GET THAT DATA – GET IT EARLY – GET IT WELL

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ABSTRACT

Good influent and effluent quality data is vital to facilitate advanced planning of capital expenditure in a treatment plant, optimise operating costs, and reduce the risk of consent non-compliance and the adverse public scrutiny that follows such an incident. This paper addresses the importance of preplanning and budgeting for a monitoring programme and the subsequent collection, management, QA and presentation of the influent and effluent data.

Sound data is the foundation of sound decision-making. The key is, well in advance of consent renewal or capital work, to budget for and implement a monitoring programme to collect the necessary data. Effectively, sampling needs to be part of a council's asset management or operational budget and be allowed for accordingly at appropriate points in the Long Term Plan (LTP).

It is important to have good data management and audit the data collected regularly for unusual changes or abnormal results. The processes of sample collection, preservation, custody and testing need to be rigorous and designed to identify more than just consent breaches. Regular sanity checks, including graphing of data, are invaluable. Additionally, understanding tradewaste discharges can be a fundamental part of the process, particularly at small plants where their affect can be significant.

KEYWORDS

Sampling, Influent & effluent data, Wastewater characterisation, Wastewater treatment

1 INTRODUCTION

Good influent and effluent quality data is vital to facilitate advanced planning of capital expenditure in a treatment plant, optimise the operating cost and reduce the risk of consent non-compliance and the adverse public scrutiny that follows such an incident. This paper addresses the importance of preplanning and budgeting for a monitoring programme and the subsequent collection, management, QA and presentation of the influent and effluent data.

Obtaining good data should be an integral part of investment in a treatment infrastructure asset, not just a painful consent requirement. The data needs of a process asset will change through its lifecycle so it is important to be prepared ahead of time in order to be flexible and adapt to changing situations.

There is nothing particularly groundbreaking or innovative in this paper, just some basic, practical suggestions. The intent is not be to patronizing with the simplicity, but rather to highlight that all sorts of errors are happening out there, from the routine to the severe, and to draw attention to how damaging a poorly executed sampling programme can be. The content is primarily sourced from experiences with Wastewater Treatment Plants (WWTPs) but many of the principles are equally applicable to Water Treatment Plants (WTPs) or in fact any monitoring programme or data analysis.

All examples are anonymous – the idea is to highlight the importance of good data collection and analysis and how easily mistakes can be made, not to point fingers at any organisations or say 'ooh look what we've done'.

2 KNOW YOUR WATER / WASTEWATER

Sound data is the foundation of sound decision making. A good WTP/WWTP monitoring and characterisation process is vital in order to determine the most appropriate processes (and sizing) for treating the water/wastewater and to operate each treatment process efficiently.

Influent composition can vary quite significantly from plant to plant, depending on factors such as water supply, tradewaste discharges, disposal of septage, inflow and infiltration.

Table 1, below, shows the mean composition of influent wastewater at seven WWTPs around the country (WWTPs 1 to 7), compared with the generic Metcalf & Eddy characterisation (M&E Range), as well as more NZ specific data from the New Zealand Municipal Wastewater Monitoring Guidelines (NZWERF Range and Typical).

Table 1: Actual NZ WWTP influent characteristics compared with the generic Metcalf & Eddy and NZ Municipal Wastewater Monitoring Guidelines characterisations

Analyte	Composition of influent wastewater (mg/L)									
	M&E Range[1]	NZ WERF Range[2]	NZ WERF Typical[2]	WWTP 1 (mean)	WWTP 2 (mean)	WWTP 3 (mean)	WWTP 4 (mean)	WWTP 5 (mean)	WWTP 6 (mean)	WWTP 7 (summer holiday 95%ile)
COD	250-800	-	-	601	709	304	859	409	-	2238
BOD_5	110-350	150-450	250	221	311	133	409	190	53	701
TSS	120-400	50-800	300	287	325	-	529	250	-	1292
TKN	20-70	-	-	46	67	47	57	35	27	112
NH_3	-	7-60	35	32	50	-	35	-	22	63
TP	4-12	3.3-13	7	7	12	-	10	8	-	13

[1] Range in characteristics of municipal wastewater, Table 3-21 Metcalf & Eddy (2014)
[2] Typical New Zealand domestic wastewater characteristics from Chapter 5, NZWERF (2002)

As can be seen in Table 1, there is significant variation in the influent composition. Some plants, such as WWTP 1, align fairly closely with the typical characterisations while others, such as WWTPs 3 and 5, are more dilute, or, like WWTP 4, more concentrated. The generic characterisations are also unable to cover less typical profiles, such as the effects of the summer holiday peak on WWTP 7 or the extreme dilution at WWTP 6.

