CITY OF DAYTON
Wastewater System Facilities Plan
Dayton, Oregon

CHAPTER 5

WASTEWATER FLOWS AND LOADS

Chapter Outline

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5.1. GENERAL

In order to select and size both collection and treatment facilities for the planning period, projected wastewater flow and organic loading must be determined. The projected flows and organic loadings were determined based on a number of variables including the following:

- Rate of projected population increase
- Land use zoning within the UGB
- Projected per capita and per acre flowrates and organic loadings.

This section develops wastewater flow and loading projections which are used for sizing the collection system components as well as the treatment plant components. The projected design flowrates were determined based on a number of variables including zoning of land within the service area, anticipated development density at buildout and within a 20-year planning period, and projected per capita and per acre flowrates.

5.2. WASTEWATER FLOWS

Dry weather flows, wet weather flows, and infiltration and inflow (I/I) are factors that are important in the design of wastewater collection, treatment and disposal facilities. The Maximum Month Dry Weather Flow (MMDWF) usually determines the maximum organic loadings of the major process units. The Maximum Month Wet Weather Flow (MMWWF) determines the size and capacity of the major process units necessary to provide the desired degree of treatment. The Peak Hour Flow (PHF) determines the hydraulic capacity of pipelines, pumps, channels, and inlet structures and the reserve capacity of units such as clarifiers and disinfection facilities.

5.2.1 Flow Classification and Design Criteria

For the purposes of monitoring wastewater flows and identifying future design flows, the following flow classifications will be used. The definitions are generally listed in order of increasing flows.

- Average Dry Weather Flow (**ADWF**) - Average daily wastewater flow during the months of May through October. During these periods with little precipitation and low groundwater levels, the flows consists mainly of sanitary sewage, as well as commercial and industrial waste discharges. Base infiltration may be present.

- Average Annual Flow (**AAF**) - Average daily wastewater flow during the entire year.

- Average Wet Weather Flow (**AWWF**) - Average daily wastewater flow during the months of November through April.

- Maximum Month Dry Weather Flow (**MMDWF**) - The monthly average flow with a 10 percent probability of exceedence during the months of May through October in any given year. In other words, this flow represents the wettest dry weather season monthly average flow that is anticipated to have a ten-year recurrence interval. For western Oregon. May or October are usually the months which have the highest dry weather flow.

- Maximum Month Wet Weather Flow (**MMWWF**) - The monthly average flow with a 20 percent probability of exceedence during November to April in any given year. This flow represents the wettest wet season monthly average flow that is anticipated to have a five-year recurrence interval. For western Oregon, December or January are usually the months that have the highest wet weather flow.

- Peak Daily Average Flow (**PDAF**) – The peak daily flow associated with a 5-year, 24-hour storm. In western Oregon the peak daily flow always occurs during the wet season. Therefore PDAF is often referred to as the maximum day wet weather flow.

- Peak Hour Flow (**PHF**) - Maximum flow over an hour duration experienced during a five-year, 24-hour storm. This value typically determines the maximum hydraulic capacity of major process units, trunk sewers and pump stations without surcharging.

The major components of the total wastewater flow rates include domestic, commercial, industrial and institutional sources which are either existing or anticipated to develop during the study period, as well as adequate allowances for infiltration and inflow (I/I). The basic criteria used for projecting future wastewater flows in this section are outlined in Table 5-1.

Table 5-1 | Flow & Loading Projection Design Basis

Flow Category	Design Criteria
• Base Sanitary Sewer Flow	90 gpcd
• Average Household Size	2.78 people/unit
• Population Density Per Acre	
- Low Density Residential (R-1)	5.5 units/acre (15.3 people/acre)
- Medium Density Residential (R-2)	6.5 units/acre (18.1 people/acre)
- High Density Residential (R-3)	6.5 units/acre (18.1 people/acre)
• Commercial	1500 gpad (15.0 people/acre)
• Industrial	0.05 MGD (total)
• Public	500 gpad (5.0 people/acre)
Peaking Factors	
• Residential Flows	3.0
• Commercial Flows	3.0
Infiltration/Inflow (I/I)	
• New Gravity Sewers	1500 gpad
• Existing Sewers	As measured
Organic Loading (BOD)	
• Residential	0.20 ppcd
• Industrial	6.0 ppad
Solids Loading (TSS)	
• Residential	0.22 ppcd
• Industrial	6.6 ppad
Design Flow = Average Sewage Flows x Peaking Factor + I/I	

A short discussion of each of these flow and loading components follows.

