Section 5: Historical and Projected Flows and Loads

5.1 Introduction

The purpose of this chapter is to provide information on existing hydraulic conditions within the City's collection system, and hydraulic, organic, and solids loading to the City's existing WWTP and to present projections of future flows and loads through the 20-year planning period. Quantifying the existing loads to the WWTP is necessary to determine the level at which the existing wastewater treatment systems are operating relative to their current capacities, and to project performance under future flows and loads.

5.2 Historical WWTP Flows and Loads

The discharge monitoring reports (DMRs) for the influent flows and loads were provided for the period January 2018 through December 2023. This period includes periods for pre-COVID 19 pandemic years (2018-2019).

The high flows observed during the winter months have necessitated the seasonal characterization of the waste stream. The flows for the two designated seasons are described as follows:

- **Dry Weather/Summer Season:** Lasting from May 1 to September 30, the primary contributors during this period are residential and commercial sanitary sewage, along with contract flows.
- **Wet Weather/Winter Season:** Spanning from October 1 to April 30.
- **Average Annual:** This reflects the average flow or loading condition calculated over the entire year.

For each of these periods, flows are further classified according to the following parameters, which are based on standard plant design criteria and help assess plant performance under various operating conditions:

- **Average Dry Weather:** The average of the total daily influent flow during the dry/summer season.
- **Maximum Month:** The highest 30-day rolling average of total daily influent flow during the specified period.
- **Peak Day:** The maximum total influent flow recorded over a single day during the specified period.

Historical data from 2018 through 2023 were analyzed to determine the average daily and maximum month influent flows, as well as $CBOD_5$ and TSS loads, for the whole-year and seasonal conditions. The results are summarized in Table 5-1 and Table 5-2, respectively.

Table 5-1: Historical WWTP Flow Summary (2018-2023)

Parameter	2018 (MGD)	2019 (MGD)	2020 (MGD)	2021 (MGD)	2022[(1)] (MGD)	2023[(1)] (MGD)
Average Dry Weather Flow (ADWF)	4.2	3.7	3.6	3.6	3.5	3.2
Annual Average Flow (AAF)	5.1	4.4	4.8	5.2	4.6	4.2
Maximum Month DWF (MM DWF)	4.6	4.0	4.0	3.9	4.3	3.6
Peak Day DWF (PD DWF)	6.2	8.7	10.4	7.3	6.9	5.8
Maximum Month Wet Weather Flow (MM WWF)	9.3	7.2	9.5	10.7	9.9	8.7
Peak Day WWF (PD WWF)	19.3	22.3	18.4	22.4	26.0	26.0

(1) Due to issues with influent measurement, effluent flow has been recorded as influent flow in the DMR since 2022.

Table 5-2: WWTP Historical Influent Loads

Parameter	2018 (ppd)	2019 (ppd)	2020 (ppd)	2021 (ppd)	2022 (ppd)	2023 (ppd)
Average Annual Load (AAL) for $CBOD_5$	8,100	7,100	6,200	6,500	7,100	5,900
Maximum Month Load (MML) for $CBOD_5$	9,900	8,400	8,300	7,700	14,000	7,500
Peak Day Load (PDL) for $CBOD_5$	15,700	12,200	17,400	13,200	21,300	10,700
AAL for TSS	9,300	9,100	8,400	7,500	8,900	7,000
MML for TSS	12,100	10,000	10,600	9,400	17,700	8,500

The average dry weather flow (ADWF) at the WWTP has remained relatively constant between 2019 and 2022, although it was reduced somewhat in 2023. The average annual $CBOD_5$ load remained relatively stable, ranging between 6,000 and 7,000, with a slight decline observed in 2023. In contrast, both the maximum month $CBOD_5$ and TSS loads saw substantial increases in 2022, with $CBOD_5$ nearly doubling and TSS increasing by approximately 50%. Aside from 2022, maximum month loads have remained at consistent levels. Through discussions with the City held in June 2024, this event was identified as an outlier and excluded from the peaking factor settings for the load projection.

Figures were created to depict both the annual average and the 30-day rolling average for influent flows (Figure 5-1), as well as $CBOD_5$ (Figure 5-2) and TSS loads (Figure 5-3). These visualizations allow for the identification of any emerging trends or patterns over time, helping to detect seasonal variations or long-term shifts in influent characteristics.