Additionally, although in general some influent might be described as ‘more concentrated’ or ‘more dilute’, the reality is that the relative proportions of each of the analytes also vary from plant to plant. For example, WWTPs 3 and 5 are both at the lower end of the table in terms of COD and BOD but WWTP 3 actually has a much higher concentration of TKN. Or comparing WWTP 2 with WWTP 4, WWTP 2 has lower concentrations of COD, BOD and TSS but higher concentrations of TKN, TP and ammonia. Although the generic characterisations do provide a starting point in the absence of any influent sample data, real data is needed to have any meaningful accuracy, whether for process design or simply determining a tradewaste agreement cost split.

3 BE PREPARED

The key to 'being prepared' is to first develop an understanding of what data will be required, when and for what purpose, then to budget for that sampling and characterisation (perhaps up to two years in advance) and, finally, to implement the sampling programme well in advance of when the data is actually needed. Effectively, sampling needs to be part of a council's asset management or operational budget and should be allowed for accordingly at appropriate points in the Long Term Plan (LTP).

Time and money is generally allocated in advance for a consent renewal process or capital works programme. However, there is often no budget or time programmed for the advance collection of the additional data that is required to underpin the decision making and design outside of typical day to day operation, which often consists only of the effluent quality data required for consent compliance. This lack of planning generally results in considerable re-work, last minute data grab and/or gross assumptions which are costly in time and money and which can easily lead to over or under conservative designs.

