TECHNICAL MEMORANDUM

From: Bruce Tiffany, P.E.
To: Industrial Users of King County Sanitary Sewer System
Cc: Industrial Waste Program Staff
Date: May 28, 2010
Re: Flow-Proportioned Sampling

The Environmental Protection Agency (EPA) requires that industrial sewer users, and the local pretreatment program, collect representative samples of industrial wastewater discharges. In order to collect a representative sample, the wastewater sample must reflect the actual conditions of the discharge. With the wide availability of advanced sampling equipment, the King County Industrial Waste Program has determined that the installation of these devices, as a component of the pretreatment system, is technology that is readily accessible for industrial sewer users. As waste discharge permits come up for renewal or new permits are issued, King County Industrial Waste Program investigators will be requiring that the industrial sewer user implement advanced sampling techniques or demonstrate the adequacy of their current sampling protocol.

The automated wastewater samplers (autosamplers) that are commonly available in the marketplace are equipped to collect samples either based on a constant time interval (time-proportioned sampling) or based on a constant wastewater volume interval (flow-proportioned sampling). Of the two sampling techniques, time-proportioned sampling is the easiest since all that is required is to set a given time interval for the collection of samples. Flow-proportioned sampling requires the integration of the autosampler with a separate flow-measurement device (e.g., flow meter, flume, etc.). The flow-measurement device reads the flow rate at discrete time intervals and calculates a discharge volume based on the flow rate and the flow rate measurement interval (e.g., 50 gallons/minute x 5 minutes = 250 gallons). Once a pre-established volume interval has been recorded, the flow-measurement device sends an electronic "pulse" that the autosampler has been programmed to recognize as a signal to collect a sample.

Examples to Illustrate Time-Proportioned versus Flow-Proportioned Sampling

Because a constant time interval is used in time-proportioned sampling too much weight is given to samples collected during low flow periods and not enough weight is given to samples collected at high flow periods. Flow-proportioned sampling, on the other hand, collects a sample based on a volume interval and is therefore sampling at a rate in proportion to the discharge rate. To illustrate this, please review **Table 1** below which compares the sampling rates for time-proportioned sampling and flow-proportioned sampling for a hypothetical discharger. For the sake of comparison, the time and volume intervals were established so both sampling techniques could achieve a similar number of samples (12).

Table 1

Hypothetical Discharger - Time-Proportioned Sampling (TPS) vs. Flow-Proportioned Sampling (FPS)

Minutes	Wastewater Flow (gpm)	Total Wastewater Volume (gallons)	TPS	FPS
0	35	0		
5	35	175		
10	35	350	X	
15	35	525		X
20	35	700	X	
25	35	875		
30	40	1,075	X	X
35	45	1,300		
40	50	1,550	X	X
45	75	1,925		
50	90	2,375	X	X
55	100	2,875		X
60	100	3,375	X	X
65	100	3,875		X
70	90	4,325	X	X
75	75	4,700		X
80	50	4,950	X	
85	45	5,175		X
90	40	5,375	X	
95	35	5,550		X
100	35	5,725	X	
105	35	5,900		
110	35	6,075	X	X
115	35	6,250		
120	35	6,425	X	
		Sample Count =	12	12