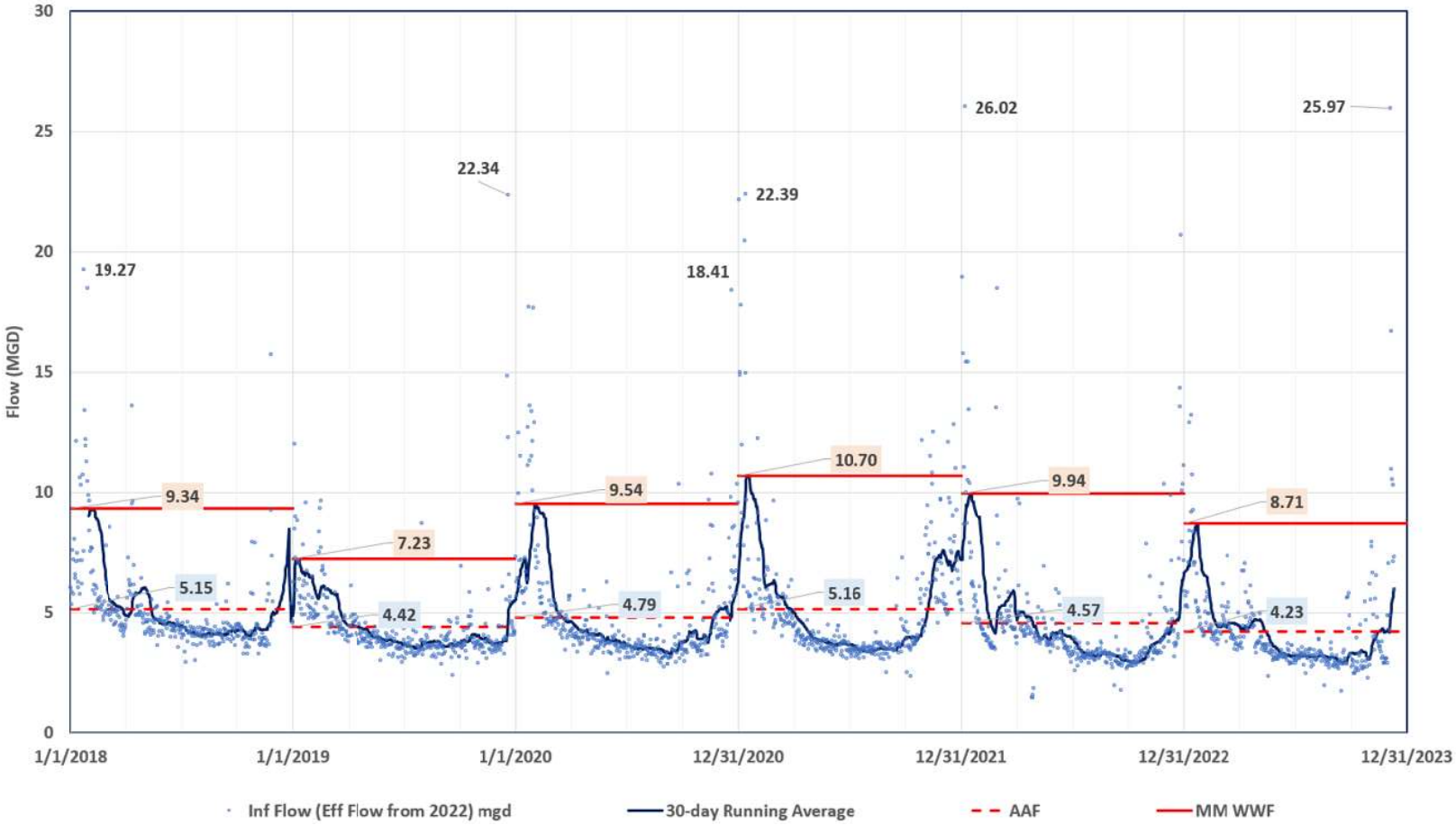

Figure 5-1: Influent Flow in MGD (2018-2023)