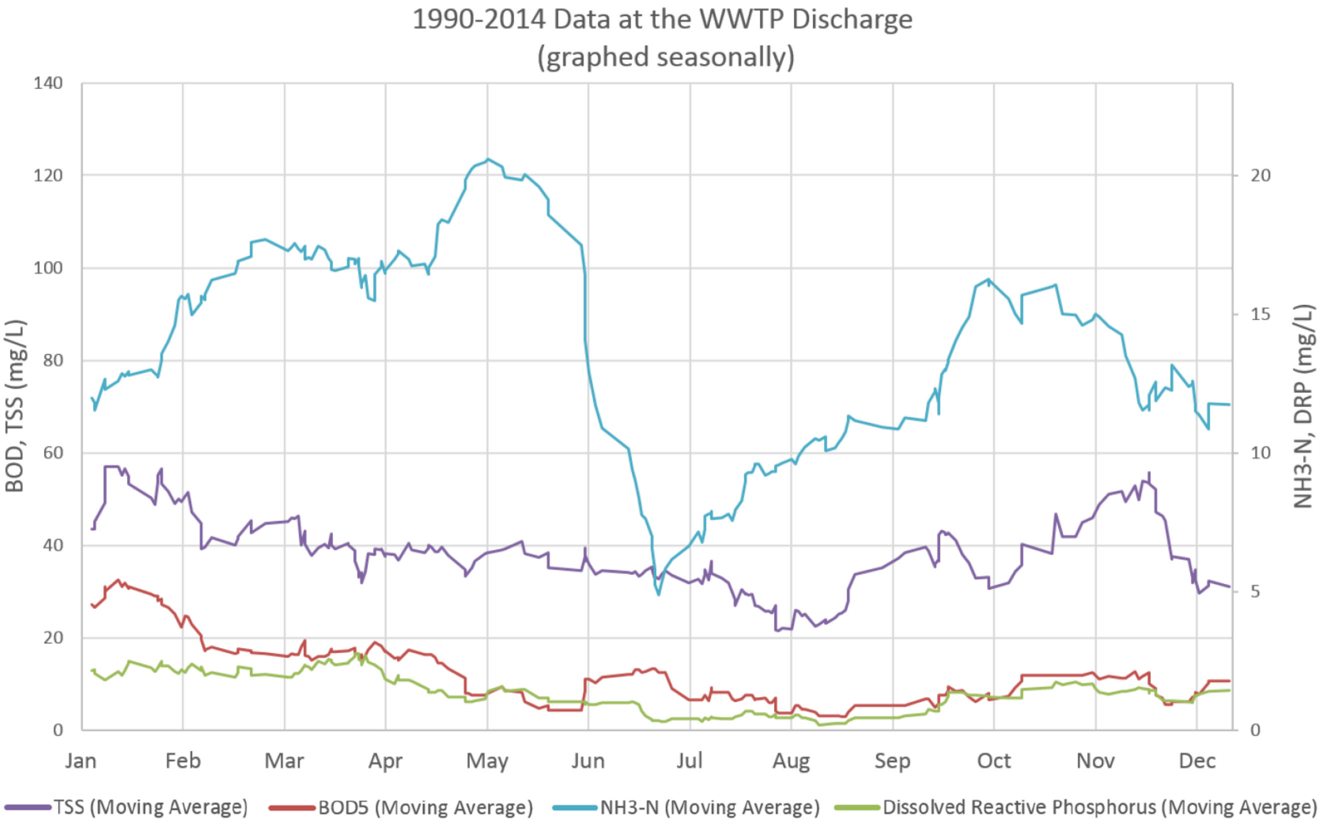
The key is therefore to budget for and implement a monitoring programme well in advance of consent renewal or capital work. Ideally, an ongoing sampling programme would exist which could simply be increased in intensity as required, or tailored for specific work. Preferably, a consent renewal or a capital works programme would commence with a minimum of two (three or four would be better) years of collection of the data specifically required for that work programme. The monitoring programme would not then need to be as intensive and could normally readily be undertaken in conjunction with the regular consent monitoring programme. What is important is that the programme captures the seasonal, weekly and sometimes diurnal (for at least a couple of intensive days) patterns that are exhibited in the raw water/wastewater and at the discharge of key unit processes.

4 DON'T RUSH

One of the reasons for advance implementation of a monitoring programme is the importance of analyzing data over an adequate time period. It is important to understand temporal patterns over the most recent two or three years to make sure that no particular season was anomalous and to see how plant performance is tracking as growth occurs. Additionally, most consents require reliable performance throughout the year, whereas the influent and effluent vary. Some consents are quite specific, perhaps driven by particular temporal variations in the receiving environment. However, the composition of the influent wastewater at any particular WWTP varies with time of day, day of the week, season, weather, etc. It is therefore important to allow a long enough sampling period to identify patterns and, equally importantly, identify anomalies – not only anomalies in the data itself, but also anomalies in the environment producing the data.

Figure 1, below, shows WWTP effluent data from 1990-2014 graphed with the years overlaid to show the seasonal pattern. The graph shows WWTP effluent rather than WWTP influent because influent data isn't available. The pattern shown by the fifteen years of overlaid effluent data includes the combined effects of temperature, inflow and infiltration, variations in tradewaste, seasonal population changes, etc., throughout the year.

Figure 1: Seasonal variation in WWTP effluent quality



The data shown in Figure 1 was selected because it is from a WWTP with significant tradewaste flows as well as a large annual temperature variation. Particular tradewaste discharges can have a distinct temporal pattern and a large influence on influent composition and this is discussed in more detail in Section 8.

The performance of many treatment processes is related to temperature and while these technologies may perform well during the warmer season, performance, and hence effluent quality, typically drops off during colder months, particularly with respect to nitrogen removal.

Imagine trying to apply for a consent or size a new process for the plant shown in Figure 1 with just a month or two of data collected in mid-winter…

5 DO THE BASICS PROPERLY

Design the sampling programme adequately, focusing on getting the basics right. The 'nice to have' bits can always be added in later.

