Flow Proportional Sampling Techniques

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Flow Proportional Sampling

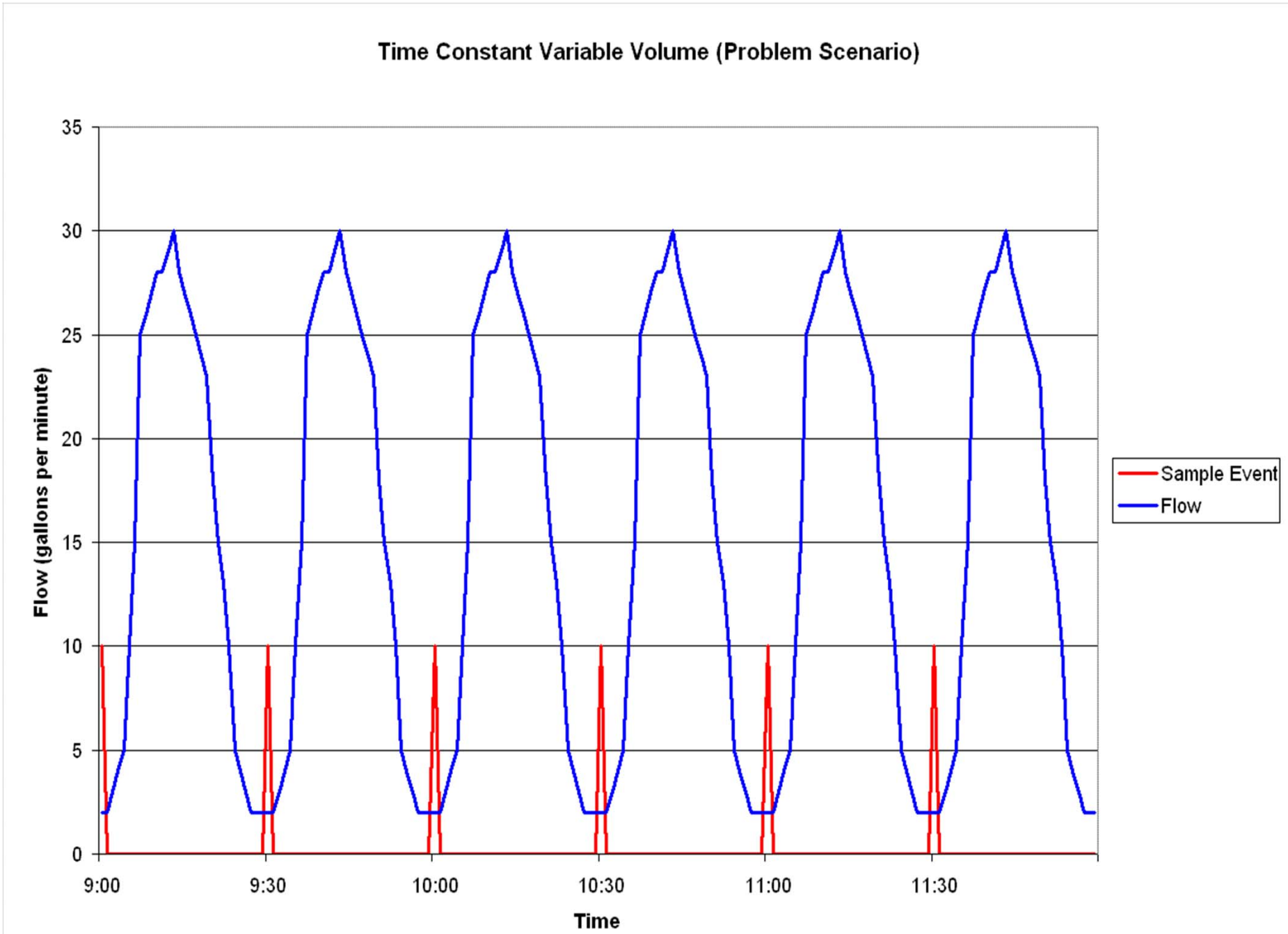
- Individual sample (aliquot) collection interval is determined by variation in discharge flow.
- Requires some type of flow meter.
- Flow meter (or other output) provides trigger signal to sampling equipment.
- Variable number of samples.
- Requires knowledge of discharge volumes and pumping rates.
- How much composite volume do you need for analysis?