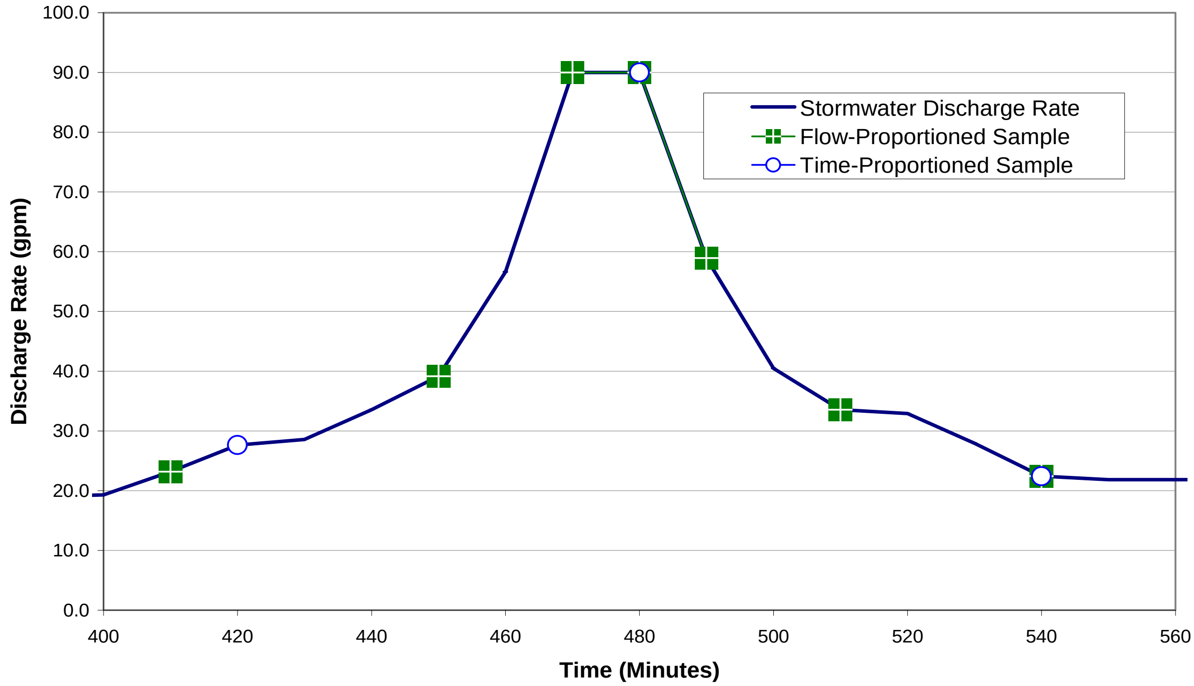
Sampling Intervals:

TPS = 10 minutes/sample
FPS = 500 gallons/sample

The flow-proportioned sampling interval was selected based on the flow-measurement interval (5 min.) and the peak flow rate (100 gallons/minute). The resulting volume interval (5 min. x 100 gallons/minute = 500 gallons) is high enough to collect a sample at peak flow.

Time-proportioned sampling collects a sample regardless of the flow conditions. In contrast, the sampling rates for flow-proportioned sampling demonstrates reduced sampling at lower flow rates and increased sampling at higher flow rates. An illustration of this can be observed on **Figure 1** below which presents flow rate and sampling information for a hypothetical contaminated industrial stormwater discharger.

Figure 1: Santa Barbara Urban Hydrograph (SBUH)
1 Acre (Impervious) - 1-inch 24-hour Rainfall (Type 1A Storm)
Stormwater Discharge Peak Flow (Q_{max} = 0.2 cfs/acre = 90 gpm/acre)



The stormwater hydrograph presented on **Figure 1** is for a hypothetical industrial sewer user with authorization to discharge contaminated industrial stormwater to the sanitary sewer and with stormwater detention and flow-restriction capabilities to limit the discharge to the King County acceptance criterion of 0.2 cubic-feet-per-second per acre (cfs/acre). The sampling intervals for the time-proportioned samples and for the flow-proportioned samples were selected so approximately similar sample counts could be obtained over the 24-hour duration of the hypothetical storm event. For this example, the time-proportioned sampling rate was 24 samples per day (60 minutes/sample) and the flow-proportioned sampling rate was 21 samples per day (1,000 gallons/sample). These 24-hour total sample counts are on the lower end of acceptability, but this can be sometimes necessary for discharges that have a high peaking factor, as is commonly encountered with contaminated industrial stormwater discharges. For the sake of illustration, only the peak stormwater discharge of the hydrograph is presented.