Having said that, a basic sampling regime should be designed to identify more than just consent breaches. The intent should also be to collect data in order to operate the WWTP effectively, have forewarning to avoid potential consent breaches and to plan for upgrades and consent renewal processes. This means that, at times, it is definitely necessary to sample more than just the final effluent!

Beyond this, there is no universal 'how to' guide for WWTP sampling. The Wastewater Monitoring Guidelines (NZWERF, 2002), although primarily focused on the monitoring required for resource consent conditions, do provide a good risk-based framework with tools and techniques to assist in developing a sampling plan but no document can provide all the 'answers'. Each community, WWTP and receiving environment is different and the monitoring programme needs to be individually tailored accordingly. Every sample costs money but missing something important can cost a whole lot more. An intensive trial sampling period can be used to initially sample more analytes at higher frequency in order to work out what needs to be sampled on an ongoing basis. For example, perhaps if there is very little information available about possible tradewaste discharges it might be necessary to sample the WWTP influent for up to twenty parameters every six or eight days initially until a picture forms. After this, potentially sampling at weekends could be stopped or greatly reduced in frequency to save overtime labour costs and the list of parameters reduced to a dozen or so. Or, if planning an upgrading programme, it is important to understand the performance of each of the existing unit processes to gain an appreciation of where to focus the upgrading activities and how the performance or capacity of one unit process is likely to affect those downstream of it.

Good communication is vital. This includes not only clearly communicating the sampling requirements to operations staff, but also picking the operations team's brains for information about what is really happening at the plant. Speaking directly with the operations staff is invaluable and not only provides useful insight into the day to day reality of the plant but can highlight real life issues with the data collection which cannot be detected on paper. It can also identify plant quirks and the resulting operational 'work-arounds' and 'fixes' which might help explain a puzzle in the data. There are also huge benefits to getting the operations team on board and engaged in the sampling exercise. A keen, interested person on the ground will then start asking really good questions and raising potential issues rather than just 'doing as instructed', even if it makes no sense.

6 BE RIGOROUS

Be rigorous in sample collection, preservation, custody and testing. Marvellously accurate analysis of rubbish still produces rubbish but it can give a false impression of accuracy. It is vital to sample the right stuff in the right spot.

This advice probably sounds stupidly obvious but there are plenty of horror stories out there. Pretty much everything that could go wrong does go wrong at some point, although in many cases the person taking the samples genuinely believes that they are doing the right thing.

For example, in one instance a maintenance contractor was in charge of all sampling and also providing technical advice on changes needed to a wastewater system. An abatement notice was issued and the client engaged additional help. Looking through the sampling information to try to figure out what had been going on, it became apparent that old water and juice bottles had been used for sampling, as shown in the extract from one of the laboratory reports below.

Figure 2: 'Indicative' results can be entered into a database without any disclaimer

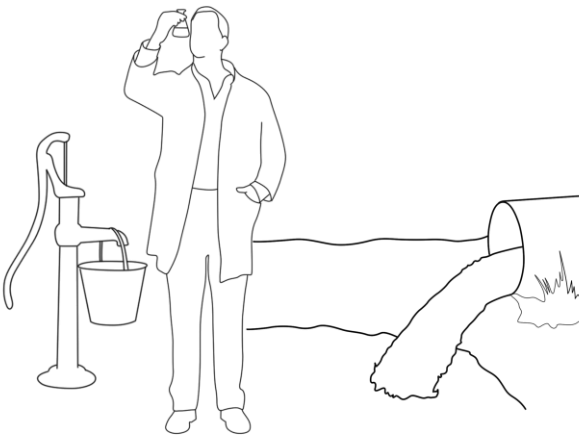
Customer Ref: [redacted]
Email Recipients: [redacted]
Project Comment: Results will be indicative only as the sample was collected in a non sterile juice container
Date Project Started: 11/09/2009 14:18

Sample Details

Laboratory ID:	[redacted]	**Sample Type:**	Effluent	**Date Sampled:**	11/09/2009
Description:	Waste Water			**Date Received:**	11/09/2009

In another example, over a period of about two and a half years samples were taken from a pipe connected to a groundwater spring, rather than from the WWTP discharge pipe. Unsurprisingly, this spring gave remarkably good results, suggesting a superb quality of effluent from the WWTP. The client spent a significant sum of money on consultants' fees, analyzing and reporting on this 'effluent' quality data but was reluctant to believe that the excellent results simply weren't credible given the treatment processes involved.

