (monthly average mg-N/L)
Lagoon	0.30	Meet ECA objectives, if any	Meet ECA objectives, if any
Tertiary Lagoon	0.15	Meet ECA objectives, if any	Meet ECA objectives, if any
Secondary	0.30	1.0	2.0
Tertiary	0.15	1.0	2.0

Notes: [1] “summer” is May to October, “winter” is November to April

Figure 7 shows the number of plants meeting the TP and TAN targets in all months of discharge, from 2012 to 2024. In 2024, 28 plants reported their monthly final effluent TP and TAN and of those plants, 11 met the TP target in each month and 19 met the TAN target in each month. Table 5 shows the percentage of months the TP and TAN targets were achieved in 2024 for each plant. The Table 5 cells are colour-coded with, green cells showing that the targets were achieved in more than 90% of the months of discharge, yellow cells showing that the targets were achieved between 50% to 90% of the months of discharge and the red cells showing that the targets were met in less than 50% of the months of discharge. Blank cells are plants with no TAN target. Achieving the targets can vary from year to year, due to changing factors such as staffing, weather conditions, equipment maintenance or operating costs. This shows the need for ongoing engagement of WWOP to support plants.

Figure 8 shows the proportion of months that all plants combined met the TP and TAN targets from 2012 to 2024. A percentage is used because some plants do not discharge year-round. Additionally, there are two plants that do not have a target for TAN. As presented in Figure 8, the TP targets were achieved 62% in 2012 and 75% in 2024 respectively. Overall, the achievement of TAN targets has improved 16% since the start of the program from 75% in 2012 to 87% in 2024. The ultimate goal is to meet the voluntary targets 100% of the time.

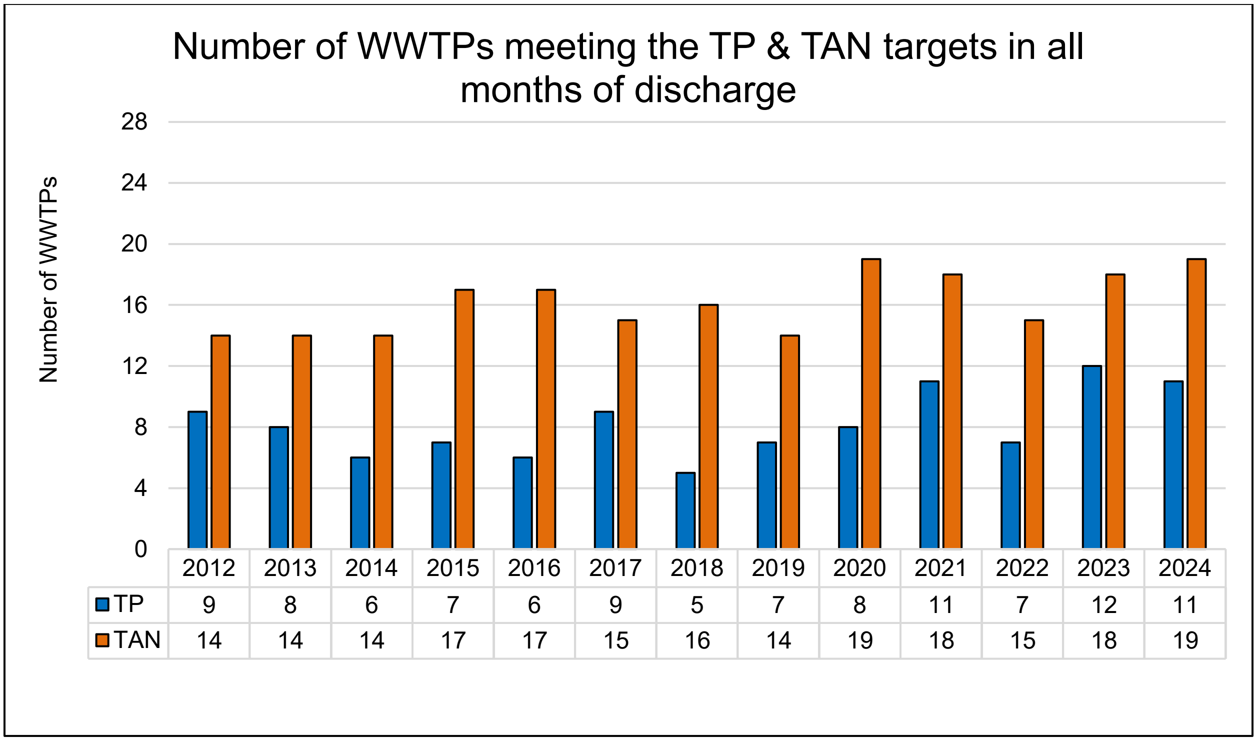


Figure 7: Number of plants meeting TP and TAN targets in all months of discharge (2012-2024)

Table 6 shows the annual average effluent TP loadings from all WWTPs combined for the years 2012 to 2024, as well as flow-weighted TP concentrations. For most plants, the TP loading was calculated based on the product of each plant’s monthly average flow and its corresponding monthly average effluent TP concentration. For plants that did not report monthly data, the TP loading was based on the annual average flow and TP concentration. The flow-weighted concentrations were calculated by dividing the total combined loading by the total average flow. In 2024, total phosphorus (TP) loading decreased by 4% compared to 2023. This reduction was largely due to improved removal at several major WWTPs in the watershed, including those in Kitchener, Waterloo, and Galt, as well as facilities in Haldimand County such as the Caledonia, Cayuga, and Dunnville WWTPs. The flow-weighted concentrations in 2024 were also lower than the previous year. From 2012 to 2024 the TP loadings and flow-weighted concentrations have dropped by 38 and 45%, respectively.

Table 5: Percentage of months plants met TP and TAN targets in 2024.

WWTP	TP	TAN
Kitchener	67%	100%
Brantford	100%	100%
Guelph	100%	92%
Waterloo	42%	100%
Galt	0%	58%
Preston	83%	100%
Hespeler	42%	25%
Fergus	17%	50%
Elmira	75%	100%
Paris	92%	100%
Caledonia	100%	100%
Dunnville	100%	83%
New Hamburg	92%	100%
Elora	17%	100%
Ayr	100%	100%
Arthur	88%	100%
Dundalk	100%	No target
Grand Valley	100%	100%
St. George	67%	83%
St. Jacobs	83%	100%
Cayuga	100%	100%
Wellesley	67%	100%
Mapleton	100%	100%
Plattsville	67%	100%
Drumbo	33%	75%
Cainsville	100%	No target
Conestogo	100%	100%
Heidelberg	67%	100%

Voluntary Targets

A study modelling future river water quality conditions suggests that water quality will incrementally improve with the adoption of effluent quality performance targets achieved through enhanced process control techniques as set out in the CCP." (Project Team, 2014

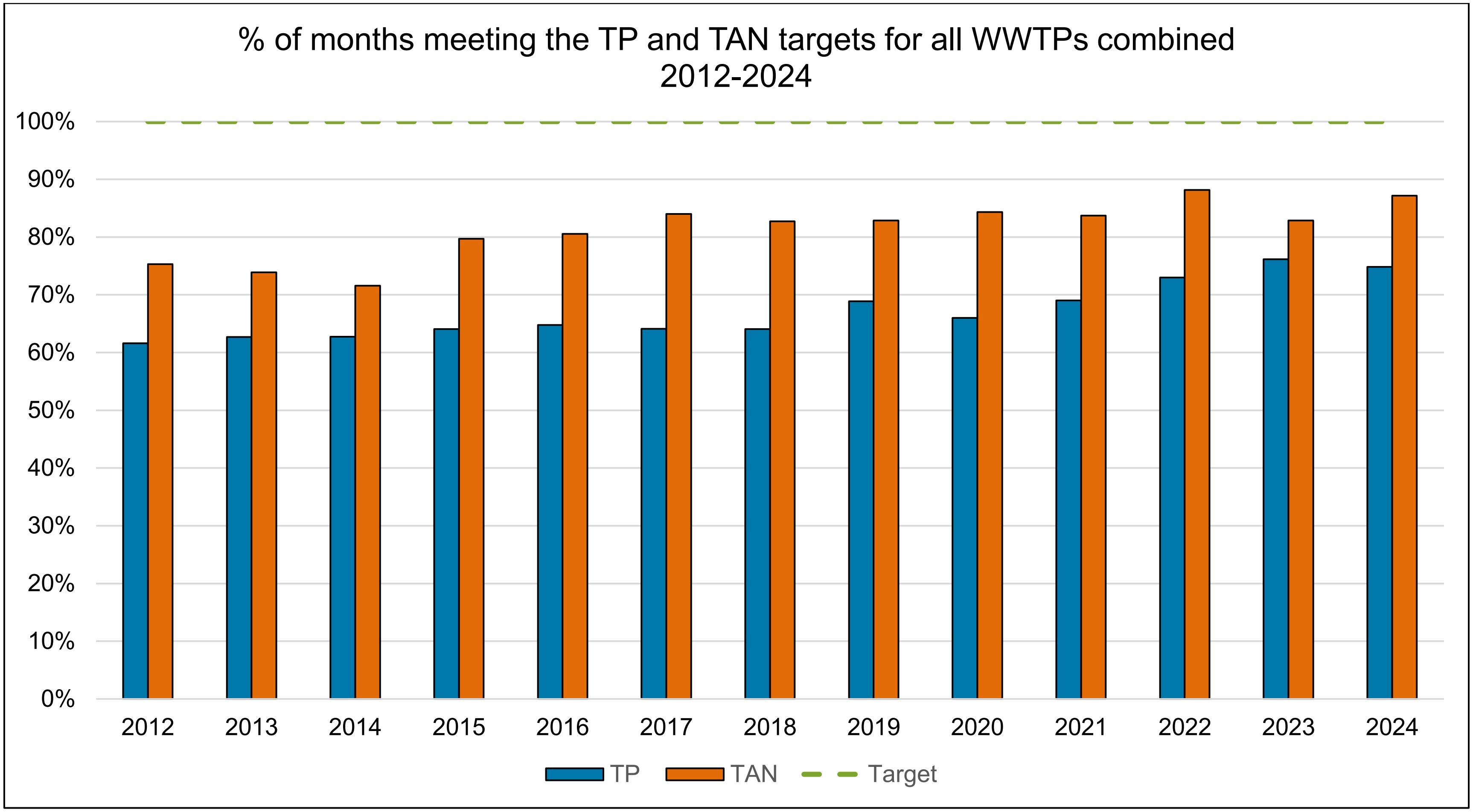


Figure 8: Percentage of months meeting the voluntary targets for all plants combined from 2012-2024

Table 6: Wastewater effluent TP loading and flow-weighted concentration to the Grand River

Year	TP Loading (tonne)	TP Flow-Weighted Concentration (mg/L)	TP Flow-Weighted Target (mg/L)
2012	36.0	0.37	0.24
2013	37.7	0.35	0.24
2014	36.8	0.33	0.24
2015	36.5	0.37	0.24
2016	33.8	0.33	0.24
2017	32.5	0.30	0.24
2018	29.8	0.29	0.24
2019	26.5	0.26	0.24
2020	21.4	0.22	0.20
2021	22.2	0.22	0.21
2022	21.1	0.21	0.21
2023	23.3	0.22	0.21
2024	**22.4**	**0.20**	**0.21**

The watershed-wide flow-weighted concentration target for TP is calculated by multiplying each plant's average daily flow (ADF) by its corresponding TP target, summing these values, and dividing by the total ADF. This target may vary from year to year as annual ADF changes. As shown in Table 6, 2024 marks the first time since the program began summarizing data in 2012, the flow-weighted concentration fell below the target. However, significant room for improvement remains, as several of the largest plants are still not meeting their individual targets.

The total annual loading of wastewater effluent TAN discharged to surface water and corresponding flow-weighted concentrations are documented in Table 7, which shows the TAN loadings separated into summer and winter periods.