The number of samples collected during the period of peak contaminated industrial stormwater discharge, as presented on **Figure 1,** illustrates the advantage of flow-proportioned sampling over time-proportioned sampling. Over the sampling interval, seven (7) flow-proportioned samples were collected and only three (3) time-proportioned samples were collected. Of these samples, the seven (7) flow-proportioned samples were evenly distributed across the peak of the contaminated industrial stormwater discharge. This contrasts with the three (3) time-proportioned samples which were collected with one (1) sample at the peak discharge and the other two (2) samples collected at the beginning and end of the peak, respectively.

King County Industrial Waste Program Position on Time-Proportioned versus Flow-Proportioned Sampling

In summary, since flow-proportioned sampling provides more representative samples, the King County Industrial Waste Program considers the use of this type of sampling equipment to be technology that is readily accessible and will be required for new industrial sewer users and for industrial sewer users at the time of waste discharge permit renewal. At this time, this is not a requirement for industrial sewer users with discharge authorizations.

For industries that feel that time-proportioned sampling provides representative samples equivalent to flow-proportioned sampling, the industrial sewer user must provide technical justification of equivalency. In order to be considered equivalent, the King County Industrial Waste Program considers either of the following two approaches to be acceptable:

- **Low Variability in Discharge - Constant Flow Rate or Consistent Wastewater Chemistry**: Time-proportioned sampling is acceptable if either the flow rate data or the wastewater chemistry data for each parameter of interest are representative of the industrial wastewater discharge and the statistics meet the following criteria:

  - **Low End of Range:** Average – 2 standard deviations is equal to or greater than 50% of the average ($0.5Q_{avg}$).

  - **High End of Range:** Average + 2 standard deviations is equal to or less than 150% of the average ($1.5Q_{avg}$).

  - **Datapoints:** A minimum of 20 datapoints are needed in order for the statistics to be evaluated.

- **Side-by-Side Comparison of Wastewater Chemistry:** Time-proportioned sampling is acceptable if side-by-side sampling of time-proportioned and flow-proportioned sampling is conducted over the same time interval and the water quality data meets the following criterion for precision:

  - **Relative Percent Difference (RPD):** For each chemical listed in the waste discharge permit, the RPD must be equal to or less than 35% when comparing the chemical concentrations from the time-proportioned sample and from the flow-proportioned sample. This 35% value was selected from the U.S. EPA *National Functional Guidelines for Inorganic Data Review* criterion for acceptable laboratory duplicate precision in soil samples. Given the chemical complexity of industrial wastewater matrices, and based on Industrial Waste Program experience, the use of the soil criterion was determined to be more applicable than use of the criterion used for a water matrix.

  - **Options for Conducting Side-by-Side Comparisons**: There are typically two options that can be used to conduct a side-by-side test of time-proportioned versus flow-proportioned sampling:

- **Automated:** This comparison involves setting up two (2) autosamplers at the point of wastewater discharge. One autosampler is dedicated to collect time-proportioned samples and the other is dedicated to collect flow-proportioned samples. The sampling tubes from both autosamplers must be positioned in close proximity to collect representative samples of the same wastestream. However, some space is needed between the inlets of the tubing to avoid the impacts of simultaneously sampling at different rates, which could affect data quality. At a minimum, the inlets should be separated by at least one (1) tubing diameter. In order for the data comparison to be considered valid, both autosamplers must collect samples over the same time interval.

- **Manual:** This comparison involves setting up one (1) autosampler at the point of wastewater discharge. The autosampler must be a sequentially sampling type with a capacity for 24 sample bottles. This could allow for the collection of a sample per hour over 24-hours or a sample every 20 minutes over eight (8) hours. The sampling interval must be coordinated with flow measurement so flow-proportioned sub-samples can be collected in relation to the flow rate. An example of how the time-proportioned and flow-proportioned samples are collected is presented in **Table 2** below.

Table 2

Hypothetical Discharger - Manual Comparison of Time-Proportioned Sampling (TPS) vs. Flow-Proportioned Sampling (FPS)

Minutes	Wastewater Flow (gpm)	TPS (mL/sub-sample)	FPS (mL/sub-sample)
20	35	100	70
40	50	100	100
60	100	100	200
80	50	100	100
100	35	100	70
120	35	100	70
	Total Volume (mL) =	**600**	**610**

Regardless of whether the comparison tests are conducted via automated or manual methods, to be considered a complete dataset for review, industrial wastewater data must comprise ten (10) complete work days of representative discharge with no more than two (2) sampling events conducted per week. For contaminated industrial stormwater discharges, the dataset must comprise three (3) months of storm event data during the wet season of November to April.