Figure 3: Sample the right stuff in the right spot



Conducting audits of the sampling process is recommended. These audits might be performed by external specialists but in most cases just a series of double checks by internal staff could pick up major problems. Key things to check are:

- Sample extraction location
- Sample collection method (grab, time weighted composite or flow weighted composite)
- Sample labelling, storage and transport to lab
- Tests undertaken (including if the laboratory service provider, test or test method has changed, for example from $cBOD_5$ back to BOD_5).

It is not unreasonable to request an audit, particularly if the information is used in a legal process or in fulfillment of legal obligations, such as consent conditions.

7 BE CONSISTENT AND SYSTEMATIC

It is important to have good data management practices and to **audit the data regularly** for unusual changes or abnormal results.

7.1 SANITY CHECKS

As discussed above, mistakes can be made in the sampling process and it is also possible that issues with the sampling sites or sample data are not identified during the sampling process due to the inexperience or lack of technical understanding of the person collecting, analyzing or reviewing the data. **Regular sanity checks**, including graphing of data, are invaluable. It is much easier, and cheaper, to conduct sanity checks as the sampling progresses, rather than risk discovering problems later on which might invalidate all the work done and potentially create a critical situation in which there is insufficient time to collect sufficient correct data.

Some simple techniques that can be easily applied to great effect include:

- Graphing

  A scatter graph can quickly show any step changes or outliers in the data which might require further investigation. Adding horizontal lines representing certain statistical measures can help to quickly visually compare sections of a graph if data stretches over long time periods.

- Conditional formatting

  Even just the pre-set conditional formatting options in Microsoft Excel can be used to help identify anomalies and ‘red herrings’ or to compare patterns.

- Comparing mean versus median, minimum and maximum versus percentiles, etc.

For 'live' data collection, creating a summary table with various statistics at the top of the spreadsheet makes it much easier to spot potential errors in the data as the results return from the lab.

- Overlaying consecutive years of data

  Plotting multiple years of data over top of each other can help show overall seasonal trends, particularly if the data set from any single year is not very large.

- Analysing data by day or the week, month, season or whatever is an appropriate interval for the circumstances

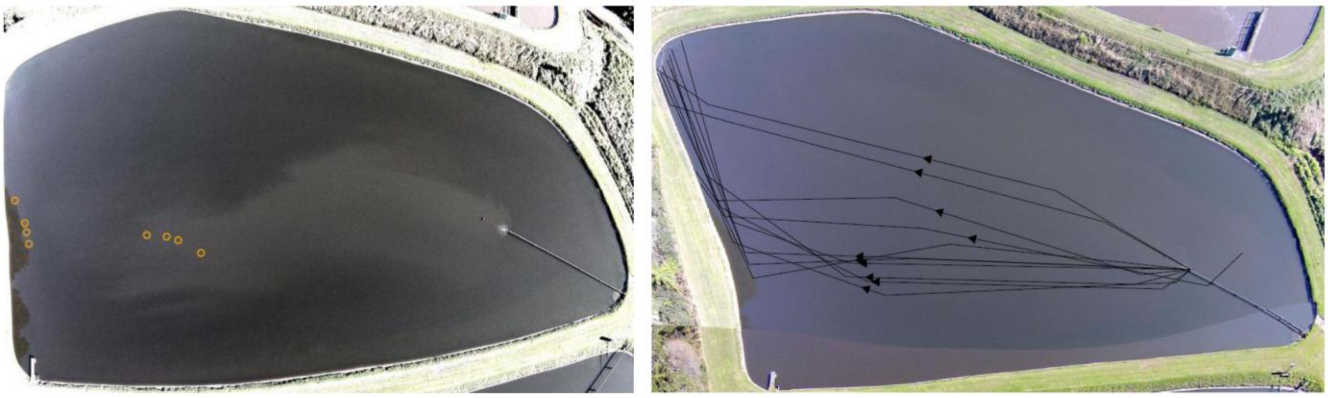
  Rather than just checking the statistics of the full data set, breaking data down into suitable intervals for analysis can be very illuminating.