5.2.1.1 Domestic Flows

Domestic flow is waste generated from normal residential households. For planning purposes, the average daily per capita rate of 90 gallons per capita per day (90 gpcd) has been selected for this study. The population densities listed in Table 5-1 were used together with the average daily per capita flow rate to project domestic use on a per acre basis.

5.2.1.2 Commercial Flows

Allowances for commercial sewage flows often can be equated with the per capita flows developed for domestic sewage. For this study, sewage flows expected from commercial areas were based on an anticipated average employed population of 30 employees per acre. Average sewage contribution from commercial areas can vary from 10 to 150 gpcd, with a typical average of 50 gpcd. Office and retail establishments usually contribute 12 to 25 gpcd while hotel and motels contribute flows from 50 to 150 gpcd. Based on 30 employees per acre and an average commercial flow of 50 gpcd, the flow contribution from commercial areas is assumed to be 1,500 gallons per acre per day (gpad). It is assumed that the peak flow for these commercial areas would follow the same relationship that has been established between the peak and average flow rates for residential areas.

5.2.1.3 Industrial Flows

It is difficult to predict the exact type or extent of future industrial development that may occur in Dayton. Industrial flows vary considerably depending on the type of industry (wet or dry). Flows from industries such as light manufacturing and machinery typically are not much greater than flows from residential areas. Whereas some industrial users (i.e., food processors or silicon wafer fabricators) require very large quantities of water and generate correspondingly high wastewater flows and loadings.

Based on discussions with City staff, the City would like to set aside some reserve capacity for industrial use. Therefore, the flow projections included in this chapter include an allowance of 0.05 MGD for a future industrial user. In addition we have assumed that the effluent received from the industrial use would be similar to residential strength effluent.

For this study, wastewater flow rates from industrial areas were based on an additional 0.05 MGD that was added directly into the flow projections from now until 2035.

5.2.1.4 Peaking Factors

Sanitary wastewater flows into the collection system will vary significantly throughout the day. In order to adequately design a sewage collection and treatment system, it is critical to be able to predict the peak wastewater flows rather than simply the average flowrates. Peaking factors are the ratio of peak flow to average flow, and are often related to the population served. It can be noted that as the population increases, the peaking factor tends to be less pronounced. At the population levels projected to occur in the basins throughout the City, peaking factors of 2.75 to 3.5 are typical. For the purposes of this report a peaking factor of 3.0 was assumed.

5.2.1.5 Infiltration and Inflow

Estimates of peak I/I flows are necessary for the design of new facilities to prevent these flows from overloading the sewers, pump stations and treatment facilities, resulting in possible bypasses of untreated or partially treated sewage into waterways or other areas. Non storm related infiltration and dry weather infiltration are less important. Although these I/I flows require pumping and treatment, their cost to the City is relatively minor by comparison.

Although modern sewer construction techniques make it possible to install sewer systems that will be relatively tight initially, infiltration and inflow into these systems may increase over time due to various physical factors and deterioration of sewer system components. Proper inspection and maintenance of the collection system is essential to controlling I/I over the long term.

As part of the preparation of this report, the City's Discharge Monitoring Reports (DMRs) were not used to determine the extent of the I/I contribution to the system flows due to the inaccurate inflow measurements. Therefore, I/I estimates were based on assumed peaking factors described in **Section 5.2.2**.

5.2.2 Existing Wastewater Flows

To determine the existing wastewater flows, the DMR data from January 2007 through the January, 2011 was analyzed. A summary of this DMR data is presented in **Appendix D**. After an analysis of the data, it appears that the daily influent flow measurements are extremely low. After investigating the problem with Public Works, it was determined that the influent flow meter was drastically under reading flow values at the headworks for the DMR record. For example, the February 2009 DMR shows a minimum influent flow rate of 0.004 MGD and a maximum influent flow rate of 0.040 MGD, which corresponds to 1.6 gallons per capita per day (gpcd), and 16 gpcd, respectively. Generally, during the summer months flow rates should be about 90 gpcd, which corresponds to a ADWF of approximately 0.234 MGD. For reference, in the Water Master Plan the Dayton average annual water demand is 147 gpcd. Due to these unrealistic flows, the influent flow and loading data listed on the DMR's cannot be used. Therefore, we have estimated the ADWF, AAF, AWWF, MMDWF, MMWWF, PDAF, PHF based on general per capita demands and assumed peaking factors.

The ADWF was based on a per capita demand of 90 gpcd. Peaking factors as shown in Table 5-2 were used to estimate other wastewater flow components.

