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# Sampling uncertainty at wastewater treatment plants – a discussion

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## Why do we collect data from treatment plants? [data collection = sampling + analysis]

- For regulatory compliance
  - Effluent BOD, TSS, ammonia
  - Whole effluent toxicity tests
  - Coliform, chlorine residual
- For operation
  - Optimize oxygen delivery
  - Control wasting rates
  - Plan dewatering schedules
- For design
  - Process modeling
  - Equipment sizing
  - Life-cycle assessments and long-term planning

Accurate data minimizes risk and saves money

## Laboratory analyses are rigorous and objective:

- Typically follow Standard Operating Procedures
- Typically include, at routine intervals:
  - Blanks
  - Standards
  - Duplicates
  - Matrix spikes
- Requires routine calibration of instruments, scales, pipettes
- Regulatory certification process ensures standards are maintained and laboratories are in compliance

This is all great!

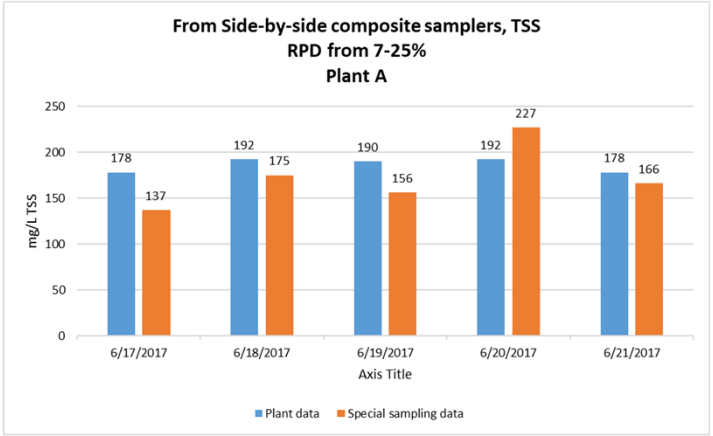
## But sampling is not as rigorous – should it be?

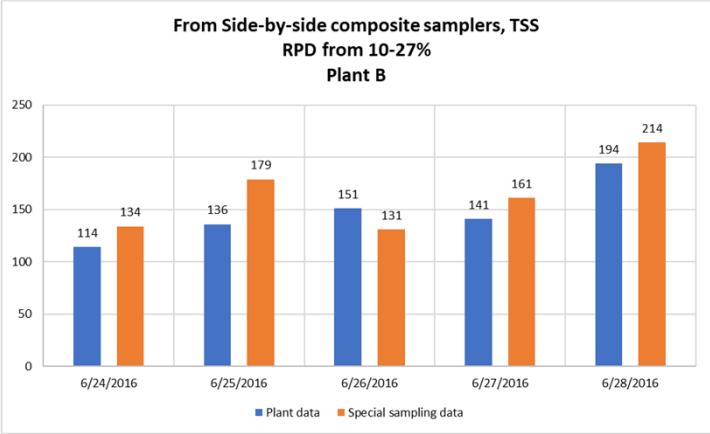
- Example, Influent sampling – typically:
  - Single composite sampler, daily 24/hour composite
  - Drawn from influent channel, submerged mid-channel
  - 2.5 gallon carboy, 2-3L sub-samples taken to lab for analysis
  - Assumed to be representative
- Example, WAS sampling - typically:
  - grab sample during wasting period (Beginning? Middle? End?)
  - Single sample per pump or WAS line per day
  - Assumed to be representative

How do we know we are collecting representative samples?