- Array formulae

  Array formulae (press Ctrl + Shift + Enter to insert {} around the formula) can perform several calculations to generate a single result, for example to calculate the median value of March data only, all in one cell.

Simple physical techniques can also be applied, for example releasing oranges into the sewer upstream of an oxidation pond to determine the flow path and avoid taking samples in a stagnant corner while the main flow isn't sampled. The 'NZ Standard Orange Test' is shown to great effect in Figure 4 below. The image on the left is a photograph taken by a drone showing the oranges in action (fruit circled in orange to be more visible at this scale) and the path taken by each of the oranges is plotted on the plan on the right. The photograph colouring has been adjusted slightly to show the effluent plume more clearly. If a likely problem is determined by a simple method such as this, then a more intensive and accurate follow up investigation can be planned.

Figure 4: The NZ Standard Orange Test in action



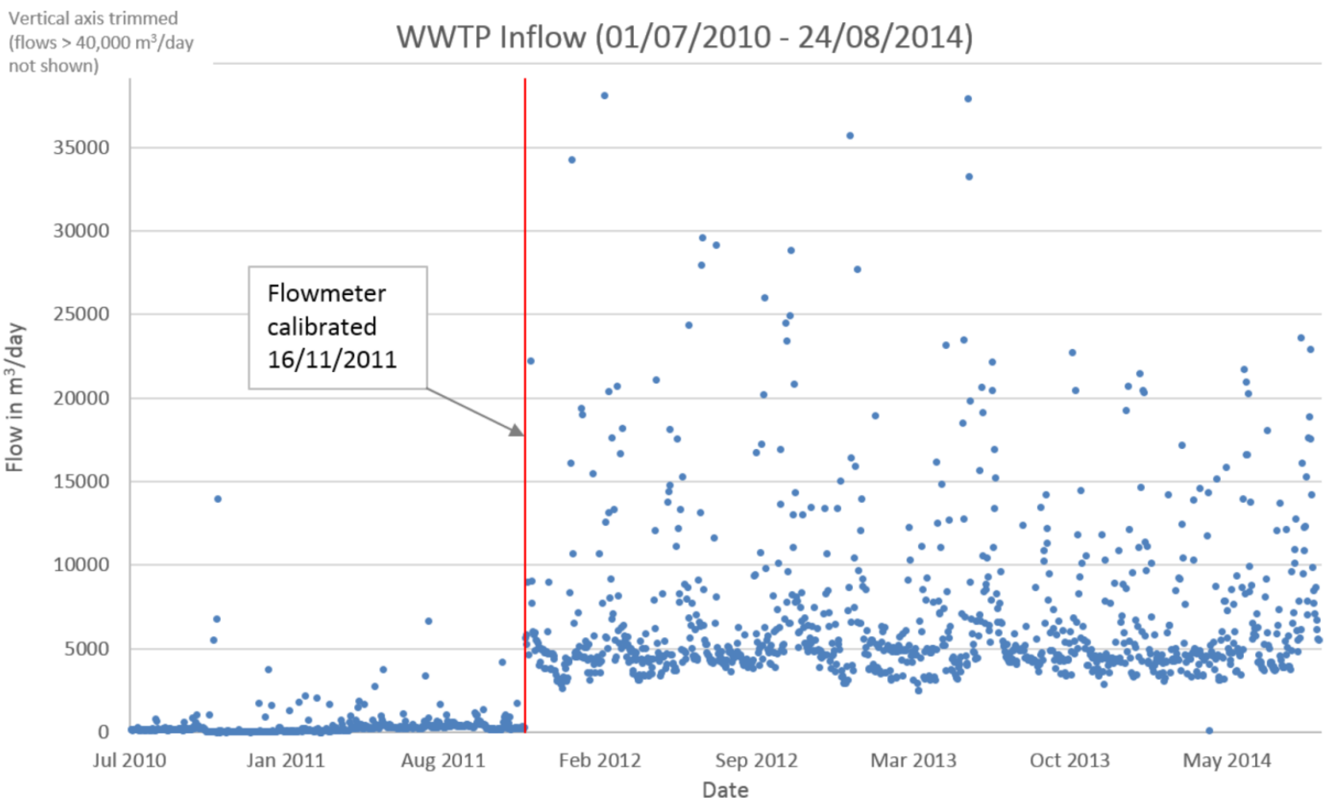
Each of these techniques is best suited to identifying a different problem with the data. Spotting a simple manual data entry error mistaking the position of the decimal place while transcribing lab results for example, requires a different methodology from identifying a systematic error in how the flowmeter pulse signals are counted, added and transmitted.