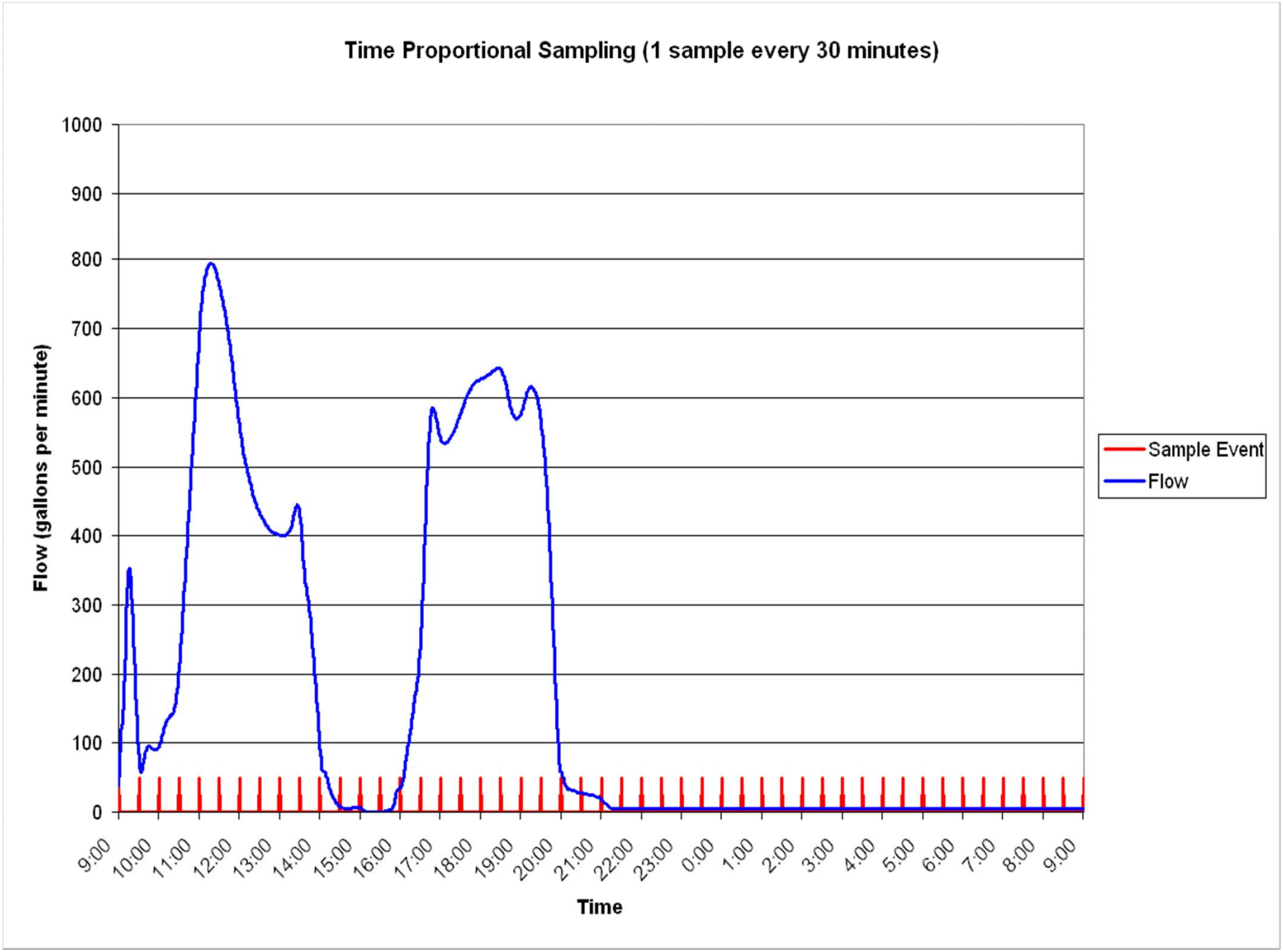
Time Proportional vs. Flow Proportional

- Time proportional:
  - Fixed aliquot volume at defined time interval (i.e. once per 15 minutes)
- Flow proportional:
  - Fixed aliquot volume at defined flow volume interval (i.e. once every 1000 gallons), OR
  - Variable aliquot volume at defined time interval.

Flow Proportional Variable Aliquot Issues

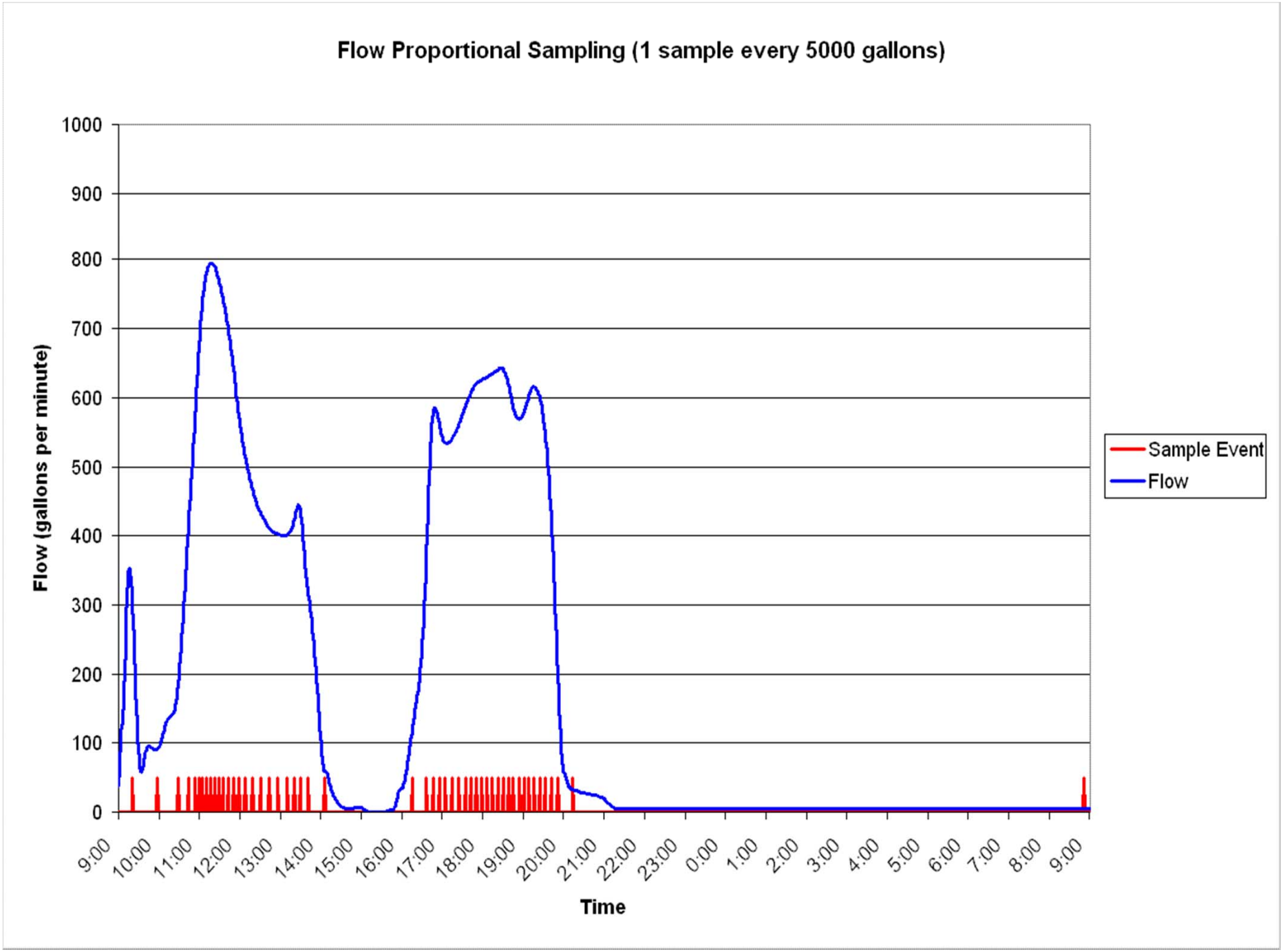
- Variable aliquot volume at defined time interval can be difficult to set.
  - Sampling equipment may not support method.
  - Time interval may not coincide with cyclic discharges.
  - Always catching high discharge flow volumes may cause sampler to reach maximum composite volume before end of monitoring period.
  - Always catching low discharge flow volumes may cause sampler to not take enough composite volume for analysis.