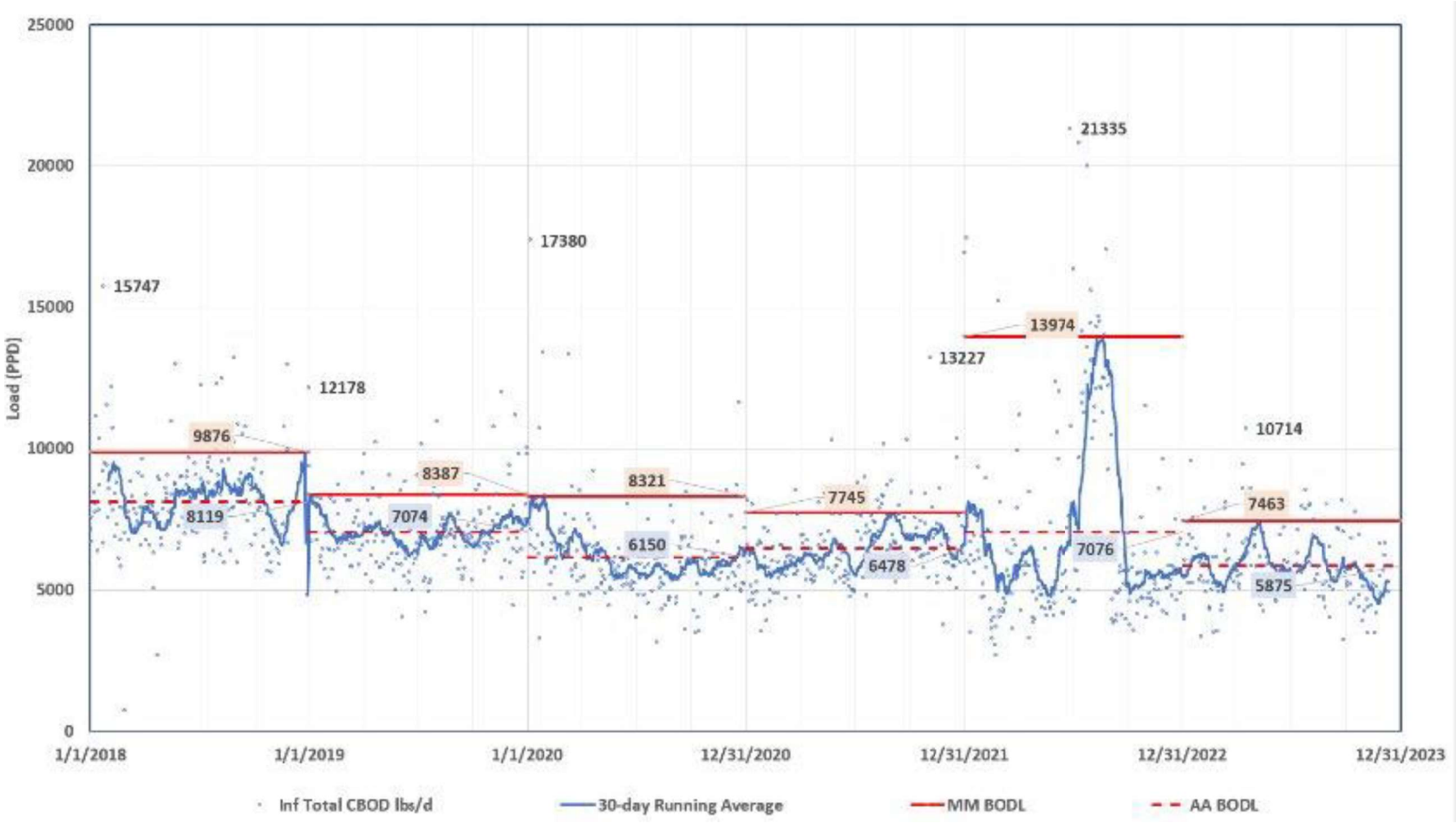

Figure 5-2: Influent $CBOD_5$ Load in ppd (2018-2023)

