CITY OF PHILOMATH
Wastewater System Facilities Plan,
Philomath, Oregon

Section 5

Wastewater Flows and Loads

SECTION 5
WASTEWATER FLOWS AND LOADS

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 MMDWF usually determines the maximum organic loadings of the major process units. The MMWWF determines the size and capacity of the major process units necessary to provide the desired degree of treatment. The 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 which 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	100 gpcd
• Population Density Per Acre	
- Low Density Residential (LDR)	10.7
- Medium Density Residential (MDR)	20.4
- High Density Residential (HDR)	30.0
• Commercial	1500 gpad (15.0 people/acre)
• Industrial (assumes 'dry' industries)	2750 gpad (27.5 people/acre)
• Public	500 gpad (5.0 people/acre)
Peaking Factors	
• Residential Flows	3.0
• Commercial Flows	3.0
Infiltration/Inflow (I/I)	
• New Gravity Sewers	1600 gpad
• Existing Sewers	As measured
Organic Loading (BOD)	
• Residential	0.22 ppcd
• Industrial	6.0 ppad
Solids Loading (TSS)	
• Residential	0.24 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 average commercial flow of 50 gpcd, this would mean that flow contribution from these areas would 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 Philomath. 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.

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. For the purposes of this study, projected wastewater loadings from projected industrial development in Philomath are based on "dry industries" which typically contribute 2,750 gpad per acre or less. BOD and suspended solids concentrations similar to domestic sewage are assumed. This decision is based in part by the capacity of the City's water treatment plant. The water treatment plant does not have capacity to provide the quantities of water required to support "wet" industries.

Should any industrial user capable of producing large wastewater flows, higher concentrations, or hazardous effluent want to locate in Philomath, a careful review should be made to determine if the collection system and the treatment and disposal system can adequately serve the industry.

For this study, wastewater flow rates were based on an average employed population of 55 persons per acre and an average employee wastewater flow contribution of 50 gpcd. This means for industrial land within the study area, the average flow would be 2,750 gpad. The peak flow for these industrial acres would follow the same general relationship as was discussed previously for residential areas.

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 most necessary to 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 (in areas with clay soils) 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 DMRs were reviewed to determine the extent of the I/I contribution to the system flows.

5.2.2 Existing Wastewater Flows

To determine the existing wastewater flows, the DRM data from the winter of 1997 through the winter ending in April 2002 was analyzed. A summary of the DMR data is presented in **Appendix E**. The summer 2002 flow data was discarded due to the fact that it appeared to have been in error. After investigating the problem, the City determined that the summertime gears in the influent meter were not properly calibrated when installed and made corrections. The population of Philomath in 1997 was 3700. The current population is 4100. This increase should not have a significant impact on the flow data over this period. The DMR data was compared to the rainfall data collected at the Hyslop Field weather station near Corvallis.

The dry weather sanitary sewage flow presently averages about 0.454 mgd. The wet weather flow averages approximately 1.100 mgd. The wet weather flow is approximately two and one-half times the dry weather flow. This observation is typical in western Oregon where rainfall induced inflow and infiltration is significant. The sanitary sewage flows vary from a low occurring in the early morning hours to a peak flow, often occurring between 7:00 a.m. and 10:00 a.m.

At present, there are approximately 1,465 active sewer connections in the City. **Table 5-2** contains a breakdown of these service connections by user category.

TABLE 5-2 **Sewer Connection Summary** (As of January 2003)	
User Classification	Number of Services
Residential/Multi-Residential	1,276
Commercial/Schools	179
Industrial	10
Total	1,465

Table 5-3 contains a summary of the average wet weather and average dry weather flows measured at the treatment plant over the past five years.

TABLE 5-3 **Historical Influent Flows at the WWTP**		
Water Year Ending In October	AWWF (mgd)	ADWF (mgd)
1997	1.154	0.502
1998	1.151	0.453
1999	1.383	0.435
2000	1.127	0.465
2001	0.612	0.417
2002	1.223	NA
Average	1.100	0.454

OAR 340-041 prohibits the discharge of raw sewage to waters of the State except during storm events greater than the 5-year, 24-hour storm for the wet weather period and the 10-year, 24-hour storm for the dry weather period. To this end, 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.