Time Constant Variable Volume (Problem Scenario)
Flow (gallons per minute)
35
30
25
20
15
10
5
0
9:00
9:30
10:00
10:30
11:00
11:30
Time
Sample Event
Flow


Time Proportional Sampling (1 sample every 30 minutes)
Flow (gallons per minute)
1000
900
800
700
600
500
400
300
200
100
0
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
Time
Sample Event
Flow

Sampling Scenario (Time Composite)

- Sampler collects 26 aliquots during low flow (8pm to 9am).
- Water during low flow is clean water from treatment process (approx. 5 gpm).
- Half of composite volume is essentially clean water.
- Composite sample results are diluted nearly 50%.
- Sample is NOT representative of actual discharge.


Flow Proportional Sampling (1 sample every 5000 gallons)
Flow (gallons per minute)
1000
900
800
700
600
500
400
300
200
100
0
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
Time
Sample Event
Flow

Sampling Scenario (Flow Proportional)

- Sampler collects aliquots at fixed flow volume.
- Water during low flow is clean water from treatment process (approx. 5 gpm).
- Few (if any) samples collected during low flow.
- Composite sample results are not diluted.
- Sample is representative of actual discharge.

Flow Proportional Sampling

- What trigger input does your sampler accept?
  - 4~20mA?
  - Contact closure?
  - 5 to 15volt DC pulse?
- What connector is on your sampler?
  - Brand
  - Size
  - Number of pins
- What pin on the input connector does what?
  - Check schematics in the owner's manual.
- Be nice to your electrician/electronics specialist!

4 to 20 milliampere (mA) Interface

- Flow meter or other equipment sends a variable current signal to sampling equipment.
- 4mA represents minimum flow.
- 20mA represents maximum flow.
- Sampling equipment must recognize signal directly or through interface.
- Must know min. and max. flow rates.
- Must know discharge flow totals.

Contact Closure Interface

- An external flow meter is programmed to trigger a contact closure at a set volume.
- During contact closure, a relay in the flow meter closes momentarily at the set trigger volume.
- Relay closure completes a circuit with the sampler controller triggering a sampling event.
- The Sampler may be set to use more than one contact closure to trigger a sample event.
  - The meter may provide a contact closure every 1,000 gallons.
  - The sampler is programmed to take a sample every 6 contact closures (6,000 gallons)

DC Pulse Interface

- An external flow meter is programmed to deliver a voltage pulse at a set volume.
- Typically, the pulse is a 5 to 15 volt DC signal.
- The equipment must be electrically compatible.
  - Voltage, ground and other signal wires to correct pins in connector.
- The Sampler may be set to use more than one pulse to trigger a sample event.
  - The meter may provide a pulse every 1,000 gallons.
  - The sampler is programmed to take a sample every 6 pulses (6,000 gallons)

What is a “Pulse”?

