Design flow and loading determination guidelines for wastewater treatment plants

Introduction

Determination of design flow and loadings is one of the most important items when planning a new or expanded wastewater treatment facility. Sound engineering judgement along with these minimum guidelines will determine the hydraulic and pollutant load capacity required by the proposed facility to meet all permitted limits.

All influent sources must be accounted for when completing design flow and loading determination including residential, seasonal, institutional, commercial, industrial, inflow, infiltration, any recycle streams, and any other unique aspect of flow and pollutant contributions. During the treatment facility design process, possible impacts of design flows and loadings on each upstream and downstream unit process should be considered.

Definitions

Existing flow data for critical low and peak wet weather events are used to estimate the following flow conditions critical to the design of wastewater treatment plants.

Term	Definition
ADW	**Average dry weather** flow is the daily average flow when the groundwater is at or near normal and a runoff condition is not occurring.
AWW	**Average wet weather** or peak/max month flow is the daily average flow for the wettest 30 consecutive days for mechanical plants or for the wettest 180 consecutive days for controlled discharge pond systems. The 180 consecutive days for pond systems should be based on either the storage period from approximately November 15 through May 15 or the storage period from approximately May 15 through November 15.
PHWW	**Peak hourly wet weather** **Existing collection system:** flow is the peak flow during the peak hour of the day at a time when the groundwater is high and a five-year one-hour storm event is occurring. To determine this five-year one-hour storm event for a specific location, please refer to Map Number 1. **New collection system:** 2.5 or higher multiplier or AWW for residential, commercial + peak hourly industrial. (Ten States Standards Figure 1, Chapter 10)
PIWW	**Peak instantaneous wet weather** **Existing collection system:** flow is the peak instantaneous flow during the day at a time when the ground water is high and a twenty-five year one-hour storm event is occurring. To determine the twenty-five year one-hour storm event for a specific location, please refer to Map Number 2. **New collection system:** 2.5 or higher multiplier or AWW for residential, commercial + peak hourly industrial. (Ten States Standards Figure 1, Chapter 10)

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Minimum design requirements

Table 1 contains a summary of the minimum recommended flow and loading conditions for only a select group of processes. Specific design parameter details for individual treatment process units shall be in accordance with **Ten States Standards.**

Where the Minnesota Pollution Control Agency (MPCA) determines that the above design flow considerations will not provide adequate protection to the receiving waters, facility capacity in excess of peak instantaneous wet weather and/or organic loading calculation may be required.

Table 1: Design conditions summary.

Item	Design
Collection system	Must be capable of transporting all flow to the treatment facility without bypassing.
Lift station	Must be capable of transporting all flow to the treatment facility without bypassing.
Flow equalization basin	If PHWW/ADW > 3, or if PHWW/AWW > 3, flow equalization must be considered. If equalization is not provided, a discussion of how the facility will handle the transition in flow must be included. See flow equalization section of this document.
Facility piping and pumping	PIWW
Preliminary treatment unit (screens, grit removal, influent filters, etc.)	PIWW
Clarifiers (surface settling rate and weir loading rate)	PHWW + recirculation flow see "Ten States Standards"
Disinfection (detention time)	PHWW see (Ten States Standards)
Organic loading	Minimum BOD of 0.17 #pcd plus commercial, industrial, and other non-residential flow Minimum TSS of 0.20 #pcd plus commercial, industrial, and other non-residential flow

Design flows

Actual flow data should be used to determine design flow when possible. At a minimum, 100 gallons per capita per day should be used. Include the following information with design flow calculations.

- Data used and data excluded. At least 5-years of facility flow records should be evaluated. Extreme wet or dry weather events may be excluded where appropriate. Map 1 and 2 can be used to analyze wet weather events to determine if an event exceeds the rainfall event for design purposes.
- Water use information, particularly during dry weather flow periods.
- Total and per capita pollutant loadings during a range of flow events.
- Reliability of flow monitoring equipment, pump station performance and methods used to estimate flow reductions or contributions from inflow and infiltration.

Discussion of a method to use when existing flow data is and is not available is included below.

New treatment system and new collection system (no existing flow data)

Use Table 2 for flow calculations. Table 3 is not a required submittal. Other methods of determining design loadings are acceptable, but must be attached with this form. Design loadings in pounds per day (#/day) must be entered in Summary Table 4. Table 2, 3 and 4 can also be found electronically in Excel format here: https://www.pca.state.mn.us/sites/default/files/wq-wwtp5-20a.xlsx. Table 2 and 4 are required submittals with facility plans.

For mechanical plants, if the industrial flow varies during the day or week, the design flow should be based on the average flow on the peak day during the period when the industry or industries are operating. This condition is called "rated flow." For example, if the industry discharges 10,000 gallons over eight of the twenty-four hours, the rated flow is 30,000 gallons per day. For controlled discharge pond systems, if the industrial flow varies during the day or week, the average design flow may be based on a weekly average.