From 2023 to 2024, summer total ammonia nitrogen (TAN) loadings decreased by 49%, largely due to improved performance at the Guelph, Kitchener, Dunnville, Galt, and Waterloo wastewater treatment plants (WWTPs). In contrast, winter TAN loadings increased by 20% during the same period. Since 2012, annual total TAN loadings have decreased by 93%, and flow-weighted concentrations declined by 94%. As shown in Table 7, both the summer and winter flow-weighted concentrations are below the TAN targets of 1 mg/L for summer and 2 mg/L for winter, respectively.

Table 7: Wastewater effluent TAN loading and flow-weighted concentrations to the Grand River

Year	TAN summer Loading (tonne)	TAN summer Conc.* (mg/L)	TAN summer Target Conc.* (mg/L)	TAN winter Loading (tonne)	TAN winter Conc.* (mg/L)	TAN winter Target Conc.* (mg/L)	TAN Annual Loading (tonne)	TAN Annual Conc.* (mg/L)
2012	417	9.0	**1**	534	10.6	**2**	951	9.8
2013	346	6.7	**1**	426	7.6	**2**	773	7.2
2014	343	6.2	**1**	512	9.2	**2**	855	7.7
2015	206	4.2	**1**	353	7.0	**2**	560	5.6
2016	124	2.6	**1**	223	4.0	**2**	347	3.3
2017	77	1.5	**1**	182	3.3	**2**	259	2.4
2018	49	1.0	**1**	97	1.7	**2**	146	1.4
2019	31	0.6	**1**	118	2.3	**2**	149	1.5
2020	15	0.3	**1**	54	1.0	**2**	70	0.7
2021	24	0.5	**1**	44	0.9	**2**	68	0.7
2022	14	0.3	**1**	44	0.9	**2**	58	0.6
2023	31	0.6	**1**	44	0.8	**2**	75	0.7
2024	16	0.3	**1**	53	0.9	**2**	69	0.6

*all concentrations are flow-weighted average concentrations

Influence of WWTPs on the Grand River

TP Loading to Lake Erie from Grand River

Figure 9 shows the estimated TP loading to Lake Erie from the Grand River at York[1] (shown in blue) and the annual TP load from WWTPs (shown in orange) in the Grand River watershed,

[1] York, in Haldimand County, is the location of GRCA's southern-most flow monitoring station on the Grand River. Annual loadings from the Grand River to Lake Erie are calculated by Environment and Climate Change Canada and made available on-line through the Environment Canada Data Catalogue

from 2012 to 2024. The annual load from the Grand River to Lake Erie is highly variable because of high flows and agricultural non-point sources of phosphorus in the spring which are closely linked to climate factors such as precipitation, the timing/volume of snow melt, etc.

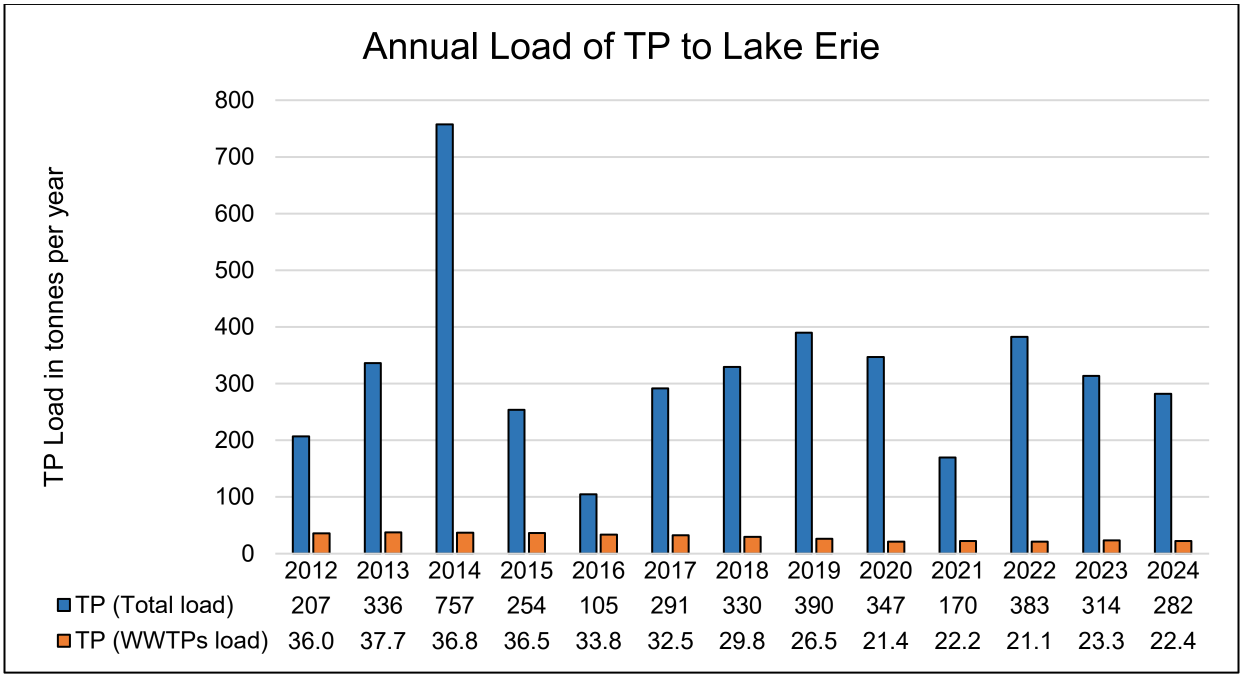


Figure 9: Annual TP Load to Lake Erie at York

Over the 12-year period from 2012 to 2024, TP loading from York averaged 324 tonnes per year and ranged between 105 tonnes per year (in 2016) to 757 tonnes per year (in 2014). The TP load from WWTPs in the watershed ranged from 21.1 to 37.7 tonnes per year, averaging 30 tonnes per year, or about 12% of the Grand River's TP load to Lake Erie. In 2024, the total TP load to Lake Erie declined to 282 tonnes, down from the previous year, with WWTPs contributing 22.4 tonnes.

Precipitation

Figure 10 shows total precipitation (i.e. snow and rain) at selected sites in the watershed. In 2024, January to July and December were wetter than normal, with precipitation exceeding the long-term average. In contrast, conditions from August to November were generally drier than normal. The spring melt occurred early, during the winter season, leading to peaks in streamflow in January and February 2024. Despite this early melt, the highest flows in the Grand River were recorded in mid-April, driven by spring rainfall rather than snowmelt. During the summer, flow conditions were slightly above typical low-flow levels due to a few rain events in mid-July and early August. In contrast, fall monitoring conditions aligned with typical low-flow patterns. Over longer periods (12 to 18 months) recorded precipitation remained close to or slightly above the long-term average overall (Anderson, et al., 2024).

Table shows the relative influence of wastewater effluent on the Grand River by comparing the total volume of treated effluent in each of the years from 2012 to 2024 to the annual average river flow at York for the same years. In addition, Table 8 also contains a statement characterizing the precipitation in each year with respect to the long-term average precipitation in the watershed.

Table 8: WWTP effluent flow as a percentage of Grand River total flow over 2012-2024 period.

Year	Precipitation Characterization*	% Annual Average Flow	% August Average Flow
2012	Low end of typical	6.8%	13.9%
2013	Higher than typical in some areas	3.1%	5.4%
2014	Long-term average	2.6%	9.5%
2015	Low end of typical	5.0%	11.5%
2016	Long-term average	4.7%	9.0%
2017	Higher than typical	3.5%	7.3%
2018	Long-term average	3.6%	8.7%
2019	Higher than typical	3.6%	10.3%
2020	Long-term average	4.7%	11.7%
2021	Long-term average	5.1%	12.6%
2022	Low end of typical	5.5%	14.5%
2023	High end of typical	5.0%	7.1%
2024	Long-term average	5.3%	8.5%
	Overall Average	**4.5%**	**9.9%**

* (Shifflett, 2012) (Shifflett, 2013) (Shifflett, 2014) (Shifflett, 2016) (Shifflett, 2017) (Shifflett, 2018) (Shifflett, 2019) (Shifflett, 2020) (Shifflett, 2021) (Shifflet, 2022) (Taleban, 2023), (Anderson et al., 2024).

The volume of treated effluent ranges from 2.6% to 6.8% of the total river flow on an annual average basis. By comparison, based on low-flow conditions observed in the month of August, under summer low-flow, the proportion of treated effluent ranges more widely from 5.4% to 14.5% of the river flow. This shows that the influence of WWTP flow on the river varies from year to year depending on precipitation.

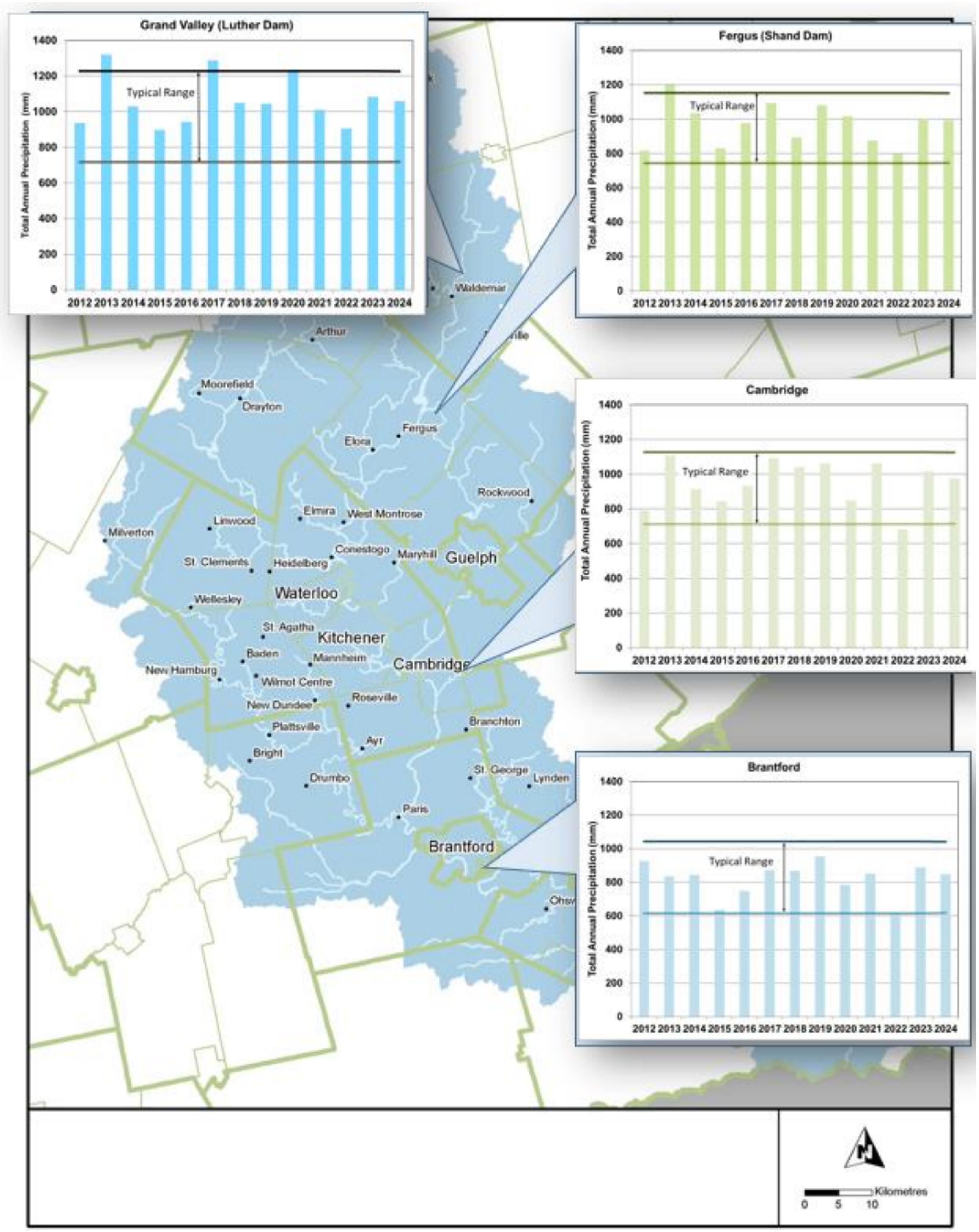


Figure 10: Total annual precipitation (in mm) at selected locations across the watershed. Typical range is based on 5th and 95th percentile of historical observations over the past 50 years.