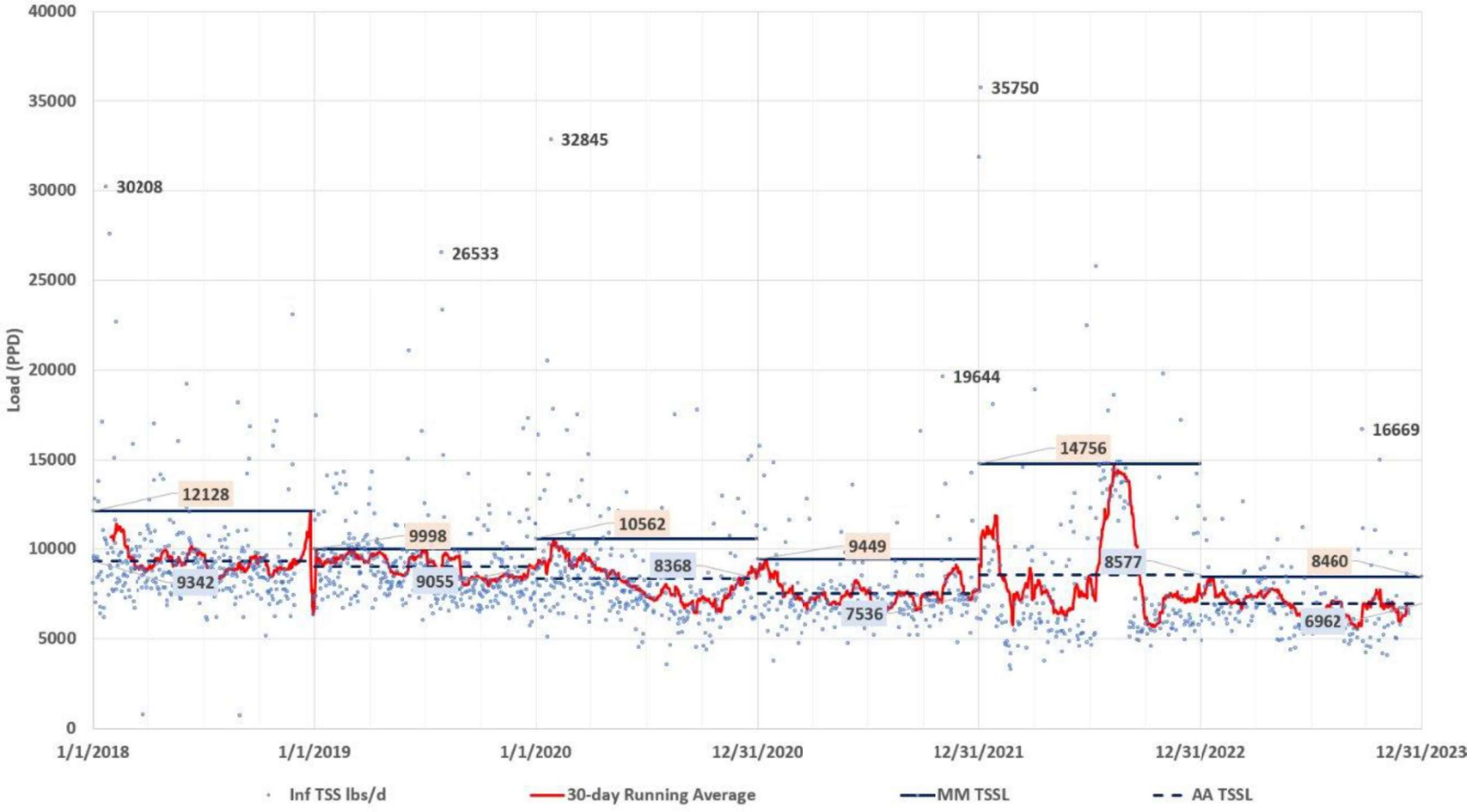

Figure 5-3: Influent TSS Load in ppd (2018-2023)

The figures show that maximum month flow typically occurs between December and February, aligning with the wet season, and the 30-day rolling average follows a consistent, repetitive trend. However, the maximum month load has been observed at various times throughout the year rather than at a fixed period.

Peaking factors for flow and load were calculated each year from historical influent flow, $CBOD_5$, and TSS load data, using ratios of various flow and load conditions, such as MM WWF/AAF and PDL/AAL. These peaking factors, summarized in Table 5-3 were used to establish additional design flows and loads based on the baseline values in the following sections.

Table 5-3: Influent Flow and Load Peaking Factors 2018-2023

Parameter	2018	2019	2020	2021	2022	2023	Average
ADWF/AAF	0.83	0.84	0.75	0.69	0.77	0.75	0.77
MM DWF/AAF	0.90	0.91	0.83	0.76	0.93	0.84	0.86
PD DWF/AAF	1.20	1.97	2.16	1.41	1.52	1.37	1.61
MM WWF/AAF	1.81	1.64	1.99	2.07	2.18	2.06	1.96
MML/AAL for $CBOD_5$	1.22	1.19	1.35	1.20	1.97	1.27	1.24
PDL/AAL for $CBOD_5$	1.94	1.72	2.83	2.04	3.02	1.82	2.07
MML/AAL for TSS	1.30	1.10	1.26	1.25	2.00	1.22	1.23

Notes:

(1) The 2022 anomaly was excluded from the determination of peaking factors.

(2) The highest value among the five peaking factors was selected as the design peaking factor for projecting maximum monthly loads.

5.3 Projected Wastewater Flows and Loads

This section presents the projected populations, wastewater flows, and loads for the WWTP service area. The population, flow and loading estimates are determined for the base year (2023) through the year 2044 for a planning period of 20 years beginning in 2024.

5.3.1 Sewered Population Projections

The projections use demographic data prepared by Kitsap County as part of its Countywide Planning Policies (CPP), amended and adopted in October 2021, along with additional data developed by the Department of Community Development (DCD) for its service area using Traffic Analysis Zones (TAZs). Kitsap County's CPP includes population data for 2020 and projected population figures for 2044, reflecting anticipated growth during the planning period from 2020 to 2044 for both the City and the Bremerton Urban Growth Area (UGA). The DCD provides data exclusively for the City, covering a planning period from 2024 to 2044. These two sets of demographic data and projections develop population estimates for 2024 to 2044 for the areas served by the WWTP, excluding the population associated with the PSIC area.