Guidance for Implementing Flow-Proportioned Sampling

Conducting flow-proportioned sampling can be an initial challenge, but will become more routine over time as you get an understanding how the sampling integrates with the operations of the industrial facility and the characteristics of the pretreatment system. The following are important variables to consider when establishing flow-proportioned sampling:

- **Maximum Instantaneous Peak Flow Rate:** Determine the peak flow rate of the discharge in units of gallons-per-minute (gpm).
- **Flow Measurement Interval:** Establish a measurement interval for your flow measurement device. The measurement interval should be within the range of 5 to 15 minutes, with 5 minutes being the ideal measurement interval.
- **Flow-Proportioned Sample Volume Interval:** Based on the Maximum Instantaneous Peak Flow Rate (gpm) and the Flow Measurement Interval (minutes) calculate the Flow-Proportioned Sample Volume Interval (gallons). This is done to ensure that a sample can be collected at peak flow. For example, with a peak flow of 235 gpm and a measurement interval of 5 minutes, the resulting sample volume would be 1,175 gallons (235 gallons/minute x 5 minutes). For the sake of simplicity, the volume can be rounded down slightly to select a sample volume interval of 1,100 gallons/sample. (**Note**: Another variable to consider is the volume of periodic batch discharges.)
- **Minimum Daily Discharge Volume:** Use self-monitoring reports to determine the minimum daily discharge volume for the pretreatment system in units of gallons per day (e.g., 16,000 gallons/day).
- **Maximum Daily Discharge Volume:** Use self-monitoring reports to determine the maximum daily discharge volume for the pretreatment system in units of gallons per day (e.g., 72,000 gallons/day)
- **Minimum Sample Count per Day:** Use the Minimum Daily Discharge Volume (e.g., 16,000 gallons/day) and the Flow-Proportioned Sample Volume Interval (e.g., 1,100 gallons/sample) to determine the estimated Minimum Sample Count per Day (e.g., 16,000 gallons/day / 1,100 gallons/sample = 14.55 samples/day = 14 samples/day).
- **Maximum Sample Count per Day:** Use the Maximum Daily Discharge Volume (e.g., 72,000 gallons/day) and the Flow-Proportioned Sample Volume Interval (e.g., 1,100 gallons/sample) to determine the estimated Maximum Sample Count per Day (e.g., 72,000 gallons/day / 1,100 gallons/sample = 65.45 samples/day = 65 samples/day)
- **Sample Count Range:** The goal is to collect 20 to 60 samples in a day. The number of samples collected will be determined by the time duration of the discharge (e.g., 8-hour workday, 24-hour storm event, etc.) and by the variability between the minimum and maximum flows for the facility.
- **Volume per Autosampler Sample:** The Volume per Autosampler Sample is dictated by the minimum sample volume for chemical analysis and the maximum volume of the autosampler carboy collection vessel. For example, for a hypothetical sample count range of 14 to 65, an autosampler volume of 125 mL could be selected. This would allow enough sample to fill a

1-liter sample container for chemical analysis (14 x 125 mL = 1,750 mL) but not overfill the 10-liter autosampler carboy (65 x 125 mL = 8,125 mL).

Please consider these sampling variables as guidance and not strict requirements for sampling. There are a number of variables to account for when establishing the operating conditions for flow-proportioned sampling and it will take some effort to find the ideal conditions for a particular industrial facility.

On a final note, integrating the flow measurement device with the autosampler can be challenging because the devices are often made by different manufacturers. When considering makes and models of products, make sure that the vendor selected can come to your facility to ensure that the flow measurement device works with your autosampler - or vice versa. In fact, it can be beneficial to make this a condition of purchase.