Recent Studies

Since 2007, the Region of Waterloo has implemented a comprehensive surface water quality monitoring program upstream and downstream of its WWTPs. The program is designed to assess whether effluent discharges are affecting the Grand River and its tributaries, and to track how those impacts may change over time. Monitoring results have shown that some Regional WWTPs, particularly the larger facilities, can have measurable impacts on water quality, especially during the summer and fall when river flows are typically low. A 2024 surface water chemistry study conducted by LGL Limited, identified elevated concentrations of TP and TAN at stations downstream of the four major WWTPs in the Region: Waterloo, Kitchener, Galt, and Hespeler (LGL Limited, 2025). Seasonal comparisons of upstream and downstream TP and TAN concentrations for these facilities are presented in Table 9. Key findings from 2024 include:

- Winter: Elevated TP and TAN concentrations were observed downstream of the Waterloo and Hespeler WWTPs.
- Spring (high flows): No significant differences in TP or TAN concentrations were observed between upstream and downstream locations.
- Summer (low flows): Elevated TP concentrations were observed downstream of the Waterloo and Hespeler WWTPs.
- Fall: TP concentrations were elevated downstream of the Galt and Hespeler WWTPs, while elevated TAN concentrations were noted downstream of the Waterloo WWTP.

Table 9: Summary of 2024 River Water Quality Monitoring Upstream and Downstream of Select WWTPs (adapted from LGL Limited (2025)

WWTP	TP	TAN
Waterloo	**Winter**: ↑ Spring: ↔ **Summer**: ↑ Fall: ↔	**Winter**: ↑ Spring: ↔ Summer: ↔ **Fall**: ↑
Kitchener	Winter: ↔ Spring: ↔ Summer: ↔ Fall: ↔	Winter: ↔ Spring: ↔ Summer: ↔ Fall: ↔
Galt	Winter: ↓ Spring: ↔ Summer: ↓ **Fall**: ↑	Winter: ↔ Spring: ↔ Summer: ↓ Fall: ↔
Hespeler	**Winter**: ↑ Spring: ↔ **Summer**: ↑ **Fall**: ↑	**Winter**: ↑ Spring: ↔ Summer: ↔ Fall: ↔

Note: ↔ indicates there is no statistically significant difference between upstream reference condition and downstream monitoring stations concentration, ↑ indicates significantly higher concentrations identified at monitoring stations downstream compared to upstream reference condition, ↓ indicates significantly lower concentrations found at stations identified compared to the upstream reference condition.

Total Phosphorus (TP) Study

The GRCA undertook a technical study between November 2023 and September 2024, focusing on six facilities that consistently meet the (GRCA's voluntary TP targets. The study captured key phosphorus removal performance metrics, including the chemical costs associated with achieving these targets. The primary objective was to collect and share insights from these high-performing plants to help other facilities across the watershed improve their ability to meet effluent TP targets.

The study began with data collection through an Excel template sent to each participating plant (Guelph, Kitchener, Preston, Brantford, Caledonia, and Cayuga) to compile key information from 2023. Site visits were conducted at five plants, where the WWOP team met with staff to explain the study approach, review collected data and discuss expected outcomes. The visits also included plant tours, spot checks of coagulant dosing, sampling of raw and final effluent for dissolved reactive phosphorus, and staff interviews to document operational practices for meeting GRCA effluent targets.

Upon completion of the study, a comprehensive report was prepared outlining key operational practices that contribute to effective and consistent TP removal (Tolnai, et al., 2025). These practices were grouped into three main categories:

1. Sampling and Testing,
2. Chemical Dosing Spot-Checks, and
3. Data Review and Process Adjustment.

Key Conclusions and Recommendations: To consistently meet the GRWWOP targets, the following actions are required:

1. Operations staff are knowledgeable about and committed to achieving the TP targets.
2. Plants follow standardized procedures for sampling, testing, chemical dosing, and process adjustments.
3. Effluent total suspended solids (TSS) concentrations are maintained at low levels, as phosphorus bound to these particles is removed along with them.
4. Dissolved Reactive Phosphorus (a phosphorus test on an effluent sample which is filtered but not digested) is the best parameter for optimizing chemical dosage as it is a

direct measure of soluble, bioavailable phosphorus (The Water Research Foundation, 2015).

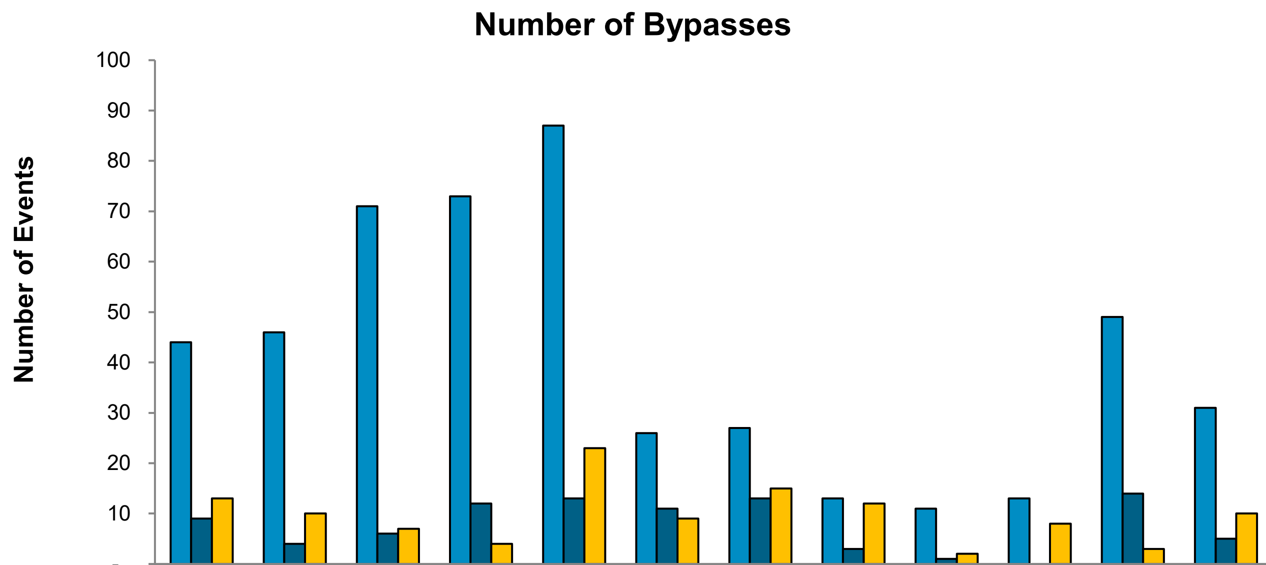
5. Phosphorus concentrations should be reported as “mg/L P” instead of “mg/L PO_4” or a combination of the two. Since compliance limits are established in terms of “mg/L as P,” the U.S. EPA recommends using this reporting convention (US EPA, 2012).
6. Because coagulants differ in metal content, dosage comparisons from plant to plant should be based on metal ion concentrations (mg/L).
7. Higher coagulant dosages increase chemical sludge production, which affects overall operating costs.
8. The cost of TP removal ($/kg TP) varies depending on:
    - Treatment level (secondary vs. tertiary),
    - Type of chemical used, and
    - Coagulant supplier and market conditions.

These findings provide guidance for optimizing phosphorus removal processes, reducing chemical costs and phosphorus discharges, and ensuring compliance with both provincial regulations and GRCA’s voluntary targets.

As a follow-up to the study, the WWOP met with the six participating plants in August 2025 to review the findings, discuss key observations, and plan next steps. A copy of this report is available on the GRCA website under the Wastewater Optimization Program, Case Studies section.

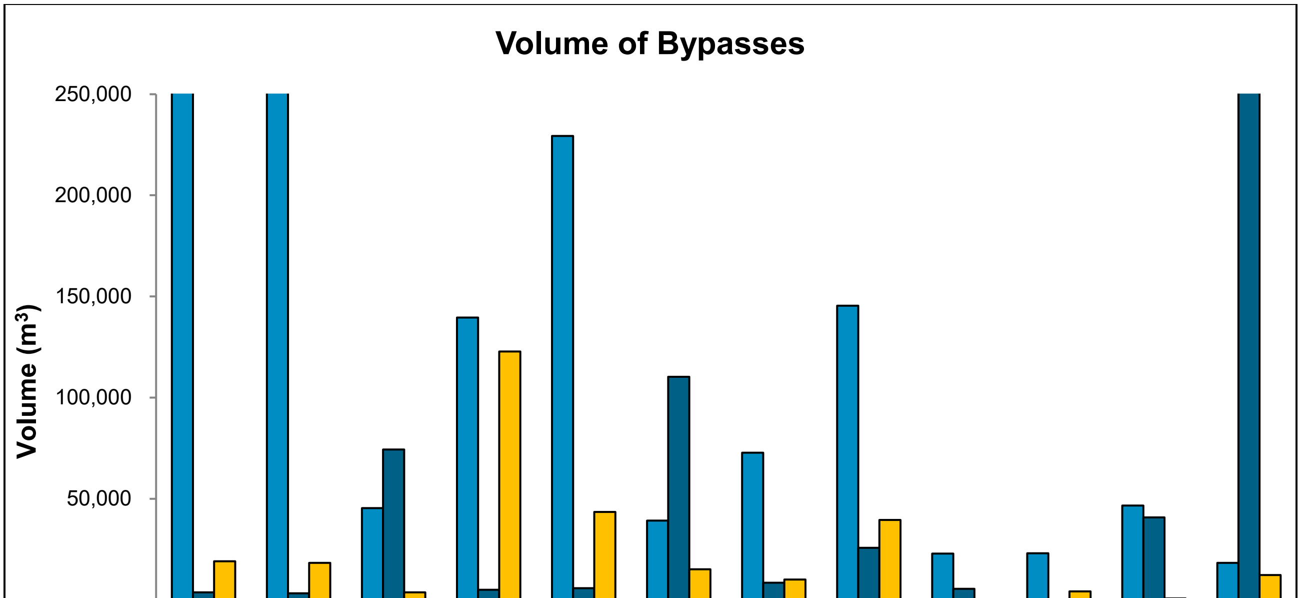
Bypasses and Overflows

Bypasses are a diversion of sewage around one or more treatment processes. The diverted sewage is combined with treated effluent at the point of discharge. Overflows are discharges to the environment from the WWTP at a location other than the effluent discharge point. Bypasses and overflows can be caused by equipment failure, power outage, weather-related events, etc. and can be classified as low, moderate, or high according to the level of risk to downstream users. In the Grand River watershed, one of the most sensitive downstream uses is the use of river water as a source for drinking water. The risk categories were developed based on the professional judgment of the Grand River Municipal Water Managers Working Group (Grand River Municipal Water Managers Working Group, 2009). For example, a bypass that has received secondary treatment and disinfection is considered low risk, whereas a bypass that has received secondary treatment without disinfection is classed as moderate risk. A high-risk bypass or overflow, for example, occurs when raw sewage is discharged to the environment without disinfection. Figure 11 presents the number of low, moderate, and high-risk bypasses from WWTPs in the Grand River watershed between 2013 and 2024. Low-risk bypasses decreased from 49 in 2023 to 31 in 2024. Moderate-risk bypasses declined from 14 in 2023 to 5 in 2024. In contrast, high-risk bypasses increased from 3 in 2023 to 10 in 2024. Figure 12 illustrates the total volume of bypasses in 2024, most of which were attributed to weather-related events that produced high peak day flows to the WWTPs.