The sewered population is estimated with the following assumptions and steps:

- 2024 Residential and Employment Populations for the City and UGA:
    - The 2024 residential population for the City is based on the estimate provided by the Washington State Office of Financial Management (OFM).
    - The 2024 City employment population, as well as the UGA residential and employment populations, are interpolated using projections from the Kitsap County CPP, assuming a constant growth rate over the 24-year planning horizon.
    - The growth projected by the TAZ data from the DCD is applied to the residential and employment populations for the City for the planning period of 2024 to 2044.
    - The growth projected in the Kitsap County CPP is adjusted to start in 2024 for the residential and employment populations in the UGA.
- Adjustments for excluding PSIC Area:
    - The PSIC's residential and employment populations of 515 and 872 for 2023, as provided in the TAZ map, are subtracted from the 2024 City's residential and employment populations.
    - The projected employment growth for the PSIC area, totaling 9,639, is subtracted from the City's employment growth figures.
    - No residential growth is projected for the PSIC area, and the adjusted figures from the Kitsap CPP for the planning period starting in 2024 remain unchanged.
    - A constant growth rate is assumed, and the 2034 milestone growth has been estimated using the calculated constant growth rate for each population category.
- Sewered Portion of the Population:
    - The sewered portions of the current residential and employment populations are assumed to be 76% and 95%, respectively, as outlined in the 2014 WWCP Update for the planning horizon from 2013 through 2033. These assumptions were

discussed with the City and accepted for use during the flow and load projection review meeting held on June 14, 2024, for the current population.

- For new growth, 100% of the City growth and 25% of the UGA growth are assumed to be sewered, according to the direction of the City.

The projection of the sewered population, starting with 2024 as the base year and including the milestone years 2034 and 2044, is provided in Table 5-4.

Table 5-4: City of Bremerton Sewered Population Projection

Residential Population Projection				
Year	**City**	**UGA**	**City Growth**	**UGA Growth**
2024	44,875 (1)	10,520	0	0
2034	53,736	11,635	8,862	1,114
2044	64,349	12,867	19,474(2)	2,347
Employment Population Projection				
Year	**City**	**UGA**	**City Growth**	**UGA Growth**
2024	45,308(3)	1,657	0	0
2034	48,270	2,521	2,962	864
2044	51,426	3,835	6,118(4)	2,178
Residential Sewered Population Projection(5)				
Year	**2024 City and UGA**	**City Growth**	**UGA Growth**	**Residential Sewered**
2024	42,100	0	0	42,100
2034	42,100	8,862	279	51,241
2044	42,100	19,474	587	62,161
Employment Sewered Population Projection(6)				
Year	**2024 City and UGA**	**City Growth**	**UGA Growth**	**Employment Sewered**
2024	44,617	0	0	44,617
2034	44,617	2,962	216	47,795
2044	44,617	6,118	544	51,279

Notes:

(1) The residential population in 2023 for PSIC areas was estimated to be 515 by multiplying 242 dwelling units by 2.13 capita per mutil-dwelling unit, based on the demographic data provided by the DCD. This number was subtracted from the City's 2024 residential population of 45,390, which is the estimate provided by the Washington State's OFM.

(2) The growth is assumed to be the same as the growth estimate provided by the DCD from 2023 to 2044.

(3) The employment population in 2023 for PSIC areas of 872 was subtracted from the City's 2024 employment population of 46,180, which was interpolated for 2024 from the projection provided in Kitsap's CPPs.

(4) The employment growth estimate for PSIC of 9,639 was subtracted from the employment growth estimate of 15,757 by the DCD from 2023 to 2044.

(5) Residential sewered population = 76% x 2024 City and UGA population + 100% x City Growth + 25% x UGA Growth

(6) Employment sewered population = 95% x 2024 City and UGA population + 100% x City Growth + 25% x UGA Growth

5.3.2 Sewer Flow and Waste Load Projections

According to the 2020 Water System Plan by the City of Bremerton Water Utility, water consumption per Equivalent Residential Unit (ERU) was estimated at 143 gallons per day (gpd) from 2013 through 2019. Assuming an average of 2.33 people per ERU, residential water consumption was estimated at 61 gallons per day per capita (gpcd). The employment water consumption rate was assumed to remain the same as the 42 gpdc estimated in the 2014 WWCP Update.