To determine the flowrates associated with a particular storm frequency requires a quantitative knowledge of the relationship between wastewater flowrates and rainfall. The DEQ published guidelines that present a methodology for determining wastewater flowrates in areas impacted by rainfall induced inflow and infiltration. This methodology is based on the assumption that under saturated subsurface conditions (high groundwater levels), wastewater flowrates can be directly correlated to rainfall. This assumption is valid for areas that receive large amounts of rainfall such as the Willamette Valley. To establish a relationship between monthly rainfall and average monthly flow, the average monthly wastewater flow rates for wet weather months are plotted against their corresponding monthly rainfall values. This data is plotted in figure **Figure 5-1.** A linear regression is performed to establish the relationship between monthly rainfall and monthly precipitation. This relationship can be used to predict plant inflows as a function of monthly rainfall depth.

The MMDWF is the monthly average flow for the rainiest summer month of high ground water. In the Willamette Valley the MMDWF invariably occurs in May. The DMR data for Philomath supports this observation. As previously mentioned, MMDWF is defined by the 10-year recurrence interval. Therefore, the MMDWF may be estimated by the monthly flowrate for the month of May with a 10-year recurrence interval. The relationship established in **Figure 5-1** may be used if the rainfall depth for the month of May that is associated with a 10-year recurrence interval is known. Rainfall depths corresponding to various exceedence probabilities have been calculated for the Hyslop Field data set. For the month of May, rainfall depth associated with the 90% exceedence probability (a.k.a., 10-year recurrence interval) is 3.49 inches. Using this rainfall depth in the relationship established in **Figure 5-1** the MMDWF can be estimated.

The MMWWF represents the highest monthly average attained during the winter period of high groundwater. The DEQ methodology is based on the assumption that high groundwater levels are not consistently maintained until the month of January. Therefore, heavy storms do not begin to cause a reliable or consistent infiltration and inflow response until January. This leads to the assumption that the MMWWF occurs in January. Therefore, in the same manner used to determine the MMDWF, the rainfall depth associated with a 20% probability of exceedence (a.k.a., 5-year recurrence interval) for the month of January is used in the correlation between plant flows and rainfall to determine the MMWWF.

The PDAF is defined as the peak daily average flow associated with a 5-year storm. The PDAF will occur under saturated subsurface conditions when the influence of rainfall on infiltration and inflow is the strongest. The PDAF is determined by plotting observed peak average daily flow against the corresponding daily rainfall depths. The 5-year 24-hour rainfall depth is used in a linear regression of the data to determine the PDAF. The data used to determine the PDAF is plotted in **Figure 5-2**. These data points were carefully selected to ensure that groundwater levels were saturated for the period over which flow data was collected.

A statistical approach is used to determine the PHF. This approach involves assuming that a particular year includes a 5-year storm with high groundwater conditions producing the MMWWF and the PDAF. During this 5-year storm the PHF occurs within the peak day. These assumptions enable one to determine the portion of the year over which each flow component occurred. For example, the MMWWF occurs 1/12 of the time or with an 8.33% probability, the AAF occurs half of the time or with a 50% probability, and so on. The rainfall depth is assumed to be a random variable with a log-normal probability distribution. If this assumption is accurate, the AAF, MMWWF, and PDAF should plot as a straight line on log-probability paper. These flow components are plotted on **Figure 5-3**. Since the PHF occurs 1 hour out of this hypothetical year (i.e., 1/8760 or 0.011% probability), by extrapolating a linear regression to a probability of 0.011% the PHF may be determined.