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
low	44	46	71	73	87	26	27	13	11	13	49	31
moderate	9	4	6	12	13	11	13	3	1	-	14	5
high	13	10	7	4	23	9	15	12	2	8	3	10

Figure 11: Number of low, moderate, and high-risk bypasses from 2013-2024



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
low	1,133,8	1,132,7	45,437	139,538	229,320	39,250	72,739	145,406	22,858	23,062	46,607	18,298
moderate	3,786	3,211	74,364	5,063	5,807	110,275	8,470	25,667	5,528	-	40,711	440,489
high	19,040	18,241	3,697	122,775	43,499	15,161	10,139	39,579	270	4,133	735	12,309

Figure 12: Volume of low, moderate, and high-risk bypasses from 2013-2024

Data Integrity Checks

Several data integrity checks were used to determine if the monitoring conducted at a WWTP is truly representative of plant performance. A sludge accountability analysis for mechanical activated sludge plants compares the amount of sludge reported to the amount of sludge projected based on plant loadings and removals, on an annual basis. The reported sludge includes sludge intentionally wasted by the operator to control the biological process and unintentional wasting (i.e., solids lost from the plant in effluent TSS). Projected sludge can include an estimate of primary sludge, biological sludge generated by the conversion of organics to biomass, and chemical sludge (i.e., solids produced as a result of coagulant addition). The formula to calculate sludge accountability is as follows:

$$\frac{projected\ sludge - reported\ sludge}{projected\ sludge} * 100\%$$

If the result is within a range of ± 15%, the sludge accountability is considered to “close” (US EPA, 1989). If the value is outside of this range, then the monitoring may not be truly representative of plant loading or performance. In the case of sludge accountability that does not close, further investigation is warranted to review sample frequency, sampling techniques, analytical methods, flow measurement accuracy, etc.

Common sources of sludge accountability analysis discrepancy include:

- Non-representative sampling (poor sampling techniques or analytical procedures, inadequate sampling frequency, a sampling location which is not representative, etc.),
- Lack of flow measurement on some process streams or inaccurate flow measurement, and
- Neglecting to consider all inputs and outputs (e.g., no measurements on return streams such as filter backwash or digester decant, etc.).

Table 10 shows the results for 24 plants in the watershed that conducted sludge accountability for 2020-2024. For 2024, Guelph, Waterloo, Brantford, Galt, Hespeler, Fergus, Elmira, Dunnville, New Hamburg, Elora, Grand Valley, Wellesley, Drumbo, and Conestogo WWTPs have a sludge accountability analysis that closed within ±15%. Sludge accountability results for all plants, including reported and projected sludge values can be found in Appendix 1: Sludge Accountability and Water Balance Summary.

Table 10: Summary of 2020-2024 Sludge Accountability analyses

WWTP	2020	2021	2022	2023	2024
Kitchener	-14.2%	8.3%	-3.1%	-1.0%	15.5%
Guelph	-13.9%	-6.3%	9.6%	10.0%	-1.5%
Waterloo	7.5%	14.9%	-3.6%	-10.7%	-1.9%
Brantford	6.3%	-3.8%	13.5%	6.8%	13.3%
Galt	14.8%	25.7%	4.7%	-14.5%	-13.0%
Preston	-10.7%	7.8%	-7.3%	5.8%	20.8%
Hespeler	-24.4%	1.7%	9.9%	-2.5%	13.2%
Paris	-10.3%	-23.1%	13.5%	-77.5%	-119.2%
Fergus	NA	-21.6%	NA	32.3%	-3.8%
Dunnville	15.7%	0.6%	-32.2%	-36.8%	-3.3%
Elmira	-27.7%	-19.1%	-35.3%	4.6%	-2.4%
New	-100.0%	-47.6%	-17.0%	17.3%	13.1%
Caledonia	7.6%	21.6%	10.5%	18.5%	27.3%
Elora	NA	-43.1%	#NA!	27.7%	-5.7%
Ayr	-3.4%	-9.9%	19.6%	14.1%	19.9%
Arthur	NA	NA	-27.3%	NA	19.0%
Grand Valley	NA	NA	-4.0%	NA	-4.2%
St. Jacobs	-5.4%	26.3%	12.2%	-20.7%	-41.2%
Wellesley	15.4%	15.9%	12.2%	8.7%	-5.1%
Cayuga	-32.2%	-32.2%	-42.1%	-9.0%	-16.7%
St. George	NA	-36.0%	-48.3%	-79.4%	-127.1%
Drumbo	-11.0%	-4.3%	11.6%	11.8%	12.9%
Alt	-119.3%	-51.5%	-83.0%	-82.0%	-54.2%
Conestogo	53.2%	11.0%	14.7%	-6.6%	12.7%

Under the Grand River WWOP, a water balance analysis was developed for lagoon systems as a performance check since sludge accountability cannot be performed. A water balance analysis compares the difference between the measured net precipitation and the projected net precipitation and is reported as a percentage of influent flow. The measured net precipitation is based on the net precipitation and the lagoon surface area. Projected net precipitation is determined using lagoon level measurements, total influent sewage and effluent volume on an annual basis. The formula for calculating a water balance is as follows:

$$\frac{reported\ net\ precipitation - projected\ net\ precipitation}{influent\ flow} * 100\%$$

If the result is within a range of ± 15%, the water balance is considered to "close". If the value is outside of this range, then the flow measuring devices or lagoon level measurements may not be accurate. Further investigation is warranted to review all flow measuring devices and confirm their accuracy.

Table 11 shows the results for the lagoons that conducted a water balance analysis for 2020 - 2024. A detailed summary of water balance results is in Appendix 1: Sludge Accountability and Water Balance Summary. Sources of discrepancy in the calculation may include the following: inaccurate flow measurement, inaccurate surface area information, uncertainties in precipitation and/or evaporation data and error in lagoon storage measurements.

Table 11: Summary of 2020-2024 Water Balance analyses of lagoons

Lagoon	2020	2021	2022	2023	2024
Dundalk	10.4%	6.4%	15.6%	17.0%	14.4%
Drayton	NA	NA	NA	NA	2.6%
Plattsville	-6.5%	13.8%	11.2%	0.0%	6.5%
Cainsville	66.9%	25.9%	85.2%	83.2%	85.1%

Wastewater Treatment Plant Loading Summary

Influent flow

Figure 13 shows a summary of the average daily flow (ADF) to each plant for 2020 to 2024 compared to the Nominal Design Flow (NDF) of the plant as stated in the plant's ECA (shown in grey). Figure 13 shows three vertical scales since the nominal design of the WWTPs in the watershed vary by orders of magnitude and range from 130 m^3/d to 122,745 m^3/d. Figure 14 shows the ADF as a percentage of the NDF. In 2024, Wellesley WWTP experienced an ADF that was higher than the NDF. Since 2012 four plants have experienced ADFs higher than their NDF: Arthur (2012 to 2014 and 2017), Drumbo (2013 and 2014), Cainsville (2014 and 2023), and Wellesley (2019 and 2024). The NDF for the Arthur plant was re-rated in 2020 from 1,465 to 1,860 m^3/d, while the Drumbo plant was re-rated in 2024 from 300 to 450 m^3/d.

Another way to look at influent flow is to normalize it based on the serviced population and express it as per capita flow. Per capita wastewater flows vary from location-to-location, but typical values used in the CCP are from 350 to 500 L/person/d (US EPA, 1989). Figure 15 shows per capita flows for WWTPs in the watershed between 2020 and 2024. From this figure, plants in the Grand River watershed were generally at or below the low end of the typical range. The watershed median in 2024 was 295 L/person/day, nearly identical to the 2023 median of 296 L/person/day and represents a 5% decrease from the 2012 median of 310 L/person/day.

Some plants experience higher-than-average per capita flows for various reasons. For example, the Cainsville WWTP primarily serves industrial users, resulting in higher per capita flow rates compared to typical domestic systems. As a result, the Cainsville WWTP is excluded from the per capita and ratio figures. Other plants, such as Arthur, St. Jacobs, and Dundalk, may also show elevated flows due to significant inflow and infiltration (I/I).

Figure 16 shows the ratio of peak day flow to ADF, which is another indicator of significant I/I. The ratio or peak day flow to ADF varies from year-to-year depending on climate factors such as heavy rainfall or snowmelt events. The median ratio for plants across the watershed was 2.2 in 2024. Most plants were within the typical range of 2.5-4.0 or less. Several plants are known to experience higher I/I (such as Dundalk, Wellesley, Dunville, or Cayuga WWTP) and this is reflected in Figure 16.

Year-to-year variability in per capita flow is largely due to differences in inflow and infiltration related to precipitation. On a watershed-basis the highest per capita flows were 351 L/d per person in 2013 which was a “wet” year. The smallest per capita flows were 280 L/d per person in 2022.