In the 2014 WWCP Update, the sewer generation factor was calculated by assuming a reduction from the water consumption factor to align the estimated sewer generation with the 2012 Average Dry Weather Flow (ADWF). This same methodology was used to determine the reduction from the updated residential water consumption rate and the 2014 employment water consumption rate to the corresponding sewer generation factor. A 20% reduction from water to sewer was assumed to match the calculated sewer generation with each historical ADWF from 2020 through 2023, with an average difference of 2% overall.

With the 20% reduction, the following sewer generation factors were assumed for each sector:

- Residential sector: 49 gpdc
- Employment sector: 34 gpdc

The ADWF projections were developed using sewer generation factors applied to the projected sewered population as summarized in Table 5-5.

Table 5-5: Average Dry Weather Flow (ADWF) Projection

	Sewered Population		Base Flow ADWF Projection		
Year	**Residential**	**Employment**	**Residential**	**Employment**	**ADWF**
2024	42,100	44,617	2.1	1.5	3.6
2034	51,241	47,795	2.5	1.6	4.1
2044	62,161	51,279	3.1	1.7	4.8

To establish other design flow baselines, historical peaking factors of AAF to ADWF, and those of peak day (PD) and maximum month (MM) flows to AAF were estimated from DMR data over the past six years for both wet weather flow (WWF) and dry weather flow (DWF). The average of the six peaking factors (PFs) was used to project all flows except for the MM WWF, where the highest PF among the six historical PFs was used. These additional projected design flows are listed in Table 5-6.

Table 5-6: Additional Design Flow Projections in MGD

Year	ADWF	AAF	MM DWF	PD DWF	MM WWF
2024	3.6	4.6	4.0	7.4	10.1
2034	4.1	5.3	4.6	8.6	11.7
2044	4.8	6.2	5.3	9.9	13.5

Peaking Factors	0.77	1.00	0.86	1.61	2.18

The projection for peak day flow adhered to the methodology from the 2014 WWCP Update, where a peak day flow was estimated by adding a constant inflow/infiltration (I/I) of 23 MGD—derived from a 2012 storm event—to the projected ADWF. Recent five-year data for primary influent flow showed that the difference between the PDF and ADWF was estimated to be 22.8 MGD, nearly matching the previous I/I figure.

An additional I/I for a new service area of 2,321 acres defined in Table 4-8 of the 2014 WWCP Update was added, separate from the final PDF projected over the planning horizon. Based on the sanitary sewer flow projections provided in Chapter 4.2.3 of the 2014 WWCP Update, this new service area encompasses eight sub-areas: Marine Drive, Port Blakely, Rocky Point, West Hills, State Route 304 (Sherman Heights), Trenton, Tracyton, and Tracyton Beach. As the City has no confirmed plans for the development of these new service areas or the extension of the sewer collection system, the previous planning figures from 2014 WWCP Update were assumed for the projection. It was further assumed that the new service area would be added evenly over the planning horizon.

The peak hour flow (PHF) was estimated using a multiplier of 1.78, derived from the average of six historical peaking factors (PHF/PDF) to the projected PDF. Table 5-7 provides a summary of the flow projections.

Table 5-7: Peak Wet Weather Flow Projection in MGD

Year	ADWF	Current I/I	New Area I/I	PD WWF	PHF
2024	3.6	22.8	0	26.4	46.9
2034	4.1	22.8	2.8	29.7	52.9
2044	4.8	22.8	5.6(2)	33.2	59.0

Notes:

(1) PHF = PD WWF x 1.78 (calculated as the average of six historical peaking factors: PHF/PD WWF).

(2) Additional I/I for assumed new area estimated at 2,400 gal/day/acre for 2,321 acres, following the method from the 2014 WWCP Update.

To project the loading associated with residential and employment areas, the loading factors estimated by King County for their three WWTPs in the 2014 WWCP Update for treatment plant flow and wasteload projections were used. Although the City is not part of King County and neither the City nor its county has specific loading data available, King County's figures were adopted, with the assumption that they would be comparable for this region. The use of these values was further supported by checking the assumptions against historical data, which demonstrated that they align closely with local conditions. According to the report, the average BOD loading factors for residential and commercial areas were 0.15 and 0.04 pounds per day per capita (ppdc), respectively, and the average TSS loading factors were 0.16 and 0.04 ppdc, respectively. Using these assumptions, the total BOD and TSS loads were estimated to be close to the historical influent BOD and TSS loads in 2020, 2021, and 2022, with an average difference of less than 2%. The average annual load (AAL) projections were developed by applying these BOD and TSS load generation factors to the projected sewered residential and employment population and summarized in Table 5-8**Error! Reference source not found.Error! Reference source not found.**.

