Peak Flow Projections

Keep up data collections to assist engineers with developing the best sanitary collection systems

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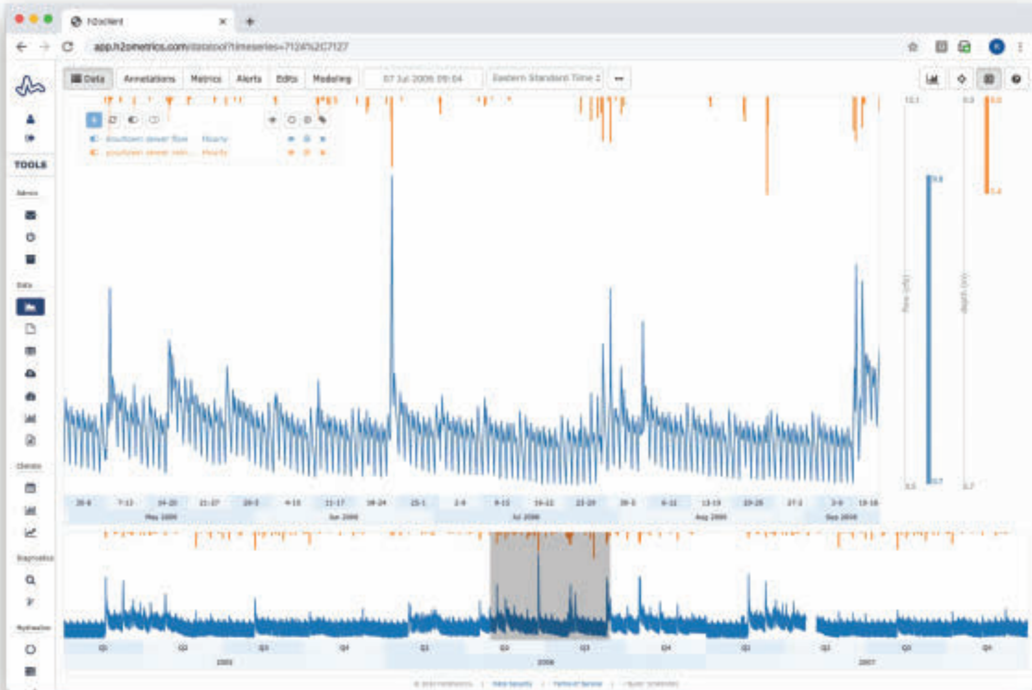
Sanitary collection systems owners and operators often are faced with the challenge of determining how much peak flow their systems generate. This might be needed for master planning purposes, to plan for capital upgrades, or to correct a capacity or overflow issue.

Rainfall often drives peak flows because of inflow and infiltration (I/I) dynamics. It is, therefore, important to understand the relationship between rainfall and flow to answer the peak flow question. All systems are different and exhibit different levels of I/I, depending on the system age, condition, material, construction method, and many other factors.

Under these circumstances, it is critical to collect good flow and rainfall data, as shown in Figure 1 (p. 44) to understand the dynamics that are driving flows, so that a good estimate can be made of design peak flows.

The following are best practices for flow and rainfall data collection, as well as explanations for why they are important for developing design peak flows from your sanitary collection system.

Figure 1. Example Data from a Permanent Flowmeter and Rain Gauge



This figure shows an example of the type of data that should be collected from a sewer system. The flow is the blue line, and the rain is the orange line. H2Ometrics

Flow and Rainfall Data

If you own or operate a sanitary collection system, collecting good data is essential for good system operation. At some point, you are probably going to be asked what the peak flow of your system is. You need data to answer this question, and you need standard data collection practices and equipment, such as a flowmeter (Figure 2, p. 45), to get the data.

The costs of corrective programs for I/I or system overflows directly relate to the magnitude of the projected design peak flow rates. Poor available data leads to poor projections of design peak flows. This can lead to unnecessary oversizing of upgrades and needless extra expenses. Data collection is very cheap compared to the cost and risk of designing a major upgrade without a basis of good data.

Using Models

A hydrologic model often determines design peak flows for sanitary collection systems. A hydrologic model is a numerical routine that describes the relationship between rainfall (the system input) and the flow (the system output). These are often referred to as rainfall–runoff models. Several available hydrologic models are suitable for modeling sanitary collection systems.

A model simulates an unobserved condition, such as the flow from a design rainfall event. Because these events are rare and occur sparsely in nature, it is often necessary to make projections of design flows from observations of flows from smaller storm events.

A good model is calibrated and validated to several storm events with various durations, intensities, and wetness conditions. Therefore, it is necessary to have good flow and rainfall data to use in developing such a model. The model will only be as good as the data available to develop it.

No Model Necessary?

If the purpose of a model were to simulate unobserved conditions, then a model would not be needed when the desired conditions have been observed and measured.

For example, some sanitary collection system owners have selected a design storm event based on an actual large event that has occurred and caused problems in the system. That is a perfectly legitimate method to select a design condition.