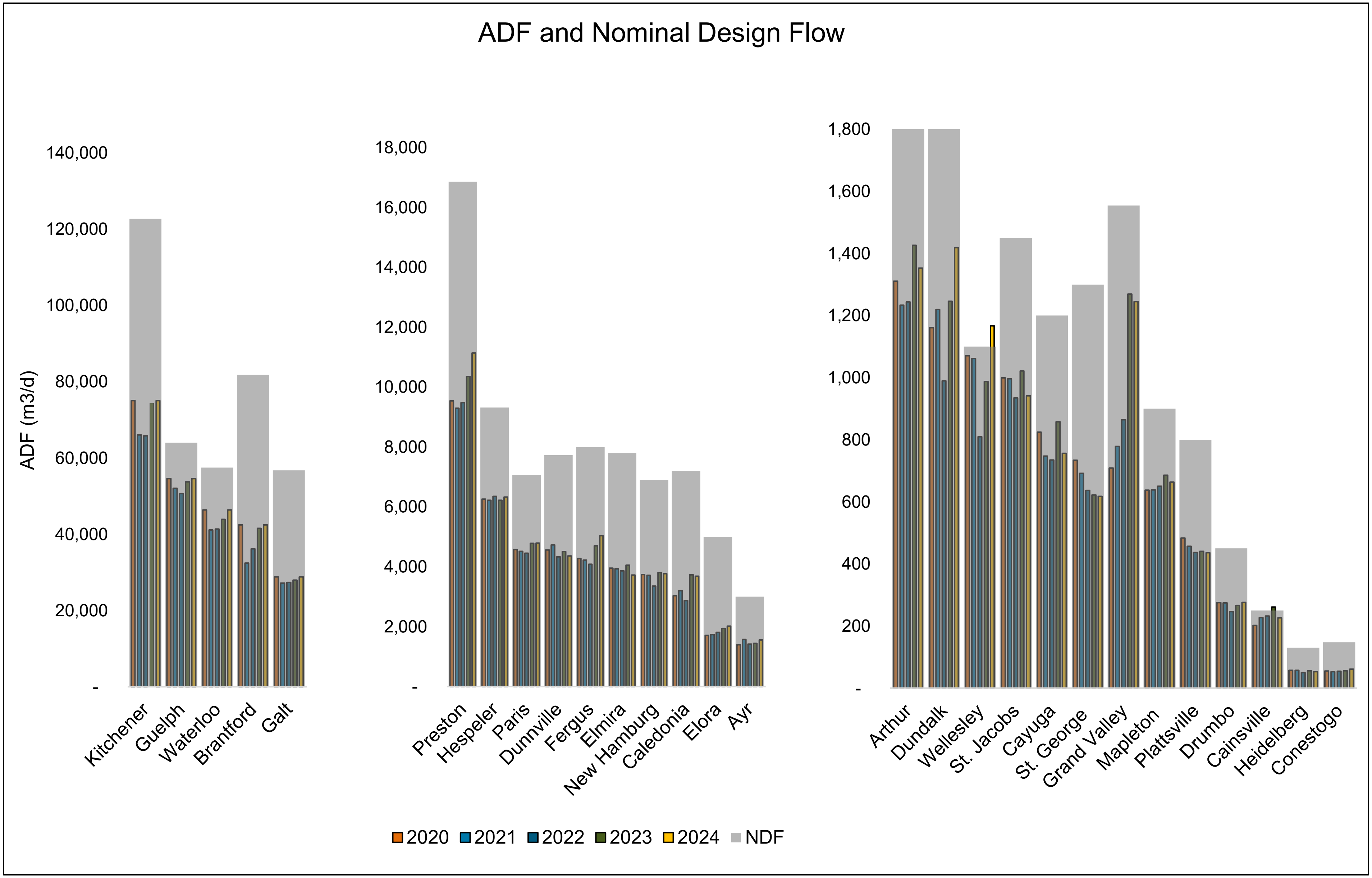


Figure 13: ADF and Nominal Design Flow of watershed WWTPs

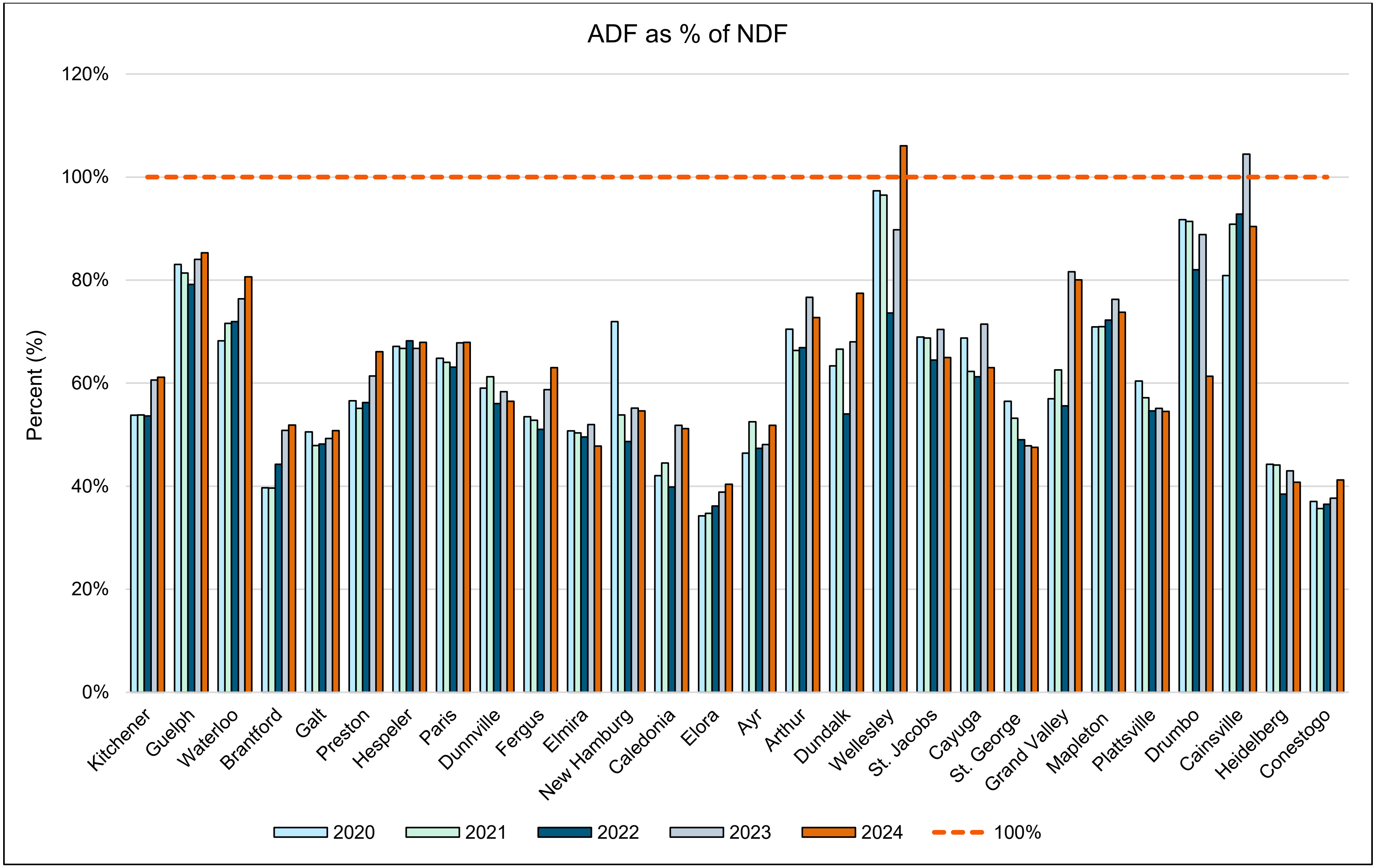


Figure 14: Annual average flow as a percentage of rated plant capacity

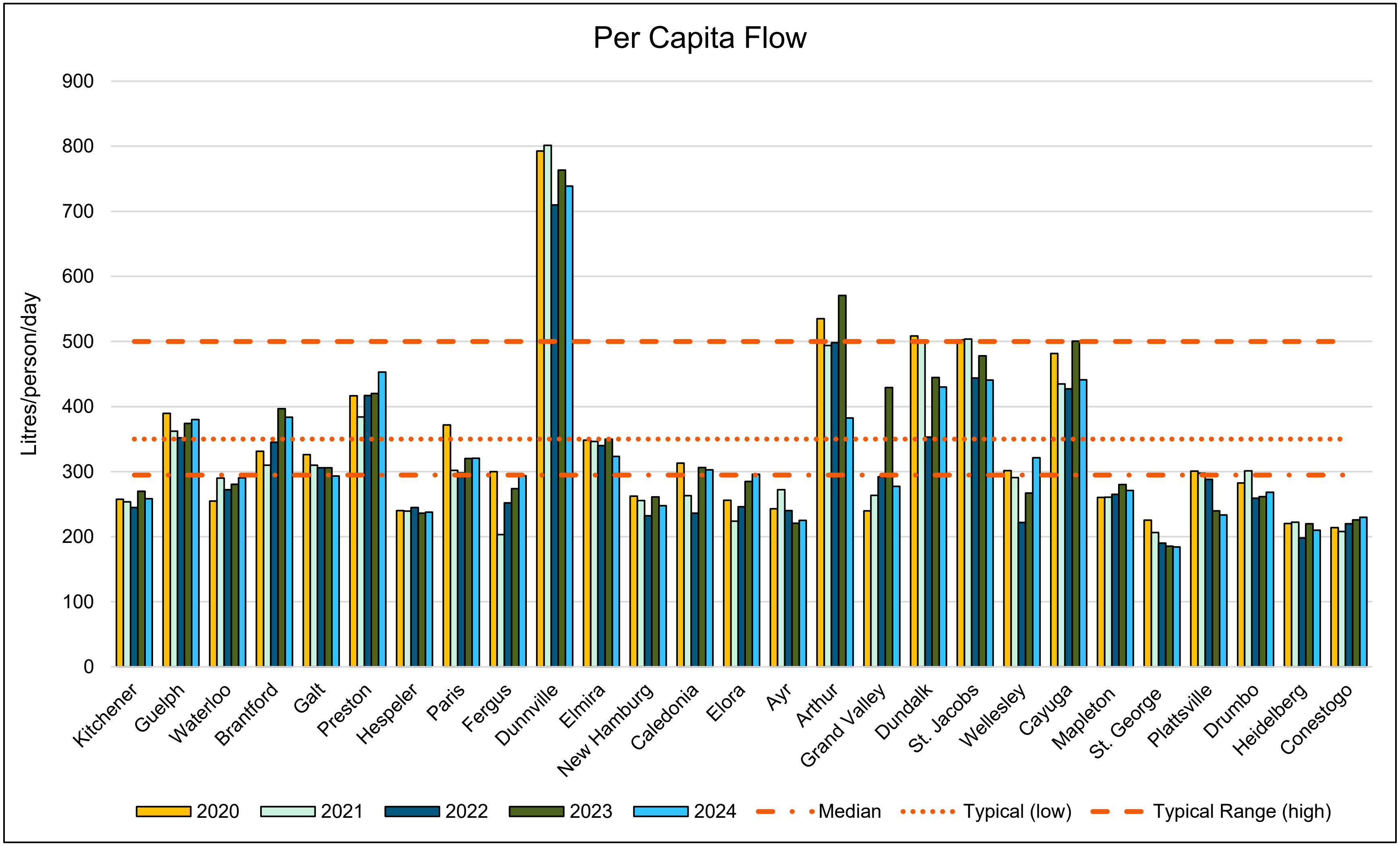


Figure 15: Per capita influent flow

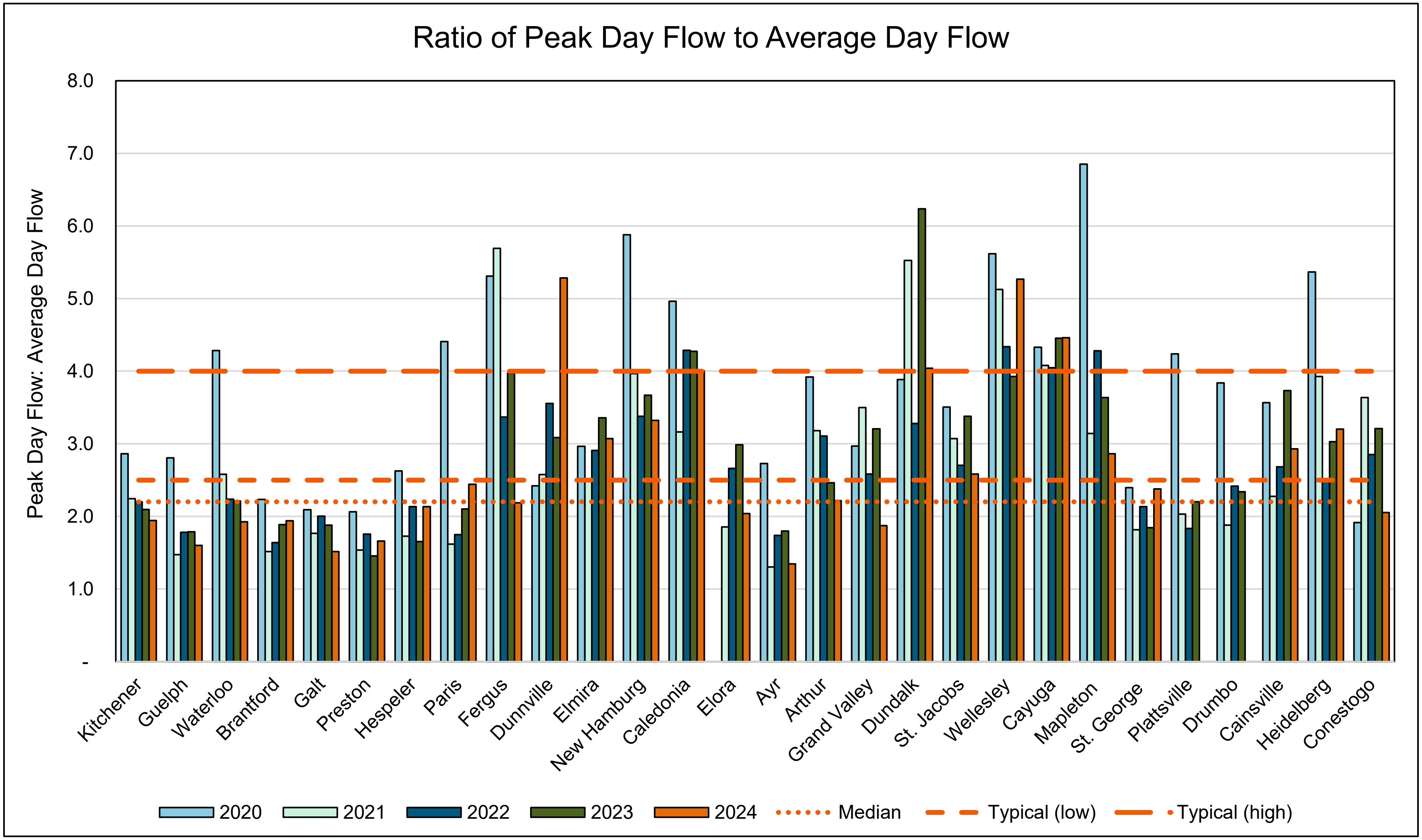


Figure 16: Ratio of peak day flow to annual average flow

Raw Influent Loads

Characterization of raw wastewater is important to ensure effective wastewater treatment, assist with future planning, and identify any issues or changes occurring in the collection system. The loading of raw influent TBOD, TSS and TKN can be calculated by multiplying raw influent concentrations by flow. These loads can be expressed on a per capita basis and compared to values typical of domestic sewage.