# Influent sampling variability

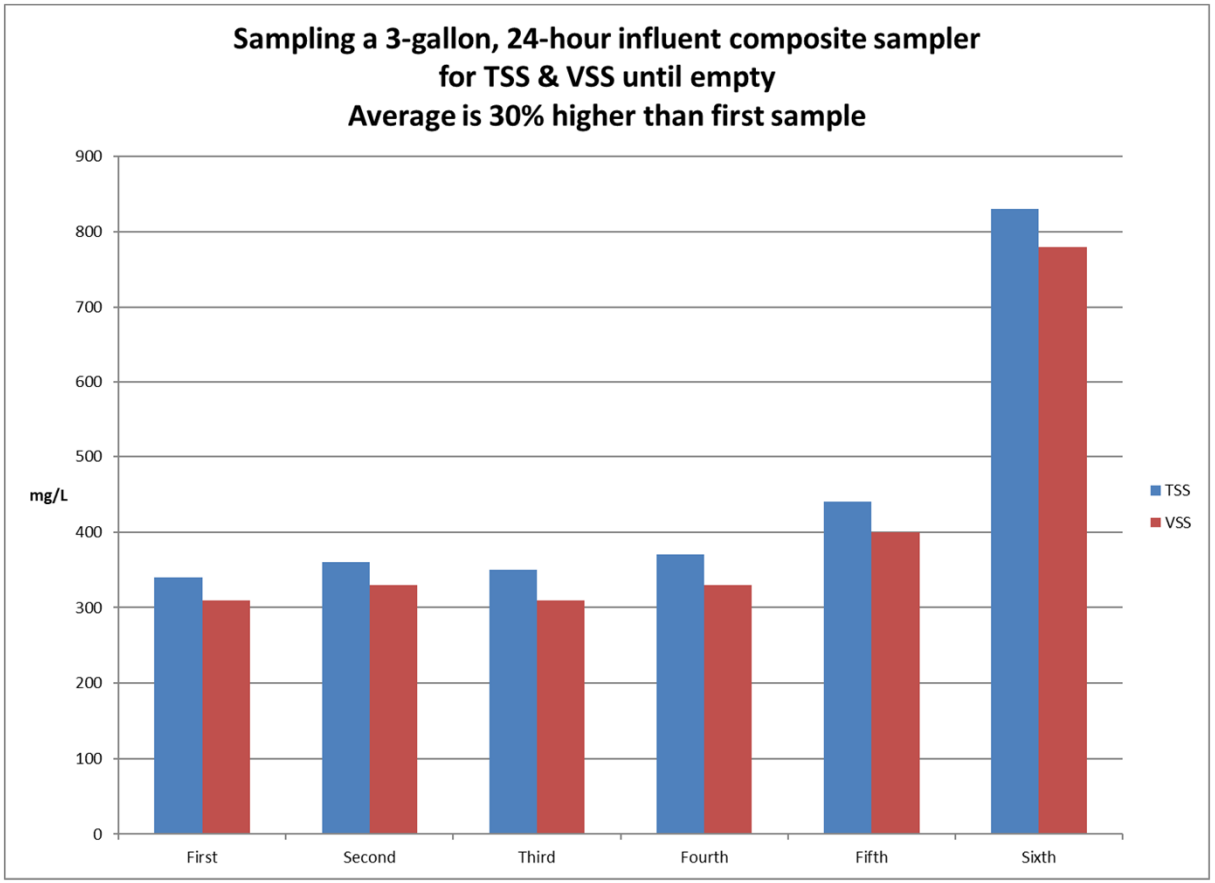
- Uncertainty = sampling error + analytical error
- Analytical error is regularly quantified; sampling error is not
- If sampling error is random, not a big deal over the long term, depending on what the data is used for
- What's an acceptable level of sampling error?
- How do we determine between sampling error and sampling bias?
- (note – corresponding BOD comparisons are worse….)