Figure 5-1
MMWWF and MMDWF Determination
(existing conditions based on DEQ guidelines for western Oregon)

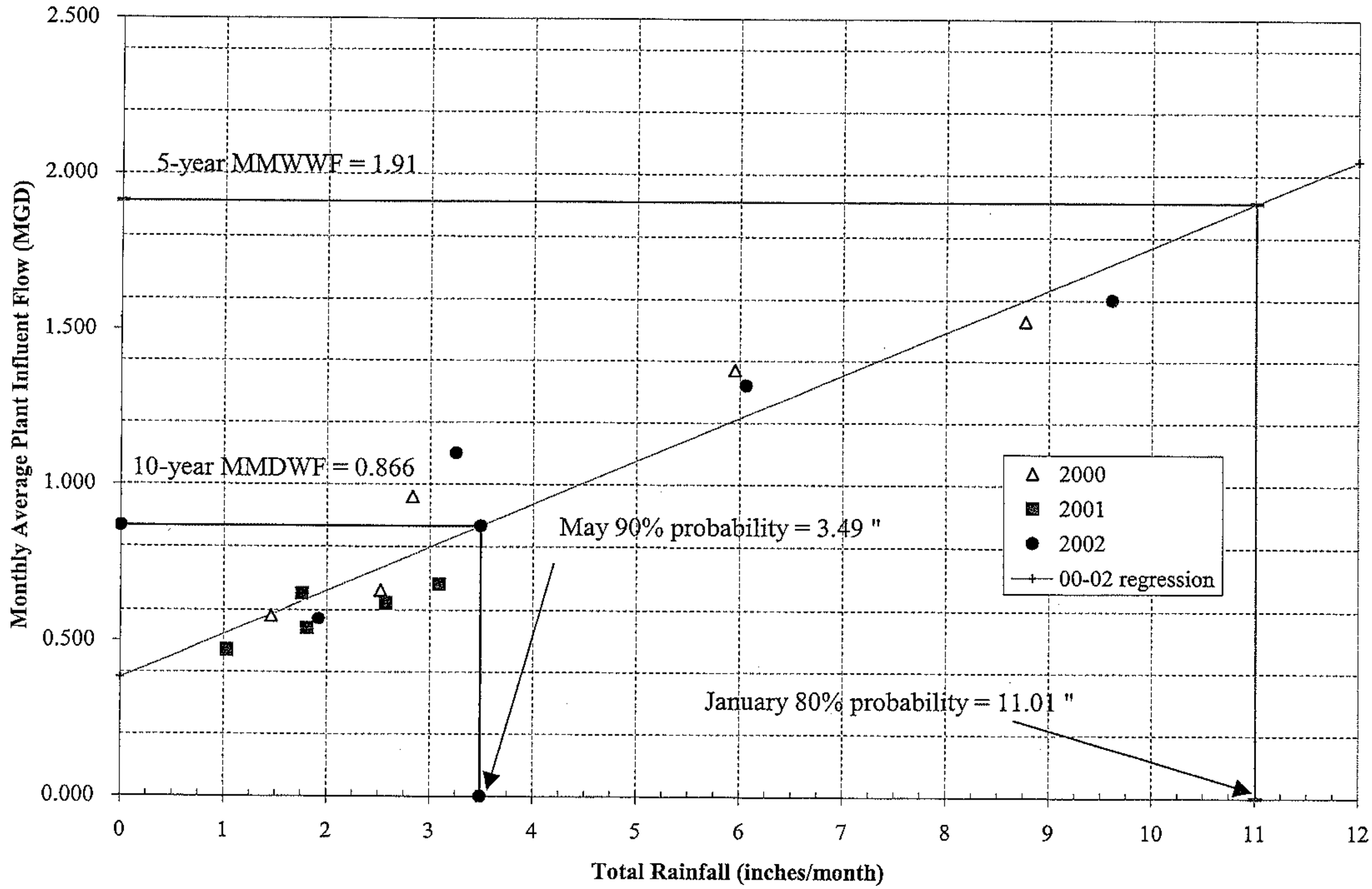

Figure 5-2
PDAF Determination
(existing conditions during significant storm events
based on DEQ guidelines for Western Oregon)