Table 5-8: Average Annual Load Projections

Year	Sewered Population		AAL for BOD (ppd)	AAL for TSS (ppd)
	Residential	Employment		
2024	42,100	44,617	8,100	8,500
2034	51,241	47,795	9,600	10,100
2044	62,161	51,279	11,400	12,000

To establish additional design loads, historical peaking factors for maximum month load (MML), maximum week load (MWL), and peak day load (PDL) relative to annual average load (AAL) were estimated using six years of DMR data. The average of five peaking factors, after excluding an outlier from 2022, was used to project both MWL and PDL. For the MML, the highest peaking factor among the remaining five historical values was applied to the projected AAL to estimate the MML. Table 5-9 summarizes the projected BOD and TSS design loads.

Table 5-9: BOD and TSS Load Projection

	BOD Projection			TSS Projection	
Year	**AAL**	**MML**	**PDL**	**AAL**	**MML**
2024	8,100	10,900	16,800	8,500	11,100
2034	9,600	13,000	19,900	10,100	13,100
2044	11,400	15,400	23,600	12,000	15,600
Peaking Factors	1.00	1.35	2.07	1.00	1.30

All projected MM DWF, MM WWF, MM BOD, and TSS loads were below the limits currently allowed in the permit. These projected flows and loads were utilized to evaluate the current facility's capacity and identify any potential shortages. For the processes identified with capacity shortages, improvements will be developed based on the flows and loads permitted under the current Permit, with projected values adjusted to correspond to the Permit's maximum monthly flows and loads.

5.4 Sewer Basin Existing and Projected Flows

Kitsap County Planning Policies informed the flow projections across the entire Bremerton service area in Section 5.3. For sewer basin-specific existing and projected flows that can be leveraged for modelling analysis in Section 5, the following information was leveraged

- City water metering data for the 2023 year
- Select pump station flow data for the 2023 year
- Traffic Analysis Zone (TAZ) projections developed by Kitsap County over the planning period of 2024- 2044.

It should be noted that basins analyzed in the following sections account for all of the flow within the City's collection system.

5.4.1 Sewer Basin Average Dry Weather Flows

The existing and projected ADWF across Bremerton's service area broken down by basin are summarized in Table 5-10.

Table 5-10: Existing and Projected ADWF – Basin Specific

	Existing Flows (2024)		Projected Growth Flows (2024-2044)		Projected Flows (2044)	
Basin	**ADWF (gpm)**	**ADWF (MGD)**	**ADWF (gpm)**	**ADWF (MGD)**	**ADWF (gpm)**	**ADWF (MGD)**
East Bremerton[1]	-	-	-	-	-	-
Oyster Bay	355	0.51	24	0.04	380	0.55
Kitsap Lake	60	0.09	53	0.08	113	0.16
Anderson Cove	166	0.24	4	0.01	170	0.24
Warren Avenue	889	1.28	507	0.73	1396	2.01
Callow Basin	681	0.98	16	0.02	697	1.00
Pacific Avenue	105	0.15	106	0.15	211	0.30
Sinclair Park[2]	244	0.35	270	0.39	514	0.74
Kitsap Sewer District No. 1[2]						
Southwest Bremerton[2]						
Total	**2,500**	**3.60**	**981**	**1.41**	**3,481**	**5.01**

Notes:

(1) During dry weather, all East Bremerton basins flow into Warren Avenue via CE-1.

(2) 2023 Pump station data unavailable. Basins combined for analysis.

5.4.2 Sewer Basin Average Dry Weather Flows Methodology

To define the existing basin-specific ADWF, City water meter data from 2023 was leveraged with an assumed 96% sewer generation rate. In GIS, the sewer basin boundaries were overlain on the water meters attribute, and a report was generated. During the initial basin-specific analysis, the total ADWF calculated was 3.04 MGD. A 18% global adjustment was applied to match the WWTP influent data per Table 5-5.

To define the projected growth in ADWF across the planning horizon of 2024-2044, KJ performed basin-specific analyses based on the County-provided Traffic Analysis Zone data. The demographic projections from the County and City are allocated to small geographic areas called Traffic Analysis Zones (TAZs). TAZs for the City are developed by Kitsap County to estimate population and employment growth throughout the County. The TAZ boundaries are independent of Bremerton's sewer service areas. Therefore, GIS analysis was used to determine which portions of the TAZ fall within Bremerton's sewer service area. The TAZ data was overlain onto the City's service area and a report was generated, factoring in the sewer generation rates described in Section 0. Ultimately, the calculated ADWF at the end of the planning horizon (2044) was calculated to be 5.01 MGD (see table above), 4.4% higher than the

projected WWTP 2044 influent ADWF per Table 5-5. The disagreement is likely due to the application of the sewer generation factors related to UGA vs. non-UGA growth, which the populations TAZ-based population growth forecasts do not include. The difference is considered minor, and basin-specific flows are considered acceptable in utilization for later analyses.