- A single electrical event recorded by the sampler controller.
- Sampler may be programmed to take a sample by single or multiple pulses.
- Contact closure provides a pulse by feeding a voltage signal from the sampler controller through a relay, and back to the sampler controller.

Flow Proportional Sampler Setup

- Trigger volume is determined by external meter or by 4-20mA interface.
- Need to know recent discharge flow volumes.
- Potential number of sample events is dependent on flow.
- Sample (aliquot) volume is determined by potential number of samples programmed and sample container volume.
- Number of actual sample aliquots is dependent on discharge flow.
- Composite volume is sample aliquot volume multiplied by number of actual samples collected (at least it should be...).

Flow Proportional Sampler Setup

Example: Sampler with external flow meter (delivering pulses/contact closures)

- Industry flow has recently been discharging approximately 40,000 gallons per day.
- Industry flow meter is set to deliver a pulse every 100 gallons.
- Sample composite maximum volume programmed into sampler controller = 10,000mL.
- Target of 48 samples during sampling event (will set to 50 samples for safety factor).
- Sampler takes 43 samples during sampling event.

40,000 gallons per day discharge / 50 sample events = 800 gallons per sample event.

800 gallons per sample event / 100 gallons per pulse = **8 pulses per sample event**.

10,000mL composite volume / 50 sample events = 200mL per aliquot.

43 sample events during discharge X 800 gallons per sample event = 34,400 gallons discharged.

43 sample events X 200mL per aliquot = 8,600mL composited volume.

Flow Proportional Sampler Setup

Example: Sampler with external flow meter (delivering 4-20mA signal)

- Industry flow has recently been discharging approximately 40,000 gallons per day.
- Industry flow meter is set to deliver a 20mA signal at 40 gallons per minute.
- 4-20mA interface module provides 5 pulses per minute at 20mA.
- Sample composite maximum volume programmed into sampler controller = 10,000mL.
- Target of 48 samples during sampling event (will set to 50 samples for safety factor).
- Sampler takes 43 samples during sampling event.

40 gallons per minute flow rate / 5 pulses per minute = 8 gallons per pulse.

40,000 gallons per day discharge / 50 sample events = 800 calculated gallons per sample event.

800 gallons per sample event / 8 gallons per pulse = **100 pulses per sample event**.

10,000mL composite volume / 50 sample events = 200mL per aliquot.

43 sample events during discharge X 800 gallons per sample event = 34,400 gallons discharged.

43 sample events X 200mL per aliquot = 8,600mL composited volume.

4-20mA Sampler Interface Calculations

Example:

Max flow rate at 20mA	**100**	gallons per minute (GPM)
Min flow rate at 4mA	0	gallons per minute (GPM)
Industry discharge volume	**12,800**	gallons per day (GPD)
Number of samples desired	**48**	

This interface module provides 5 pulses per minute with a 20mA signal.

Formula #1
Max flow rate at 20mA (GPM) / 5 Flow pulses per minute = Volume in Gallons (Gal/pulse)
100 gallons per minute / 5 Flow pulses per minute = 20 gallons per pulse

Formula #2
Industry average discharge volume in gallons per day / desired number of samples = gallons per sample trigger event
12,800 gallons per day / 48 desired number of samples = 266 calculated gallons per sample trigger event

Formula #3
Trigger volume per sample (gallons) / Gallons per pulse = number of pulses between samples
266 calculated gallons per sample trigger event / 20 gallons per pulse = 13 Pulses per sample

Formula #4
Flow volume per sample event
20 gallons per pulse * 13 Pulses per sample = 260 actual gallons per sample event

Flow Proportional Sampling
(A Balancing Act)

Examples: Decreasing the aliquot volume to allow more sample events.