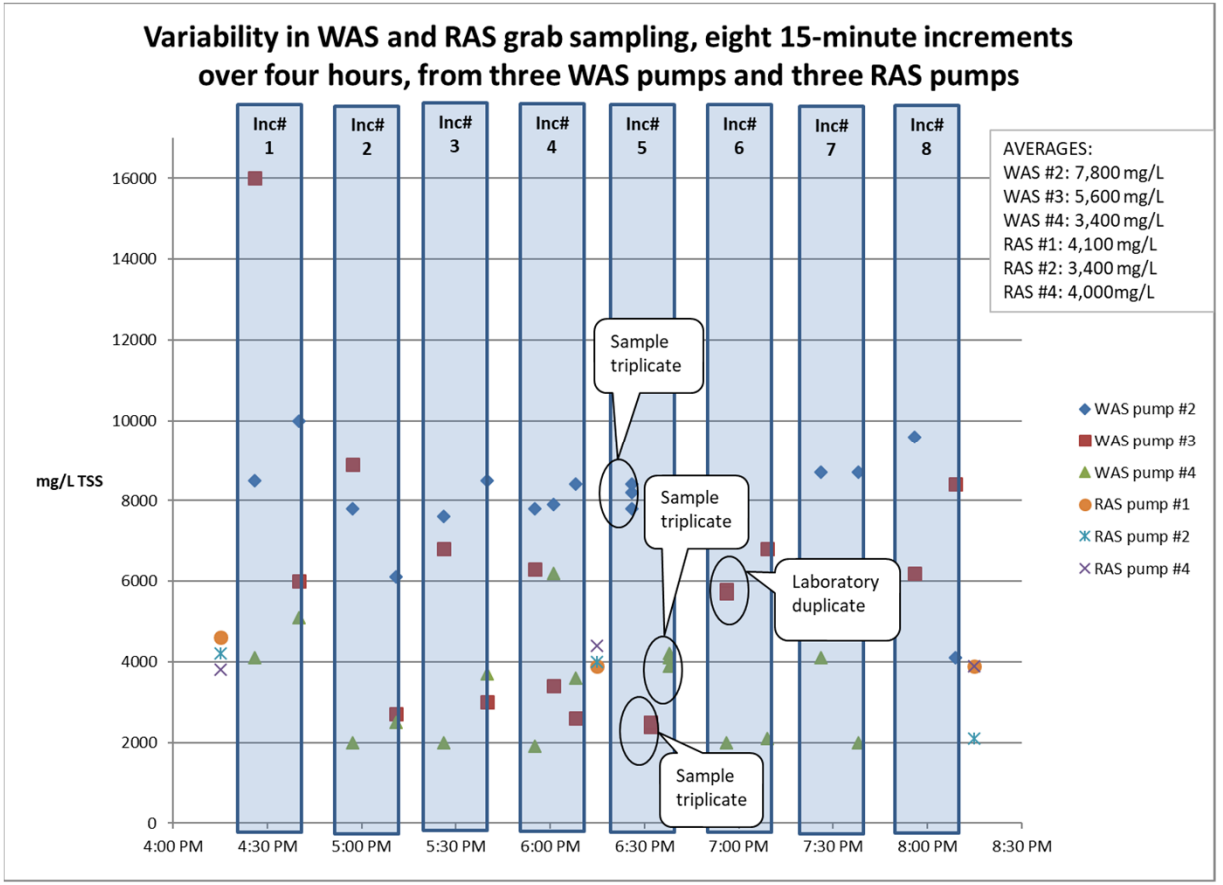
# Influent sampling - bias

- Only a single example, on raw influent
- Vigorous shaking prior to decanting each sub-sample
- Would like to repeat this
- Is this typical?
- Is there an inherent flaw in standard practice of sub-sampling 24-hour composite carboys?



# WAS sampling -

- Intermittent WAS pumping, continuous RAS pumping
  - RAS was assumed to equal WAS
  - Plant had a nitrification problem
- ~60 TSS samples in 4 hours
  - (should have just been TS)
- What's number to use for SRT/MCRT/sludge age calculation?
- How often should they be sampling WAS?



# Standard Methods, Section 1060 (APHA et al., 2012)

Guidelines for determining # of samples to estimate a mean concentration

$$N \geq \left(\frac{ts}{U}\right)^2$$

where:

$N$ = number of samples,
$t$ = Student-$t$ statistic for a given confidence level,
$s$ = overall standard deviation, and
$U$ = acceptable level of uncertainty.