A model also is unnecessary when there is a lot of observed data available. A great example of this is a U.S. Geological Survey (USGS)

Figure 2. Doppler Flowmeter for Measuring Flow in a Sewer Pipe

This is a very common flowmeter used to measure sewer collection systems flows. Photograph used with permission from Teledyne ISCO. All rights reserved.

stream gauge with a long period of record, such as 50 to 100 years. With so much data available, it is not necessary to use a hydrologic model to determine design floods such as the 10-year or 25-year flood.

The level of these floods can be determined from a statistical probability analysis of the observed data. In fact, this is the methodology the U.S. Federal Emergency Management Agency uses to determine floodplains.

However, it still might be useful to build a model to understand unobserved conditions in the system. Even a system owner who selects a large observed rain event as the design condition, could develop a hydrologic model of the system to understand the distribution of flows across the system at unobserved locations. Likewise, a model could help understand the shape of the hydrograph for storage design. In the USGS stream gauge example, a hydraulic model may be useful to understand the water depth at locations along the stream where there is no stream gauge.

Data Collection Best Practices

The dynamics of I/I in sanitary collection system can occur very quickly, with flows rising after a rainfall within minutes or hours. The large events of interest occur rarely, with useful large events occurring only a few times per year. With these dynamics, the basic framework of a good data collection program includes the following elements:

Continuous measurement. Daily measurements will not cut it for a flow response that can come and go in a matter of minutes or hours. At a minimum, hourly data should be collected. A 5-minute sample frequency is even better.

Long-term monitoring. Because large storm events rarely occur, and because conditions can change drastically from season to season and from year to year, permanent long-term monitoring is necessary. This does not mean that you must collect data from dozens or hundreds of locations on a permanent basis. But you will increase the accuracy of your peak flow

Many municipalities use a rain gauge to collect rainfall data. Photograph used with permission from Teledyne ISCO.

projections tremendously if you have at least one location where you collect long-term data. Often, for small and medium communities, this can be at the entry of the water resource recovery facility. For larger systems, this may mean making measurement on each major branch of the system.

Data collection is very cheap compared to the cost and risk of designing a major upgrade without a basis of good data.

Uncensored data. Data affected in some way, or censored, by components of the system will not be as useful. Storage facilities, system overflows, on/off pump stations, hydraulic restrictions, and diversions will all censor the data, making the peak flows recorded less useful. If you can, collect flow data at locations that are unaffected by these facilities. For example, place meters upstream of an on/off pump station or upstream of a diversion to a storage tank or an overflow. If this is not possible, measure the flow of both the interceptor and the diversion. Measuring the flow downstream of an overflow or a diversion will produce data with limited value, as a significant portion of the peak flows for large events will not be measured (censored).

Tabulate peak flows on your monthly operating report (MOR). If you operate a water resource recovery facility, you probably have an influent flowmeter (usually a flume) to measure influent flow rate. Regulations require that the daily average flow be recorded on your MORs. It is a good practice to also record the daily peak flow on your MOR. That is the highest flow recorded during the course of the day. For small and medium systems, these data can be invaluable for validating design peak flows output from a model.

Collect good rainfall data. Do not overlook the importance of good rainfall data. It is half of the data needed to develop a good flow model. In addition to the best practices above, be sure to collect rainfall data from within or nearby the system of interest. A rain gauge 10 km (6.2 mi) away at the airport is not going to cut it, due to spatial variation of large thunderstorm rain events.

A sensor installed in a sewer pipe. Such a sensor would get installed to collect depth and flow data from a sewer system. Photograph used with permission from Teledyne ISCO. All rights reserved.

Data storage and backup. Be sure the data is accessible and backed up. Collecting all this great information is not going to do any good if it can't be accessed (trapped in an old legacy system) or is lost (because it was not backed up). While these data often are collected by supervisory control and data acquisition (SCADA) systems, SCADA is not the best repository for long-term storage, because it was designed for short-term control functions. If you do plan to use SCADA as your long-term data repository, be sure to let your integrator or IT staff know that this is an expected use-case for the system. Often long-term data storage and accessibility needs are not considered for SCADA systems. This can lead to data loss when system upgrades occur or a new system is installed.

Recommendations

Having been involved in sanitary collection system modeling projects for numerous communities around the country, I would highly recommend owners and operators of these systems implement these best practices for system monitoring. This will ensure that when the time comes to understand design peak flow rates, you have good data on which to base the peak flow projections. This will provide more confidence in the peak flow projections, which allows for better optimized upgrades, lower cost, and reduced risk of failure.

For small and medium systems, place a continuous, permanent data logger on the rain gauge and influent flowmeter at your water resource recovery facility or log peak flows on your MORs. For larger systems, consider placing a collection system flowmeter and rain gauge on each major branch of your collection system.

A good rule is to have one permanent flowmeter and rain gauge for each 10,000 to 25,000 people served, depending on the density and number of major system branches. For a community of 100,000 people, this would result in four to 10 flowmeters or rain gauges. For a system this large, with an operating budget of tens of millions of dollars and long-term capital improvements that could be on the order of a hundred million dollars, spending a few thousand dollars a month on metering to have great data for developing good design peak flows is a very good investment. This will pay dividends in the long run.

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