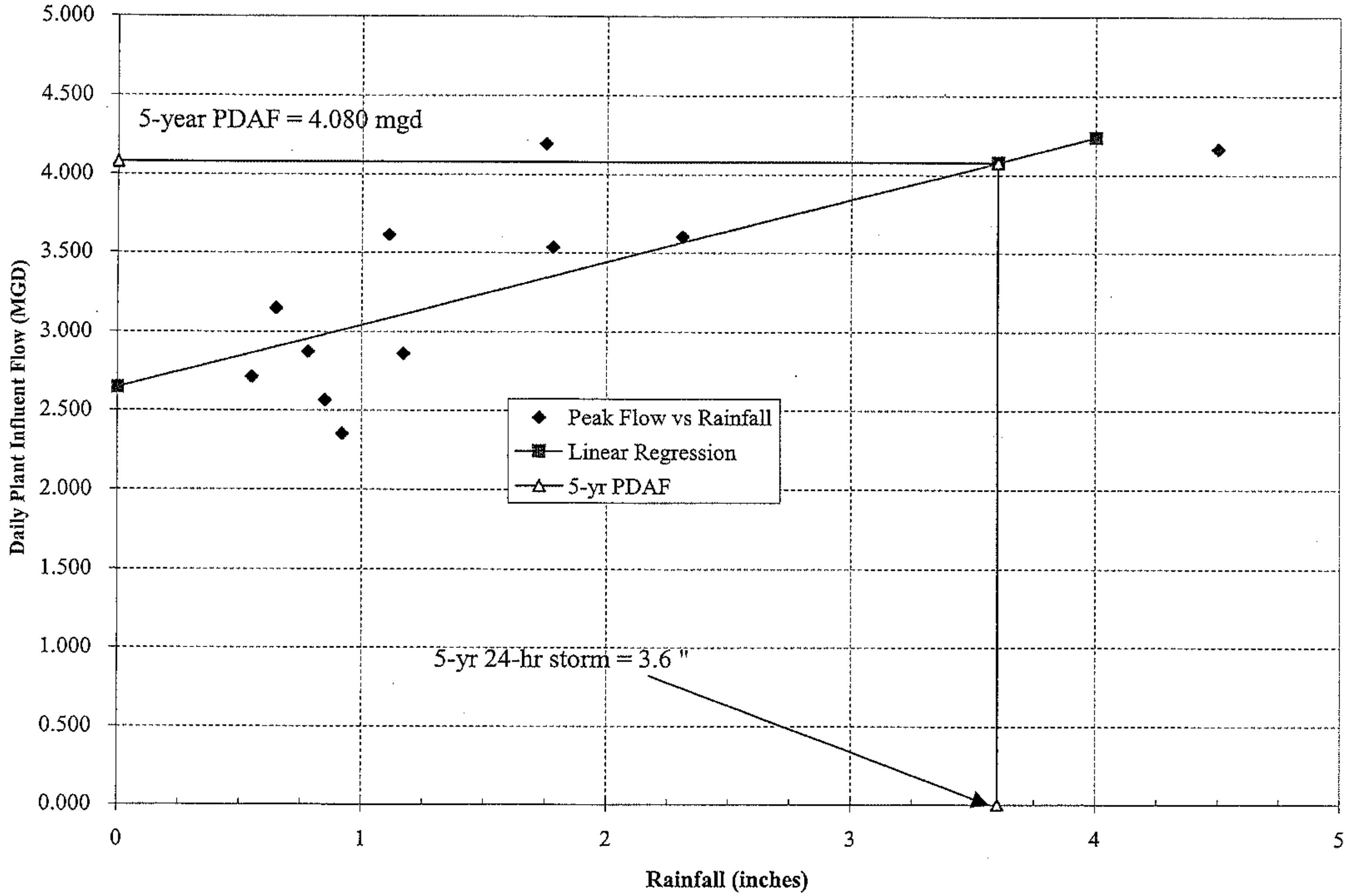

Figure 5-3
PHF Determination
(existing conditions by statistical extrapolation based on DEQ guidelines for western Oregon)