The MPCA may approve of an alternative flow design with appropriate justification. For determining the design of the collection system (including design flow), refer to Chapter 30 of Ten State Standards).

Some form of permit "control language" may be included for wastewater treatment facilities if the per capita design flow is less than what is recommended in this document. For this situation, it may become a permit violation when the permitted design flow is reached. Violation of the permitted flow could result in "no more connections" being allowed to the system, or the requirement for submittal of a report that examines the flow in comparison to the number of connections and the number of people using the system. The permittee could also be required to plan, design, and build additional treatment units upon reaching the design capacity.

Existing treatment systems and collection system (existing flow data)

For a mechanical plant, the attached Table 2 should also be used to determine the peak hourly wet weather flow, the peak instantaneous wet weather flow, the average dry weather flow, and the average wet weather flow.

Part A of Table 2 and Figure 1 are used to determine the peak hourly wet weather flow. The measured flow should be plotted for a twenty-four hour period when **groundwater is at or near normal and a runoff condition is not occurring** (Curve X on Figure 1). This should include flows data from overflows, bypasses, and emergency pumping events. The ground water elevation in relation to the sewer elevation should be noted. The present peak hourly dry weather flow is indicated by point (1) on Figure 1, and row 1 in Table 2.

The measured flow should be plotted for a twenty-four hour period when **groundwater is high and a runoff condition is not occurring** (Curve Y). This should include overflow, bypasses, and emergency pumping. The ground water elevation in relation to the sewer elevation should be noted. Point (2) on Figure 1 and row 2 in Table 2 is the peak hourly flow during a high groundwater period when a runoff condition is not occurring. The peak flow at point (2) minus the present peak hourly dry weather flow at point (1) is the peak hourly infiltration.

The measured flow should be plotted for a twenty-four hour period when the **groundwater is high and a runoff condition is occurring** (Curve Z). This should include flow data from overflows, bypasses, and emergency pumping events. The amount of rainfall and its duration should be plotted on the same graph. The peak inflow is represented by the greatest distance between Curve Y and Curve Z. The present hourly flow at the point of greatest distance between Curve Y and Z [point (5) on Figure 1 and row 5 in Table 2] minus the present hourly flow during high ground water at the same time of day on Curve Y [point (6) on Figure 1 and row 6 in Table 2] is the peak hourly inflow.

It may be necessary to adjust the measured flow based on a relationship between the data attained during a major storm event and the five-year one-hour designed storm event. Items (10) and (13) in Table 2 are determined through a cost effectiveness evaluation. The gallons per capita per day (gpcd) contribution for population increase in item (15), (25), (33), and (41) should all be 100 gpcd.

Part B of Table 2 determines the peak instantaneous wet weather flow. The present peak hourly inflow adjusted for a five-year one-hour rainfall event [see part A row (8)] is subtracted from the peak hourly wet weather flow [see part A row (19)]. To this number, add the present peak hourly inflow adjusted for a twenty-five year one-hour storm event. The resulting number is the peak instantaneous wet weather flow.

Part C of Table 2 determines the average dry weather flow. The present average dry weather flow (24) is the average flow received over a twenty-four hour period when the ground water is at or near normal and a runoff condition is not occurring. If the industrial flow varies during the day or week, the present average dry weather flow should be based on the average flow of the peak day during the period when the industry or industries are operating (rated flow). This also applies to the average flow from industrial increases.

Part D of Table 2 determines the thirty-day average wet weather design flow. The average infiltration and inflow after rehabilitation (where rehabilitation is cost effective) is the wettest thirty-day average. The amount of infiltration after rehabilitation averaged over the thirty wettest days should be the same or nearly the same as the peak infiltration after rehabilitation. This is due to the fact that the ground water could stay high for a fairly extended period of time. The amount of inflow after rehabilitation averaged over the thirty wettest days depends on the type of sources, their location, the amount of rainfall that affects the source, etc.

Part E of Table 2 correlates all related information that can impact the degree of accuracy of the determination of design flows. It is recommended that a minimum of six months of accurate data be recorded. Data associated with the critical peak wet weather flow events for a sustained wet weather period are essential for accurate estimation of design flows. Critical peak wet weather flow events typically occur in the spring (March-June) and must include the condition of high ground water with inflow.

Controlled discharge pond systems with existing sanitary sewer systems

The peak hourly wet weather and the peak instantaneous wet weather design flows to a pond system with an existing sanitary sewer system are arrived at in the same manner as in Parts A and B of the previous section. If the present industrial flow varies during the day or week, the present average dry weather flow (24) and (30) may be based on a weekly average. When computing the average wet weather flow, the average infiltration after rehabilitation (31), and the average inflow after rehabilitation (32) are averages over the wettest 180 consecutive days.

Flow equalization

This section applies to all treatment facilities except pond systems.

If the ratios described below are three or more, flow equalization should be considered. If flow equalization is not employed, an explanation must be provided describing how the facility will handle the transition from these average design flows to peak hourly wet weather design flow.