Table 5-2 | Peaking Factors Used for Existing Flow Projections

ADWF	MMDWF	AAF	AWWF	MMWWF	PDAF	PHF
1	2.25	2	2.5	3	8	14

At present, there are approximately 799 active sewer connections in the City. Table 5-3 contains a breakdown of these service connections by user category.

Table 5-3 | Sewer Connection Summary

(Info. From Table 4-1, As of November 2009)	
User Classification	Number of Services
Single Family Residential	745
Duplex	6
Triplex	3
Apartments	1
Housing Authority	2
Commercial	23
Public	5
Schools	6
Churches	7
RV Park	1
Total	799

The DEQ recommends that treatment facilities are hydraulically sized to accommodate flowrates expected from a wet weather 5-year, 24 hour storm, and that design loading rates are determined from flowrates associated with a dry weather 10-year, 24-hour storm. In an effort to ensure that sewerage facilities are sized in accordance with these requirements, the DEQ has published guidelines for correlating wastewater flowrates to rainfall amounts. Once the correlation is established, it can be used to project wastewater flows for different rainfall amounts. However, since the influent flow data at the treatment plant is unrealistic, it cannot be used to establish a correlation with rainfall. For this reason, the flow projections methodology presented in DEQs guidelines cannot be used for Dayton.

Table 5-4 contains a summary of the estimated existing flow components to the WWTP based on the existing population of 2,605, and an ADWF flow of 90 gpcd and the peaking factors located in Table 5-2.

Table 5-4 | Summary of Current Wastewater Flow Components

Flow Component	Flows (mgd)
AAF (Average Annual Flow)	0.391
ADWF	0.245
MMDWF	0.550
AWWF	0.587
MMWWF	0.734
PDAF	1.957
PHF	3.425

5.2.3 Wastewater Flow Projections

The development and forecasting of wastewater flowrates is necessary to determine the design capacity of the different components of the collection and treatment system. Average and peak flowrates need to be developed for both the existing conditions and the future (design) conditions. The design of different components of the collection and treatment system is based on different magnitude flowrates and loadings.

The sanitary component of the wastewater flow is expected to increase proportionally with the increase in population. The projected ADWF and corollary flowrates are based on the following assumptions.

- The per capita flow rate will remain constant during the planning period.

- The population will increase by the projected percentage each year during the planning period.
- The per capita flow rate multiplied by the projected equivalent population equals the residential, commercial, and industrial sanitary component of the flow.
- There will be approximately 0.05 MGD of flow from industrial growth that is at residential strength during the planning period.
- The City's infiltration and inflow reduction program will prevent any increase in infiltration and inflow into the existing collection system.
- All growth will occur in conformance with current land use policies as outlined in the City's Comprehensive Plan.

Table 5-5 summarizes the projections for the different components of the wastewater flow over the 20-year planning period for the WWTP. The rationale for the population projects is presented in **Section 2**.

Table 5-5 | Wastewater Flow Projections

Year	Population	ADWF (1) (mgd)	MMDWF (mgd)	AAF (mgd)	AWWF (mgd)	MMWWF (mgd)	PDAF (mgd)	PHF (mgd)
2011	2718	0.295	0.663	0.471	0.707	0.884	2.357	4.125
2015	2958	0.316	0.709	0.518	0.753	0.930	2.403	4.803
2020	3287	0.346	0.772	0.581	0.817	0.993	2.467	4.926
2025	3653	0.379	0.843	0.651	0.887	1.064	2.537	5.062
2030	4069	0.416	0.923	0.732	0.967	1.144	2.617	5.217
2035	4548	0.459	1.015	0.824	1.060	1.236	2.709	5.396

(1) Includes industrial flow of 0.05 MGD.

To assist in analyzing the collection system piping and pump station capacity, projected peak flows for each sewer basin were determined. The projected design peak hour flows by basin are as outlined in Table 5-6. The flow calculations shown are based on projected population and development at the end of the study period. The 2035 basin flow contributions are based on the assumption that development occurs uniformly within all basins during the study period. Clearly, this will not likely be the case. Growth is more likely to occur in an uneven, piecemeal fashion. In fact, some basins are likely to see no growth within the planning period. Therefore, as some basins develop faster than others, the net result will be that any trunk sewer improvements will be required sooner rather than later. For basins that are already fully developed, the 2035 PHF is the same as the PHF at buildout. This demonstrates a key point that is worth reemphasizing. This Facilities Plan is based on the assumption that existing I/I flows will not increase. Much of the City's core collection system is more than 40 years old. Therefore, many of the original pipes are likely to approach the end of their useful life during the planning period. As the system continues to age, the City must aggressively implement I/I correction measures. Currently, the City spends approximately $10,000 per year on I/I reduction work. This is discussed in more detail in **Section 6.**