- Sample composite maximum volume programmed into sampler controller = 10,000mL.
- Individual sample aliquot volume set to = 150mL.
- 10,000mL / 150mL = 66 sample events possible.

The sampler will stop the program after the 66th sample is taken because the controller knows the maximum volume of the composite container is 10,000mL. If the 66th sample event takes place 20 hours into a 24 hour sampling period, the composite does not represent the entire monitoring period. The composite sample is not representative.

Decreasing the aliquot volume allows more samples to be taken during the monitoring period.
10,000mL / 100mL = 100 sample events possible

Flow Proportional Sampling
(A Balancing Act)

Examples: Decreasing the number of sample events to increase aliquot volume.

- Sample composite maximum volume programmed into sampler controller = 10,000mL
- 120 sample events programmed into sampler.
- 10,000mL / 120 sample events = 83mL per sample.
- Desired aliquot volume is at least 100 mL.

Reduce the number of programmed sample events to increase the aliquot volume.

- Sample composite maximum volume programmed into sampler controller = 10,000mL.
- 100 sample events programmed into sampler.
- 10,000mL / 100 sample events = 100mL per aliquot.

Flow Proportional Sampling
(A Balancing Act)

Examples: Decreasing the number of sample events to increase composite volume.

- Sample composite maximum volume programmed into sampler controller = 10,000mL
- 120 sample events programmed into sampler.
- 10,000mL / 120 sample events = 83mL per aliquot.
- Sample volume required for analysis is 6,000mL.
- Industry discharge has been consistently triggering only *60* sample events.
- 60 sample events X 83mL per aliquot = 4,980mL composite volume.

Reduce the number of programmed sample events to increase the aliquot volume.

- Sample composite maximum volume programmed into sampler controller = 10,000mL.
- 80 sample events programmed into sampler.
- 10,000mL / 80 sample events = 125mL per aliquot.
- 80 sample events X 125mL per aliquot = 7,500mL composite volume.

Flow Proportional Sampling
(A Balancing Act)

Examples: Change the number of pulses to account for greater discharge flow.

- Sample composite maximum volume programmed into sampler controller = 10,000mL
- 96 sample events programmed
- Flow meter set for pulse event every 20 gallons of discharge flow.
- Sampler set for sample event every 10 pulses.
- 20 gallons X 10 contact closures = 200 gallons per sample event.

The sampler will stop the program after the 96th sample is taken.

- 96 sample events X 200 gallons per sample event = 19,200 gallons of discharge flow.

If the industry discharges more than 19,200 gallons of process water during the 24 hour sample event, the sample event does not cover the entire sampling period and is invalid.

Change the number of pulses at the sampler to allow for greater discharge flow.

- 20 gallons X 15 pulses = 300 gallons per sample event.
- 96 sample events X 300 gallons per sample event = 28,800 gallons of discharge flow.

Flow Proportional Sampling
(A Balancing Act)

Why program the sampler for more than 1 pulse per sample event?

<u>To allow for adjustment of sample frequency as flow changes.</u>

- Industry flow meter set for 1 pulse every 1,000 gallons.
- Industry discharge is 24,000 gallons per day.

24,000 gallons per day / 1,000 gallons per pulse = 24 pulses per day.
A maximum of 24 samples can be taken at these settings. There is no real programming flexibility with these settings. The sampler would only be able to be programmed for 1 pulse.

Change the flow meter to 1 pulse every 100 gallons.
24,000 gallons per day / 100 gallons per pulse = 240 pulses per day.
The sampler can be programmed to collect a sample at different pulse settings as discharge flow changes. The sampler can be programmed for 1 to 10 pulses with these settings, allowing much more flexibility with setup.

Flow Proportional Sampling

Examples: Changing flows affect sampling.