TBOD Loading

In 2024, all 28 plants that reported data measured raw influent TBOD. Table 11 summarizes the results of both cBOD and TBOD as reported by plants in the Grand River watershed between 2016 and 2024:

Table 12: Annual average raw influent cBOD and TBOD concentrations reported by Grand River watershed plants in 2016-2024.

Year	No. of plants reporting cBOD	No. of plants reporting TBOD	No. of plants reporting Both cBOD & TBOD	Median (mg/L) cBOD	Median (mg/L) TBOD	Range (mg/L) cBOD	Range (mg/L) TBOD
2016	18	21	11	195	208	127-389	142-411
2017	18	26	16	177	194	98-411	108-421
2018	18	26	16	182	197	94-296	112-304
2019	18	24	16	177	211	92-269	107-311
2020	17	23	14	192	203	81-322	88-396
2021	21	28	18	199	208	89-360	134-378
2022	19	28	19	214	251	113-366	134-393
2023	19	28	19	219	221	93-364	139-417
2024	20	28	19	218	224	129-358	143-523

Albertson (1995) has documented that the cBOD test underestimates the strength of raw wastewater by 20-40% (Albertson, 1995). In 2024, 19 of 28 reporting plants in the watershed measured both cBOD and TBOD. The average TBOD:cBOD ratio among these plants is 1.10. A factor of 1.2 was used for estimation in previous years.

Figure 17 shows estimated per capita TBOD loads for plants in the Grand River watershed. A typical value for domestic wastewater is 80 g/person/d (US EPA, 1989). The reported median for 2024 is 66.6 g/person/day, slightly lower than the 2023 median of 68.8 g/person/day, and below the GRCA long-term average of 69.1 g/person/day.

Per capita TBOD loads that are much higher or much lower than the typical value should be further investigated to see if there is a reasonable explanation for the discrepancy. In some cases, industrial contributions may result in elevated per capita TBOD loads. However, atypical TBOD loads may also be related to inadequate sampling frequency, non-representative sampling, errors in flow metering or population estimates, etc.

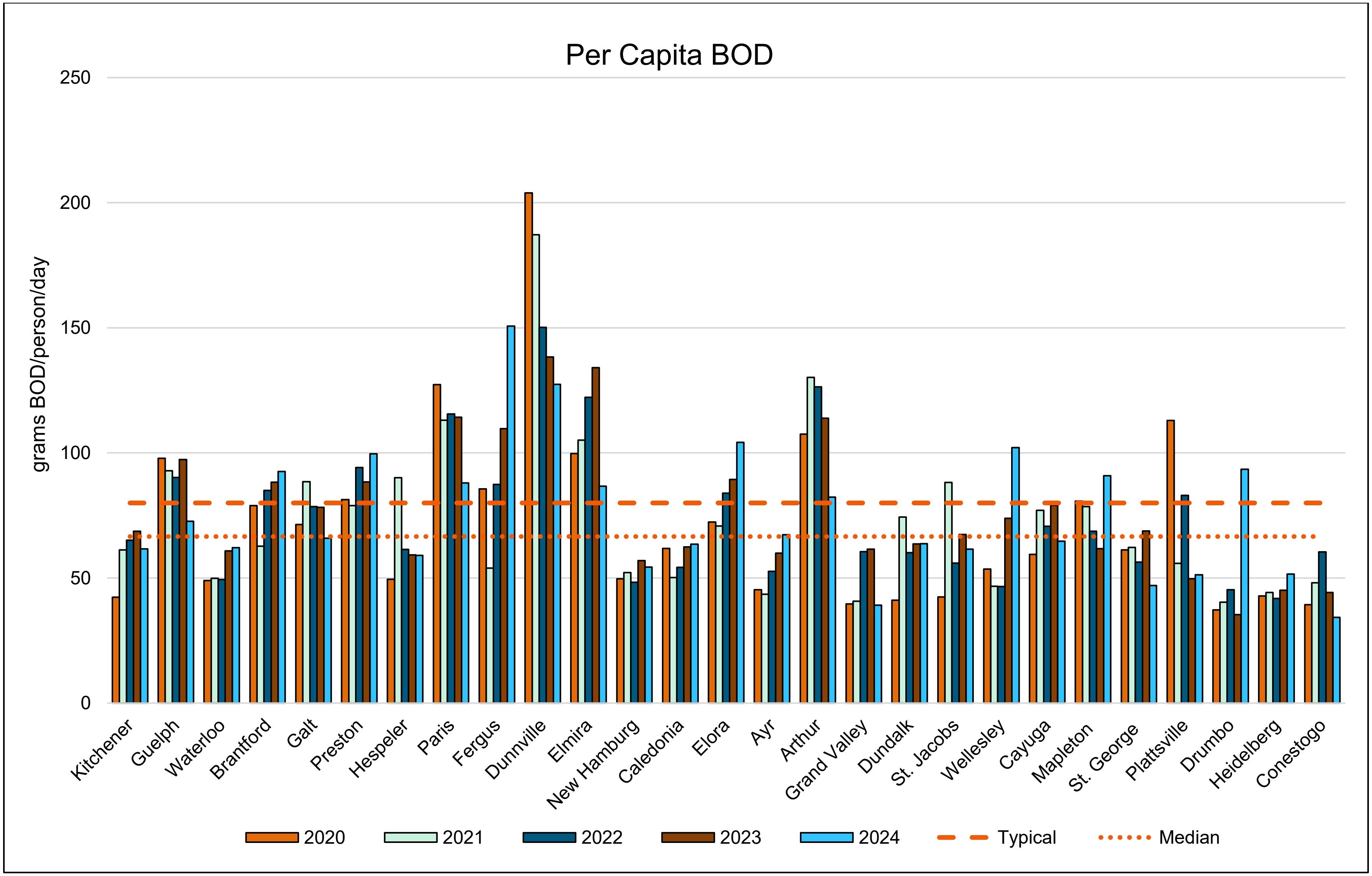


Figure 17: Per Capita TBOD Load

TSS Loading

TSS loads in raw influent for 2020 to 2024 are summarized in Figure 18. The 2024 watershed median was 75 g/person/d, which is less than the typical value of 90 g/person/d (US EPA, 1989). Where the loads are significantly less than typical, it brings into question the adequacy of raw influent sampling to accurately characterize the influent. Higher than expected loads may be attributed to industrial inputs and/or internal recycle streams.

TKN Loading

Figure 19 shows per capita TKN loads to plants in the watershed. The watershed median was 13.2 g/person/d for 2024 which is slightly higher than the typical value of 13 g/person/d (WEAO, 2010). Several plants (such as Dundalk, Elmira, Galt, Mapleton and Preston) reported TKN loads that are higher than expected and in most cases the per capita TSS and/or estimated TBOD loads were also high. A small number of plants had TKN, TSS and TBOD loads that were less than typical. Further investigation, such as characterization of raw influent and recycle streams and review of population estimates, may be helpful when per capita loadings are outside the typical range.

TP Loading

Figure 20 shows the TP loads in the raw influent for 2020 to 2024. The watershed median for 2024 was 1.7 g/person/d. This is less than the typical value of 2.1 g/person/d.