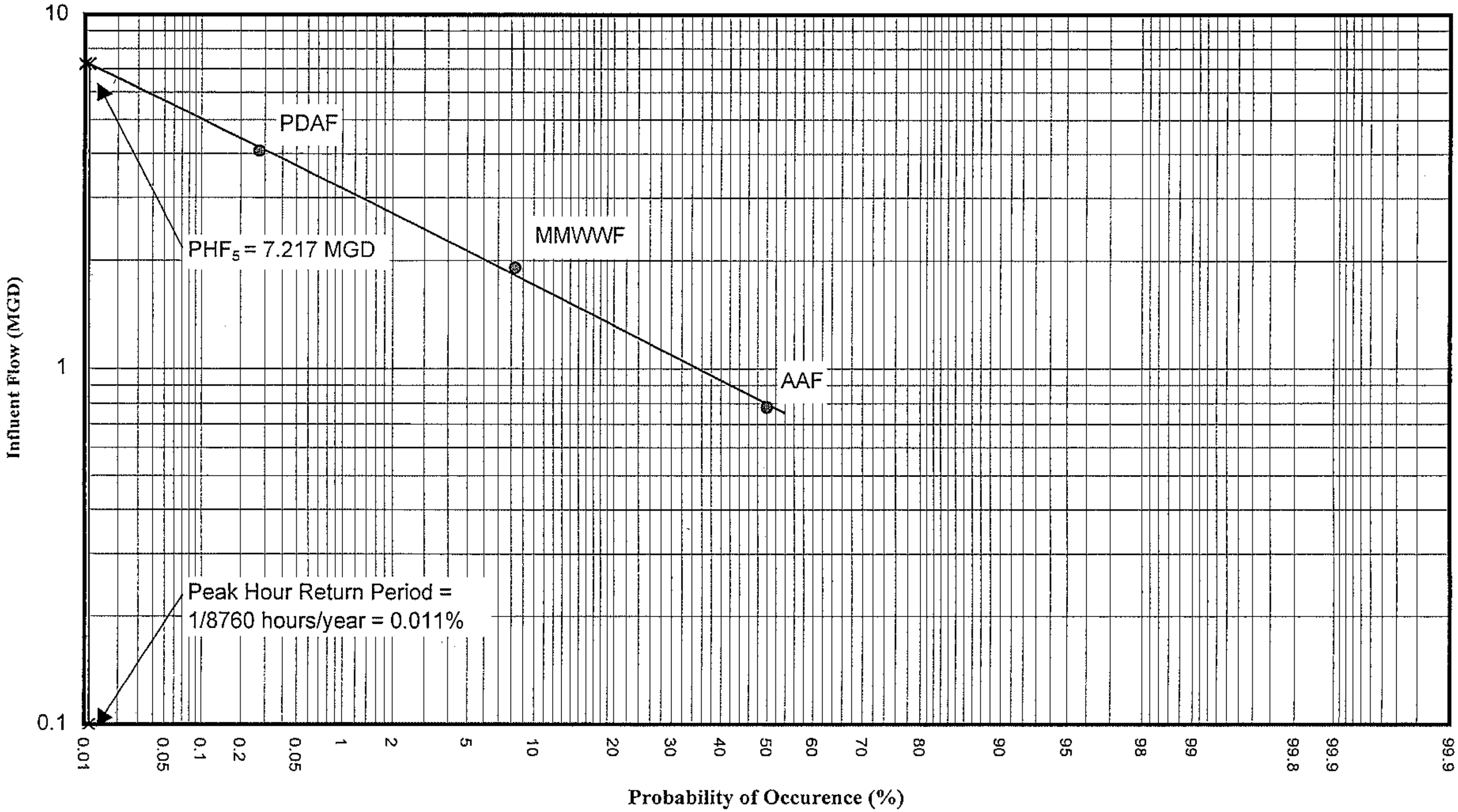

Table 5-3 contains a summary of the existing flow components to the WWTP.

TABLE 5-4 Summary of Current Flow Components	
Flow Component	Flows (mgd)
AAF (Average Annual Flow)	0.774
ADWF	0.454
MMDWF	0.866
AWWF	1.100
MMWWF	1.910
PDAF	4.080
PHF	7.217

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 no contribution from "wet" industries during the planning period. Commercial and industrial development will be "dry" with flows comparable to residential developments.
- 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.