Industrial User Daily Flow Data (gallons):

5/1/13 to 5/31/13	Min.	5,000	Max.	9,000	Avg.	7,000
6/1/13 to 6/30/13	Min.	6,000	Max.	12,000	Avg.	10,000
7/1/13 to 7/31/13	Min.	5,000	Max.	18,000	Avg.	13,000
8/1/13 to 8/31/13	Min.	8,000	Max.	16,000	Avg.	11,500
9/1/13 to 9/30/13	Min.	12,000	Max.	17,500	Avg.	14,750

- Industrial users may have swings in production volumes that affect effluent discharge.
- Flow settings based on May data may be insufficient for September sampling.
- Look at flow data over various periods of time.
- Consider quarterly, semi-annual, or annual averages when determining flow settings.

Flow Proportional Sampling

Examples: Changing flows affect sampling.

Industry flow meter and sampler set to take 1 sample every 100 gallons.

Industrial User Daily Flow Data (gallons):

5/1/13 to 5/31/13	Min.	5,000	Max.	9,000	Avg.	7,000
6/1/13 to 6/30/13	Min.	6,000	Max.	12,000	Avg.	10,000
7/1/13 to 7/31/13	Min.	5,000	Max.	18,000	Avg.	13,000
8/1/13 to 8/31/13	Min.	8,000	Max.	16,000	Avg.	11,500
9/1/13 to 9/30/13	Min.	12,000	Max.	17,500	Avg.	14,750

July data: 5,000 gallons / 100 gallons per sample event = 50 sample events.
18,000 gallons / 100 gallons per sample event = 180 sample events.

A difference of 130 sample events is possible from day to day discharge flows.

10,000mL composite volume / 50 sample events = 200mL aliquot volume.

Flow Proportional Sampling

Examples: Changing flows affect sampling (continued).

10,000mL composite volume / 180 sample events = 55mL aliquot volume.

Is the aliquot volume sufficient? This may require a change in meter/sampler settings.

If the sampler is programmed to handle the maximum flow of 18,000 gallons, and the daily discharge flow is 5,000 gallons:

55mL aliquot volume X 50 sample events = 2,750mL composite volume.

Is this enough volume for analysis?

Flow Proportional Sampling

Examples: Change in equipment without notification.

Industrial User Daily Flow Data (gallons):

5/1/13 to 5/31/13	Min.	5,000	Max.	8,000	Avg.	7,000
6/1/13 to 6/30/13	Min.	6,000	Max.	9,000	Avg.	8,000
7/1/13 to 7/31/13	Min.	5,000	Max.	18,000	Avg.	13,000
8/1/13 to 8/31/13	Min.	8,000	Max.	21,000	Avg.	11,500
9/1/13 to 9/30/13	Min.	12,000	Max.	22,000	Avg.	14,750

- The sampler has maxed out potential sample events since July.
- The sampler maxes out before the 24 hour sampling period ends.
- Does the reported flow match up with pump flow / production time info?
- What is maximum discharge volume?
- Are daily maximums consistent?

Flow Proportional Sampling

Examples: Change in equipment without notification.

Declared maximum pump output flow is 10 gpm.
Normal production is 16 hours per day.
16 hours x 60 minutes/hour x 10 gpm = 9,600 gallons expected maximum.
Effluent flow meter 20mA signal is set to 10 gpm.

Pump was replaced by a unit capable of 25 gpm.
16 hours x 60 minutes/hour x 25 gpm = 24,000 gallons
Effluent flow meter 20mA signal has been set to 25 gpm.
No notification of the equipment change was made to the sampling technician.

In this scenario:
With the new pump, using the original sampler settings, the sampler will reach the maximum composite volume in about 7 hours.

Flow Proportional Sampling

In Conclusion:

- Read your equipment manuals, learn about the hardware.
- Document the flow settings for the sample site.
- UPDATE the flow settings for the sample site on a regular basis.
- Document the calculations for the sampler/meter settings.
- Pay attention to changing trends in discharge flow volumes.
- Use the flow data to determine appropriate number of sample events.
- Communicate with equipment vendors, manufacturers, and support sites.

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