A. During a period of high ground water for that area and system, calculate the ratio of peak hourly wet weather design flow to average wet weather design flow [which is (19) divided by (37)].

B. During a normal ground water period, calculate the ratio of the peak hourly design flow during the five-year one-hour storm event [(1)+(14)+(15)+(17)+(18)] to the average dry weather design flow (29).

Infiltration and inflow

Infiltration and inflow (I/I) is a part of every collection system and must be taken into account in the determination of an appropriate design flow.

Inflow means water other than wastewater that enters a sewer system directly from sources such as roof leaders, foundation drains, yard drains, manhole covers, cross connections between storm sewers and sanitary sewers, catch basins, storm water runoff and other drainage structures.

Infiltration means water other than wastewater that enters the sewer system from the ground through defective pipe, pipe joints, and manholes.

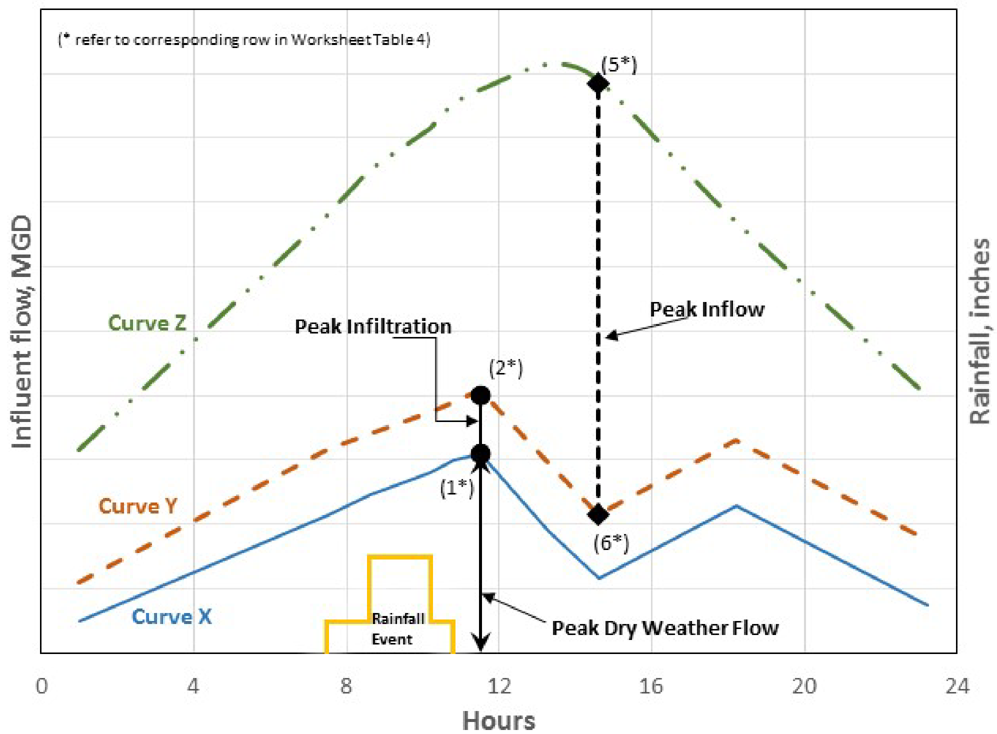
Excessive infiltration means the quantity of flow that is more than 120 gpcd (domestic base flow and infiltration).

Excessive inflow means the quantity of flow during storm events that results in chronic operational problems related to hydraulic overloading of the treatment system or that results in a total flow of more than 275 gpcd (domestic and industrial base flow plus infiltration and inflow). Chronic operational problems may include surcharging, backups, bypasses, and overflows.

Bypasses/overflows and releases

Determining the design flow is one of the most challenging parts of the design process. It is not cost effective to design a system that can capture and treat flows from every extreme event, however, bypasses, overflows and releases of any kind are prohibited by permit and rules.

Figure 1: Determination of peak hourly flows before adjustment for storm event.



- Curve X: 24 hour flow with NORMAL groundwater conditions and no runoff
- Curve Y: 24 hour flow with HIGH groundwater conditions and no runoff
- Curve Z: 24 hour flow with HIGH groundwater conditions and runoff

All of these flows should include any bypassing, overflows or bypass pumping.

For more detail see discussion in previous pages.

Note: All flow measurements taken at treatment plant with adjustments for bypasses, overflows and emergency pumping. Groundwater elevation in relation to sewers should be stated for several points in the sewer system. Dates of flow measurements should be stated.

Design Flow and Loading Determination Guidelines for Wastewater Treatment Plants (Tables 2, 3 and Summary Table 4): https://www.pca.state.mn.us/sites/default/files/wq-wwtp5-20a.xlsx

Map 1 and Map 2 are taken from the NOAA website. An interactive site specific map can also be used. Found here: https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=mn

For more information

Please contact the engineer assigned to the project or region. If the engineer is unknown, contact the MPCA's front desk.

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