*'Overall' standard deviation – sampling + analysis*

OR:

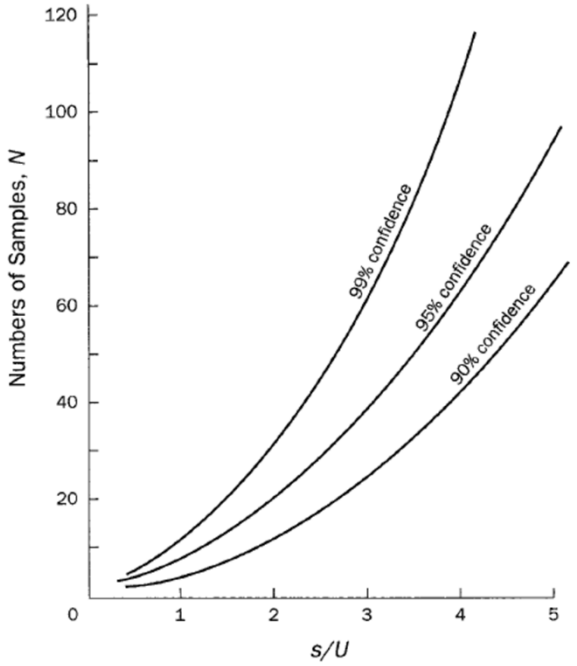
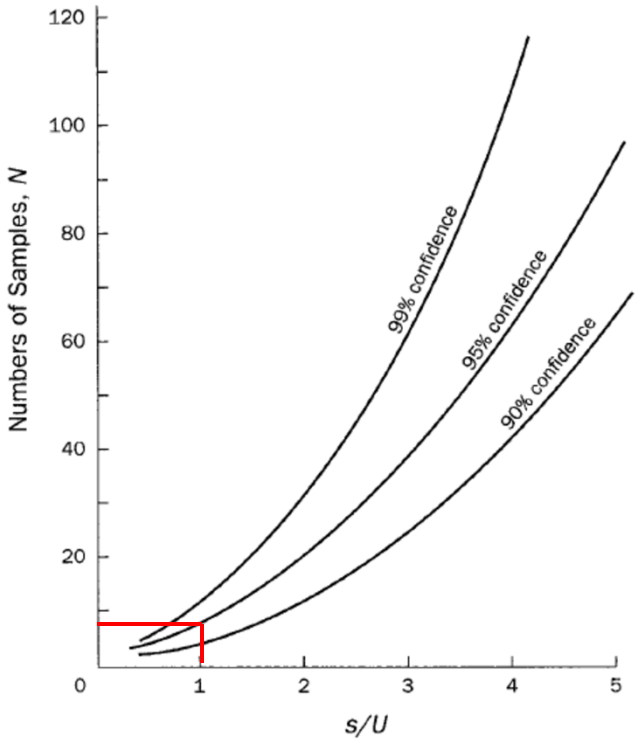



**Figure 1060:1. Approximate number of samples required in estimating a mean concentration.** Source: Methods for the Examination of Waters and Associated Materials: General Principles of Sampling and Accuracy of Results. 1980. Her Majesty's Stationery Off., London, England.

# Thought experiment – Influent sampling

- Let's assume our 'population' consists of many (10? 100?) 24-hour composite samples from an influent channel on a single day
- Assume the average 24-hour influent TSS is 280 mg/L
- Also assume the standard deviation is +/- 30 mg/L
  - (catch-22; we don't know the standard deviation unless we sample a lot first….)
- How many samples are needed to estimate a mean concentration if our acceptable level of uncertainty is simply the same as the standard deviation (s/U=1) at a 95% confidence level?
- Is this the right approach for wastewater sampling?




*~ 8 samples are needed*

# Conclusions – more questions than answers

- Are current composite sub-sampling methods inherently biased?
- Should sampling QA/QC be as rigorous as laboratory QA/QC?
- Is Standard Methods 1060 the appropriate reference for sampling at wastewater treatment plants?

# Thank You!!! Please share data, experiences and questions with:

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