Table 5-6 | Projected Peak Flows By Basin
(Estimated peak hour flows for trunk sewer sizing)

Basin	2035 PHF (1) (mgd)	Buildout PHF (mgd)
9th Street	1.039	1.039
Palmer Creek Basin	0.126	0.126
Main North Basin	0.908	0.908
Main Central Basin	0.729	0.729
Main South Basin (2)	1.040	1.040
HWY 221 Basin	0.261	0.261
RV Park Basin	0.129	0.129
Foster Basin	0.361	1.196
Kreder Basin	0.003	0.003
Total	4.597	5.432

(1) Industrial flows of 0.05 MGD are not accounted for in the basin flows above.
(2) This is the gravity flow component, for trunk sewer sizing must also include Palmer Creek & 9th Street basins because these basins are pumped to the Main South basin.

5.3. WASTEWATER COMPOSITION AND LOADING

The composition and concentration of wastewater constituents are important in the design of wastewater treatment and disposal facilities. Treatment processes are designed hydraulically to pass the design flowrates while providing adequate treatment, or removal, of the organic and solids components from the wastewater. Wastewater composition is less important for the design of collection and pumping systems where the hydraulic considerations control.

For the purposes of monitoring wastewater loads and identifying future design loads, the following classifications will be used:

- Average Load - Average daily wastewater load.
- Maximum Load - Maximum month wastewater load.

5.3.1 Historic Wastewater Composition

The BOD and TSS concentrations in the influent wastewater are measured twice monthly. However, due to the inaccurate historical influent flow records, the historical loading rates cannot be determined. Instead we used typical per capita BOD and TSS loading rates that correspond to typical loading rates of similar sized municipalities. These typical per capita loading rates are listed in Table 5-1. Based on typical per capita loading rates shown in Table 5-1 the existing BOD loading rate would be approximately 544 lbs per day (2,718 people X 0.20 ppcd), while the TSS loading rate would be approximately 598 lbs per day (2,718 people X 0.22 ppcd). Utilizing the same approach, future loading projections from present to 2035 were calculated based on the same per capita loading rates. Table 5-7 illustrates the future BOD and TSS loading projections. For reference, the design BOD loading (i.e., design organic treatment capacity) for the existing WWTP is 390 ppd BOD with a design population of 2,295.

5.3.2 Wastewater Load Projections

Similar to flows, the total wastewater loads are expected to increase in direct proportion to the increase in population. The projected loadings are based on the following assumptions.

- Design values of 0.20 ppcd and 0.22 ppcd for average dry weather load conditions were used for BOD and TSS, respectively. These values correspond very well to typical loading rates of similar sized municipalities.

- The loads associated with industrial flows will be similar to residential. Therefore, the assumed industrial flows at the end of the planning period is 0.05 MGD. Based on the assumption of a per capita demand of 90 gpcd, the industrial flows are equivalent to 556 people.

- The per capita BOD and TSS load rate multiplied by the projected population equals the residential, commercial and industrial component of the load.

- There will be no significant industrial contribution beyond typical residential strength sewage during the planning period.

The per capita loads and resulting load projections for 20-year planning are shown in Table 5-7.

Table 5-7 | Wastewater Load Projections

Year	Total Population	Avg. Daily BOD (1) Load (ppd)	Avg. Daily TSS Load (1) (ppd)
2011	2718	655	720
2015	2958	703	773
2020	3287	769	845
2025	3653	842	926
2030	4069	925	1017
2035	4548	1021	1123

(1) Includes industrial loads equivalent to 556 people.

5.4. SUMMARY OF FLOWS AND LOADING

The recommended design flows and loads for the City's wastewater treatment facilities are summarized in Table 5-8. These values will be used in subsequent sections of this Facilities Plan.

Table 5-8 | Projected Flows And Loads, 2035

Component	Flow
ADWF – Average Dry Weather Flow(mgd)	0.459
AWWF – Average Wet Weather Flow(mgd)	1.060
AAF – Annual Average Flow(mgd)	0.824
MMDWF – Maximum Month Dry Weather Flow(mgd)	1.015
MMWWF – Maximum Month Wet Weather Flow(mgd)	1.236
PDAF – Peak Daily Average Flow(mgd)	2.709
PHF – Peak Hour Flow(mgd)	5.396
Average BOD (ppd)	1021
Average TSS(ppd)	1123