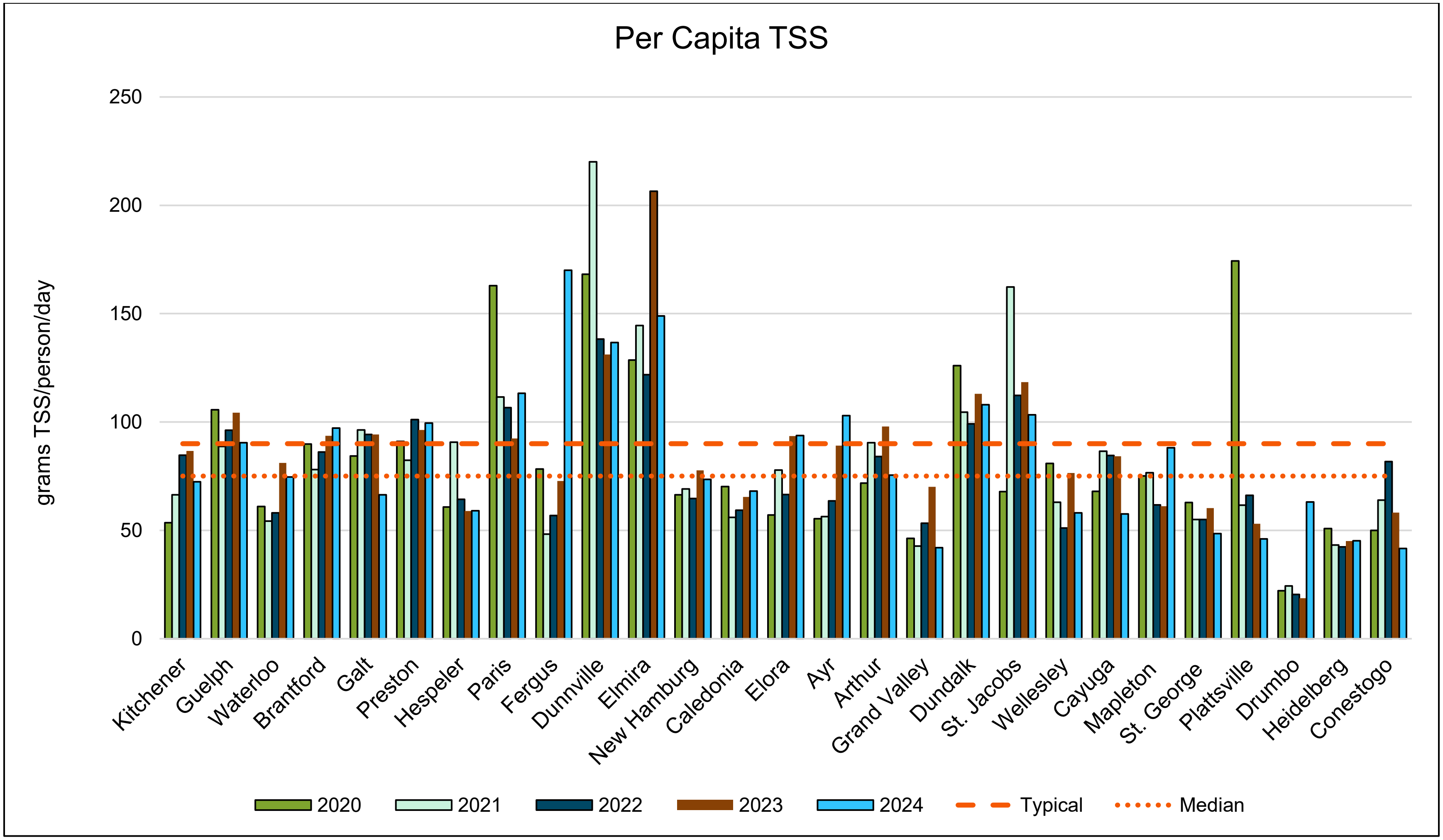


Figure 18: Per Capita TSS Load

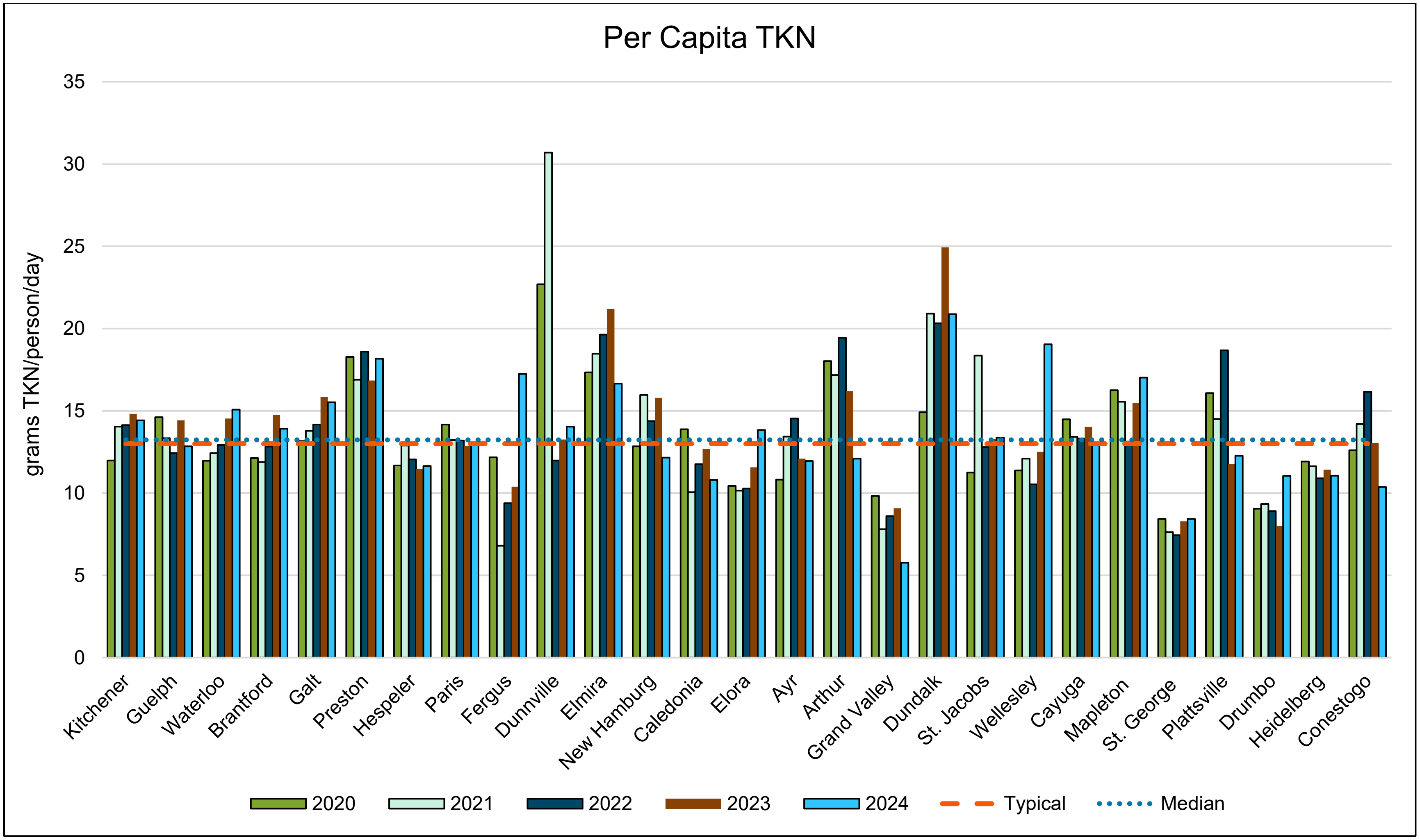


Figure 19: Per Capita TKN Load

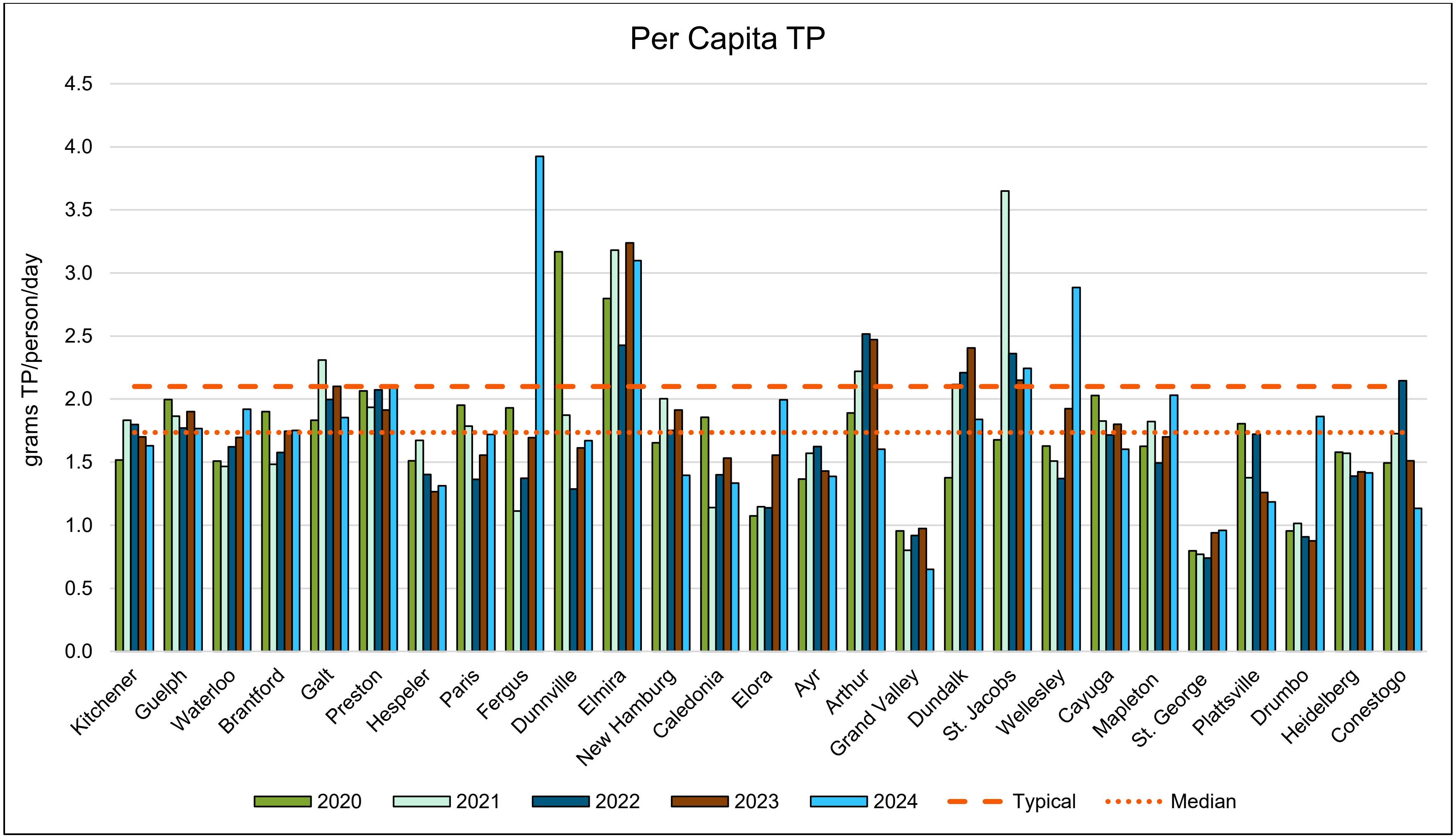


Figure 20: Per Capita TP Load

Ratios

Calculating raw influent ratios for TSS:TBOD and TKN:TBOD can be used to provide insight on what is entering the plant from the collection system as well as any potential sampling problems. Figure 21 shows the ratio of raw influent TSS to TBOD concentrations. For a typical domestic sewage system, this value ranges between 0.8 and 1.2. The median for watershed plants in 2024 was 1.09, slightly higher than 2023, which is mid-typical range, slightly less compared to previous years.

Figure 22 shows a graph for the ratio of raw TKN to TBOD, with a range of 0.1 to 0.2 considered typical. The 2024 watershed median was 0.2, which is at the higher end of the typical range but similar to previous years. Higher ratios could be attributed to recycle streams, an industrial influence on the collection system, or the fact that most plants are now reporting TBOD, which may have been overestimated in previous years.