TABLE 5-5
Wastewater Flow Projections

Year	ADWF (mgd)	MMDWF (mgd)	AAF (mgd)	AWWF (mgd)	MMWWF (mgd)	PDAF (mgd)	PHF (mgd)
2005	0.477	0.902	0.808	1.143	1.978	4.216	7.468
2010	0.520	0.968	0.868	1.222	2.103	4.462	7.925
2015	0.567	1.041	0.935	1.310	2.241	4.737	8.435
2020	0.619	1.122	1.010	1.407	2.396	5.044	9.002
2025	0.678	1.213	1.094	1.516	2.568	5.385	9.634
2027	0.703	1.252	1.130	1.563	2.642	5.532	9.906

The projected design 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 2027 basin flow contributions are based on the assumption that development occurs uniformly within all basins during the study period. Clearly, this is not 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 2027 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 50 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. 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	2027 PHF (mgd)	Buildout PHF (mgd)
A1	0.362	0.362
A2	0.307	0.523
A3	0.194	0.194
A4A	0.757	0.822
A4B	0.493	0.514
A5A	0.255	0.378
A5B	0.124	0.268
A5C	0.195	0.207
A6	0.982	0.986
A7A	0.104	0.224
A7B	0.050	0.108
N1A	0.167	0.360
N1B	0.139	0.299
N2	0.096	0.208
N3AA	0.865	0.906
N3AB	0.434	0.434
N3B	0.437	0.443
N3CA	0.557	0.566
N3CB	0.082	0.082
N3D	0.270	0.278
N4	0.223	0.481
N5	0.622	1.342
N6A	0.484	1.044
N6B	0.463	0.998
N7	0.099	0.213
N8A	0.429	0.581
N8B	0.343	0.740
N8C	0.068	0.147
P1A	0.190	0.309
P1B	0.173	0.374
P2A	0.050	0.108
P2B	0.124	0.267

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. These concentrations have been converted to loading rates and are shown for the last several years in **Table 5-7**. For reference, the design BOD loading (i.e., design organic treatment capacity) for the existing WWTP is 976 ppd BOD.

TABLE 5-7
Historical Annual & Monthly Loading At WWTP

Year	BOD		TSS	
	Average Annual (ppd)	Maximum Month (ppd)	Average Annual (ppd)	Maximum Month (ppd)
1997	859	1276	915	1598
1998	1029	1782	1025	1977
1999	869	1698	1218	4162
2000	766	1101	956	1230
2001	913	2039	988	1671
Average	887	1579	1020	2128

5.3.2 Wastewater Load Projections

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

- Design values of 0.22 ppcd and 0.24 ppcd for average dry weather load conditions were used for BOD and TSS, respectively. These values correspond very well to the loading rates presented in **Table 5-7** if one assumes an average population of 4,100 residents.

- The loads will increase proportionally with population and commercial/industrial development, which will increase by the projected percentage each year during the planning period.

- 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 5-8.**

TABLE 5-8 Wastewater Load Projections		
Year	Average Daily BOD (ppd)	Average Daily TSS (ppd)
2005	962	1050
2010	1072	1170
2015	1194	1303
2020	1331	1452
2025	1482	1617
2027	1548	1689

5.4. Summary of Flows and Loading

The recommended design flows and loads for the City's wastewater treatment facilities are summarized in **Table 5-9**. These values will be used in subsequent sections of this Facilities Plan.

TABLE 5-9 Projected Flows And Loads, 2027	
Component	
ADWF – Average Dry Weather Flow(mgd)	0.703
AWWF – Average Wet Weather Flow(mgd)	1.563
AAF – Annual Average Flow(mgd)	1.130
MMDWF – Maximum Month Dry Weather Flow(mgd)	1.252
MMWWF – Maximum Month Wet Weather Flow(mgd)	2.642
PDAF – Peak Daily Average Flow(mgd)	5.532
PHF – Peak Hour Flow(mgd)	9.906
Average BOD (ppd)	1548
Average TSS(ppd)	1689