5.4.3 Sewer Basin Peak Hour Flows

The existing and projected wet weather PHF across Bremerton's service area broken down by basin are summarized in Table 5-11.

Table 5-11: Existing and Projected PHF – Basin Specific

Basin	Existing Flows (2024)		Projected Flow Increase (2024-2044)		Projected Flows (2044)	
	PHF (gpm)	PHF (MGD)	PHF (gpm)	PHF (MGD)	PHF (gpm)	PHF (MGD)
East Bremerton(1)	-	-	-	-	-	-
Oyster Bay	2,188	3.2	133	0.2	2,321	3.4
Kitsap Lake	749	1.1	649	0.9	1,405	2.0
Anderson Cove	5,144	7.4	995	1.4	6,139	8.8
Warren Avenue	6,774	9.8	3,507	5.0	10,281	14.8
Callow Basin	12,968	18.7	459	0.7	13,427	19.3
Pacific Avenue	1,458	2.1	1,474	2.1	2,932	4.2
Sinclair Park(2)						
Kitsap Sewer District No. 1(2)	2,336	3.4	1,021	1.5	3,357	4.8
Southwest Bremerton(2)						
Total	**31,617**	**45.7**	**8,238**	**11.8**	**39,855**	**57.5**

Notes:
(1) During dry weather, all East Bremerton basins flow into Warren Avenue via CE-1.
(2) 2023 Pump station data unavailable. Basins combined for analysis. For projected growth flows and 2044 projected flows, nominal peaking factor applied.

5.4.4 Sewer Basin Peak Hour Flows Methodology

5.4.4.1 Existing Flows (2024)

Analyzing select pump station data for the 2023 year provided by the City, the peak hour flow was identified and correlated to its associated basin. These maximum values in the data sets provided were compared to the augmented ADWF in 2024 for each basin as described in Table 5-10 to yield peaking factors. The peaking factors were then applied to the collection system model to yield the peak hourly flows as shown in Table 5-11. The validation of this methodology is explained further in Section 6 of the report. For sewer basins where no pump station data was available, a nominal peaking factor of 8.5 was applied.

The total peak hour flow calculated, 45.7 MGD is within 2% of the total projected flow determined at the WWTP per Table 5-7.

5.4.4.2 Projected Flow Increases (2024- 2044)

The same approach leveraging TAZ data as explained in Section 5.4.2 was utilized to determine the ADWF increase for each basin analyzed. The same peaking factors determined in Section 5.4.4.1 were applied to the ADWFs.

5.4.4.3 Projected Flows (2044)

The existing flows and projected growth flows were combined to determine the projected peak hour flows. The total peak hour flow calculated, 57.5 MGD is within 2% of the total projected flow determined at the WWTP per Table 5-7.

5.5 Design Criteria

Table 5-12 summarizes both the projected 2044 conditions and the influent conditions allowed under the current permit. The projected 2044 conditions were used as the basis for assessing WWTP capacity, while the permit conditions and other influent conditions extended in relation to the permit conditions, were assumed as the design criteria for developing improvement alternatives.

Table 5-12: Summary of Design Criteria

Parameter	Projected 2044	NPDES Permit	Design Criteria
Average Dry Weather Flow (ADWF), MGD	4.8	-	5.5
Average Annual Flow (AAF), MGD	6.2	-	7.1
Maximum Month Dry Weather Flow (MM DWF), MGD	5.3	11.0	11.0
Peak Day Dry Weather Flow (PD DWF), MGD	9.9	-	11.4
Maximum Month Wet Weather Flow (MM WWF), MGD	13.5	15.5	15.5
Peak Day Wet Weather Flow (PD WWF), MGD	33.2	-	33.9
Peak Hour Flow (PHF), MGD	59.0	-	60.3
Average Annual BOD Load (AA BODL), ppd	11,400	-	13,400
Maximum Month BOD Load (MM BODL), ppd	15,400	18,100	18,100
Maximum Day BOD Load (MD BODL), ppd	23,600	-	27,700
Average Annual TSS Load (AA TSSL), ppd	12,000	-	17,400
Maximum Month TSS Load (MM TSSL), ppd	15,600	22,600	22,600

The existing and projected flows and loads are leveraged for collection system evaluation and WWTP evaluation in Sections 6 and 7 respectively.