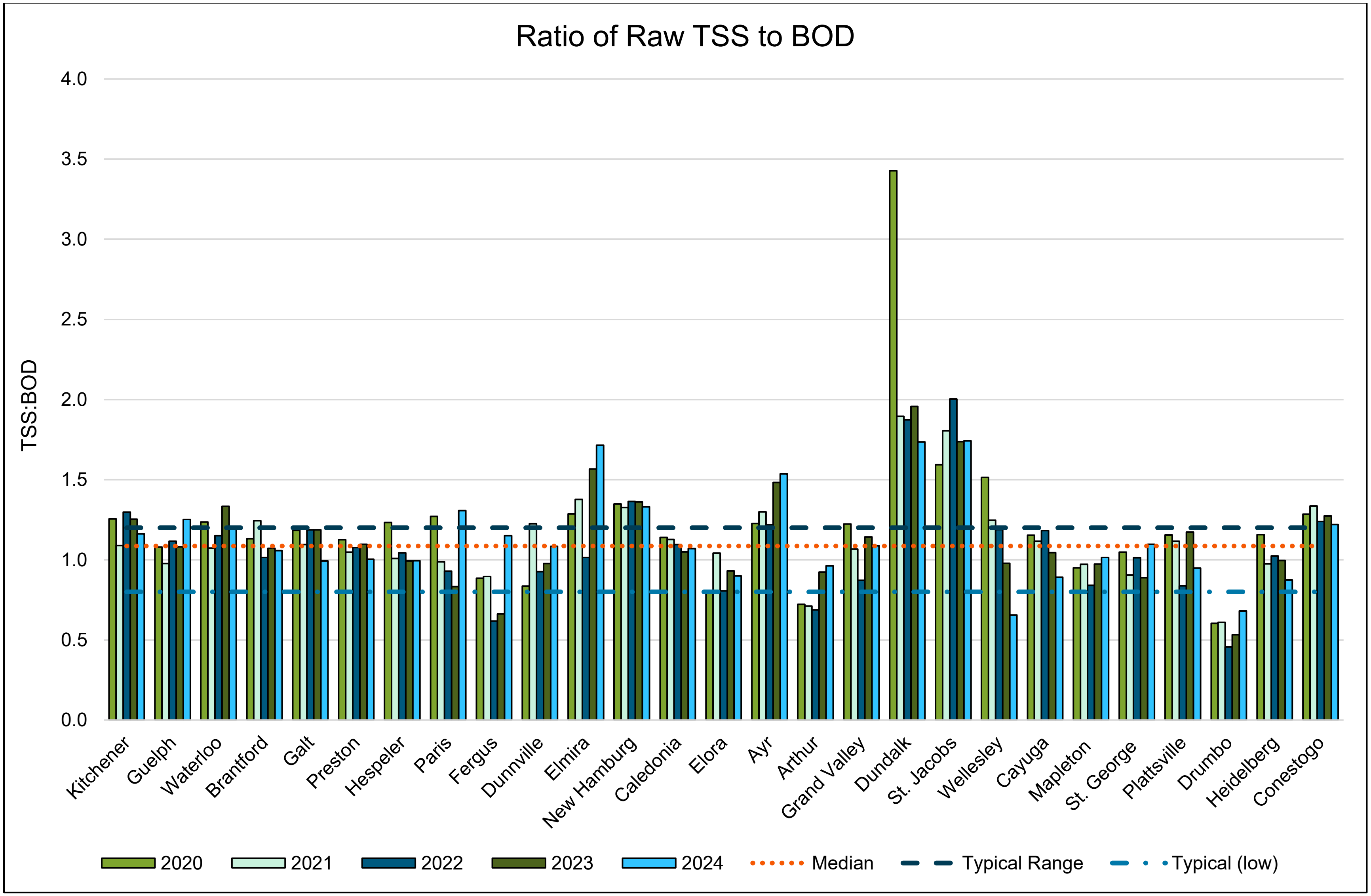


Figure 21: Ratio of Raw TSS to Raw TBOD

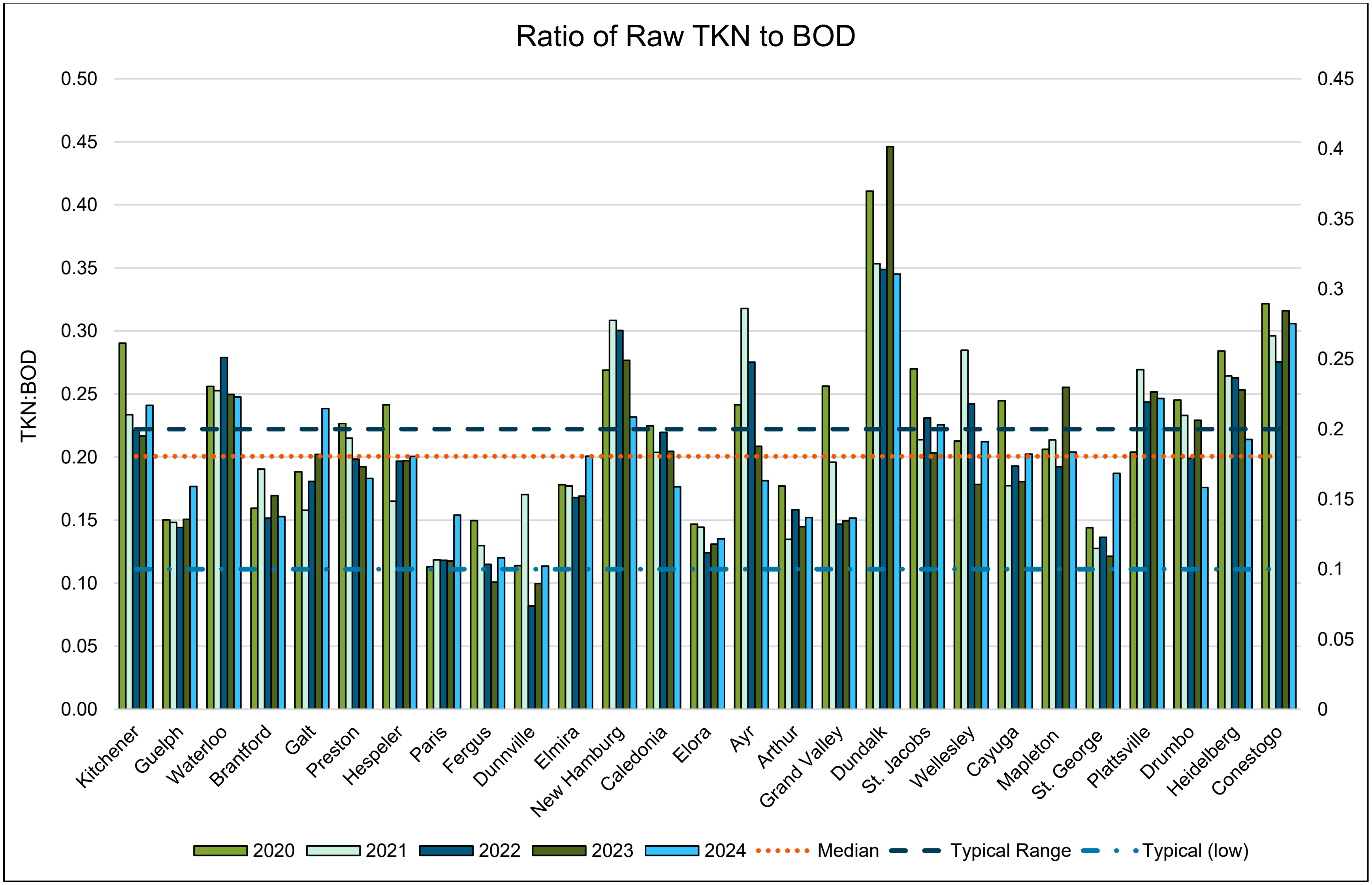


Figure 22: Ratio of Raw TKN to Raw TBOD

Final Comments

The data presented in this report documents significant improvements in effluent quality across the Grand River watershed since 2012, driven by facility upgrades and ongoing optimization efforts. These advancements have led to substantial reductions in TP and TAN discharged to the river.

Notably, 2023 marked the first year in program's history where both TP and TAN loadings increased compared to the previous year. However, in 2024, both flow-weighted concentrations and overall loadings of TP and TAN decreased relative to 2023.

Despite continued population growth in the watershed, flow-weighted TP concentrations declined from 0.37 mg/L in 2012 to 0.20 mg/L in 2024, while flow-weighted TAN concentrations fell from 9.8 mg/L to 0.6 mg/L over the same period.

Annual reporting has been instrumental in driving progress under the watershed-wide wastewater optimization program. The ongoing success of this evolving program depends on the voluntary participation of wastewater operators and managers.

The WWOP remains committed to fostering this community of practice by providing opportunities for knowledge sharing and collaboration. Through an optimization-based approach, the WWOP contributes to a healthy, sustainable watershed that supports thriving and growing communities into the future.

As part of the ongoing watershed-wide wastewater optimization program, the GRCA will continue to encourage and support municipalities to report on performance and loading metrics on an annual basis. Tracking these metrics over time will document the effectiveness of the program and help to identify candidates that may benefit from further optimization activities.

The authors thank Ministry of Environment, Conservation and Parks (MECP) for financial contribution, and WWOP participants for their efforts at voluntary reporting and encourage them to consider adopting and reporting against the Water Management Plan voluntary effluent quality performance targets for TP and TAN. By embracing an optimization approach to reduce these nutrients in wastewater effluent, municipalities can help to ensure a healthy and sustainable watershed that supports prosperous and growing communities into the future.

Further information on the Grand River Watershed-wide Optimization Program can be obtained from the Grand River wastewater optimization web page, or by contacting Simion Tolnai, the Optimization Extension Specialist at 519-621-2761 extension 2295 or Cameron Irvine at 519-621-2761 extension 2234.

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APPENDIX 1: SLUDGE ACCOUNTABILITY AND WATER BALANCE SUMMARY

Table 13: Summary of sludge accountability analysis results

Year	2020			2021			2022			2023			2024		
WWTP	Projected	Reported	Analysis	Projected	Reported	Analysis	Projected	Reported	Analysis	Projected	Reported	Analysis	Projected	Reported	Analysis
Kitchener	12,111	13,837	-14.2%	15,524	14,234	8.3%	17,057	17,591	-3.1%	23,303	23,527	-1.0%	20,061	16,955	15.5%
Brantford	10,135	9,499	6.3%	8,553	8,877	-3.8%	10,105	8,737	13.5%	9,944	9,266	6.8%	12,382	10,739	13.3%
Guelph	13,602	15,492	-13.9%	12,736	13,534	-6.3%	14,029	12,689	9.6%	14,161	12,744	10.0%	13,859	14,070	-1.5%
Galt	9,071	7,727	14.8%	10,030	7,455	25.7%	7,632	7,274	4.7%	7,935	9,084	-14.5%	6,765	7,642	-13.0%
Waterloo	9,662	8,937	7.5%	8,630	7,343	14.9%	10,419	10,798	-3.6%	17,107	18,940	-10.7%	12,655	12,896	-1.9%
Preston	2,624	2,905	-10.7%	2,363	2,178	7.8%	2,880	3,091	-7.3%	2,977	2,805	5.8%	3,082	2,441	20.8%
Hespeler	1,343	1,671	-24.4%	2,239	2,201	1.7%	1,633	1,471	9.9%	1,568	1,608	-2.5%	1,570	1,363	13.2%
Fergus	1,056	819	22.5%	1,251	1,521	-21.6%		Not reported		1075	728	32.3%	3,070	3,187	-3.8
Elmira	1,559	1,990	-27.7%	1,712	2,039	-19.1%	1600	2164	-35.3%	2320	2214	4.6%	1,686	1,727	-2.4%
Dunnville	869	732	15.7%	793	788	0.6%	643	851	-32.2%	591	809	-36.8%	665	687	-3.3%
Caledonia	974	900	7.6%	944	740	21.6%	1000	895	10.5%	1,113	907	18.5%	1,184	861	27.3%
Paris	932	1,028	-10.3%	1,060	1,305	-23.1%	1142	987	13.5%	1048	1860	-77.5%	842	1,846	-119.2%
New Hamburg	717	1,435	-100.0%	734	1,083	-47.6%	698	816	-17.0%	735	608	17.3%	783	680	13.1%
Elora	1,215	715	41.2%	566	810	-43.1%		Not reported		536	387	27.7%	942	996	-5.7%
Ayr	271	280	-3.4%	268	294	-9.9%	306	246	19.6%	349	300	14.1%	396	317	19.9%
Arthur		Not reported			Not reported		209	266	-27.3%		Not reported		289.7	234.8	19.0%
St. Jacobs	146	154	-5.4%	203	149	26.3%	155	136	12.2%	133	161	-20.7%	121	171	-41.2%
St. George		Not reported		190	258	-36.0%	139	206	-48.3%	205	367	-79.4%	165	375	127.1%
Grand Valley		Not reported			Not reported		101	105	-4.0%		Not reported		140.6	146.5	-4.2%
Wellesley	152	128	15.4%	139	117	15.9%	166	146	12.2%	238	217	8.7%	300	316	-5.1%
Cayuga	95	126	-32.2%	95	126	-32.2%	102	145	-42.1%	119	130	-9.0%	101	118	-16.7%
Drumbo	91	101	-11.0%	91	95	-4.3%	98	87	11.6%	83	73	11.8%	110	96	12.9%
Conestogo	15	7	53.2%	16	14	11.0%	18	15	14.7%	15	16	-6.6%	14	12	12.7%
Heidelberg	9	21	-119.3%	10	15	-51.5%	9	17	-83.0%	10	18	-82.0%	11	17	-54.2%

Table 14: Summary of Water Balance results from plants that report on it

Year	Plant	Dundalk	Mapleton	Plattsville	Cainsville
2016	Reported Projected Influent Flow **Water Balance (%)**	28,101 -17,969 380,883 **-12.1%**	48,910 -9,672 215158 **-27.2%**	Not Reported	Not Reported
2017	Reported Projected Influent Flow **Water Balance (%)**	60,260 7,475 404,642 **-13.0%**	Not Reported	17,107 27,493 196,483 **5%**	Not Reported
2018	Reported Projected Influent Flow **Water Balance (%)**	38,875 -16,532 380,477 **14.6%**	47,700 9,835 233,250 **16.2%**	8,237.24 15,497 172,542 **-4.2%**	Not Reported
2019	Reported Projected Influent Flow **Water Balance (%)**	23,292 -33,731 413,461 **13.8%**	Not Reported	20,381 15,522 187,078 **2.6%**	1,968.2 -62,908 84,205 **77%**
2020	Reported Projected Influent Flow **Water Balance (%)**	31,952 -8,490 388,091 **10.4%**	Not Reported	19,995 31,550 176,723 **-6.5%**	-6,547 -62,908 84,205 **67%**
2021	Reported Projected Influent Flow **Water Balance (%)**	34,984 7,451 431,240 **6.4%**	Not Reported	7,102 -19,290 81,139.6 **26%**	1,725.7 -19,290 81,139.6 **26%**
2022	Reported Projected Influent Flow **Water Balance (%)**	3,772 -52,415 360,770 **15.6%**	Not Reported	-15,208 -32,987 159,301 **11.2%**	-4,343 -76,494 84,642 **85.2%**
2023	Reported Projected Influent Flow **Water Balance (%)**	22,240 -50,974 431,398 **17.0%**	Not Reported	13,386 13,327 160,848 **0.0%**	3,948 -75,325 95,278 **83.2%**
2024	Reported Projected Influent Flow **Water Balance (%)**	40,754 -32,381 509,365 **14.4%**	50,032.0 43,672.0 242,240.0 **2.6%**	14,529 4,198 159,762 **6.5%**	2,315 -67,726 82,343 **85.1%**