7.2 INSTRUMENT CALIBRATION

Flowmeters, while extremely useful, **can also be very misleading** as erroneous data can look deceptively authoritative. In the words of one client *"They are a terrible piece of equipment for doing funny things. You need to keep an eye on them."*

The graph below shows the effect of calibrating a flowmeter – using all the data, without first graphing the 1,516 data points to look for potential problems, the mean WWTP inflow from 2010-2014 is 4,890m^3/day but using only the calibrated data, collected after 16/11/2014, the mean is 7,119m^3/day. The difference between a flow of 5,000m^3/day and 7,000m^3/day is very significant in terms of tasks like sizing equipment upgrades but still small enough not to be noticed if nobody is actually looking for it.

Figure 5: The potentially dramatic effects of flowmeter calibration



Flowmeter quirks can also be more subtle and difficult to detect. For example, comparison of two different sets of flow data from the same flowmeter, provided by two different people using different start and end times led to the discovery that the flowmeter was 'winding down' to zero sometime between 11pm and 12pm over a period of about 45 minutes, rather than resetting to zero instantly at 23:59:59 each night.

7.3 REVIEW SPREADSHEET FORMULAE

Frequently spreadsheet formulae are introduced into the data management system to amalgamate very large volumes of data, often from instrumentation interrogated by the SCADA system, into higher level, or more manageable forms. While the short duration data is required for assessing acute system responses such as pressure or flow transients, information from the same instrument is often also required on a longer duration basis, for example 30 minute average dissolved oxygen, daily total flow, average system pressure, etc. Problems with the first set of control system based integration software are covered in the section above. However, it is also very important to have the subsequent spreadsheet based data manipulation equations reviewed by someone who is not the writer, but who is familiar with the actual physical process.

One example was encountered when formulating a mass balance for a WWTP using largely empirical monitoring results from the plant. Neither the solid or liquid stream accounts would balance. The issue was eventually traced to a point in time, before the start of the current data set, when an averaging method had been changed, using an incorrect multiplier, such that it doubled the reported values for one process side stream.

7.4 IS IT POSSIBLE?

Finally, it is always important to **consider what is physically possible**. For example, in the situation pictured in Figure 6 below the outflows greatly exceed the pump capacity – when the particular piece of equipment has an internal error it turns out that it reports a flow of 55,439.00m^3/day. Repeated identical results are normally a good sign that something is amiss, for example:

- The instrument has failed and defaulted to a pre-set value
- The instrument maximum scaled value has been reached and exceeded

- Readings have not been taken for some reason and someone has filled in the gaps by guessing a 'there or there about' number to insert.

These values can be easily removed from the dataset once identified.

Figure 6: Example of instruments failing to a pre-set value

Date	XXXX Plant, Site, Daily Outflow
7/01/2015	55,439.00
8/01/2015	55,439.00
9/01/2015	55,439.00
10/01/2015	55,439.00
11/01/2015	55,439.00
12/01/2015	55,439.00
13/01/2015	742.75
14/01/2015	2,537.27
15/01/2015	3,355.14
16/01/2015	2,999.11
17/01/2015	3,323.90

Pump maximum flow rate is 9,500 m^3/day, i.e. this is not physically possible

8 UNDERSTAND YOUR TRADEWASTE DISCHARGERS/ES

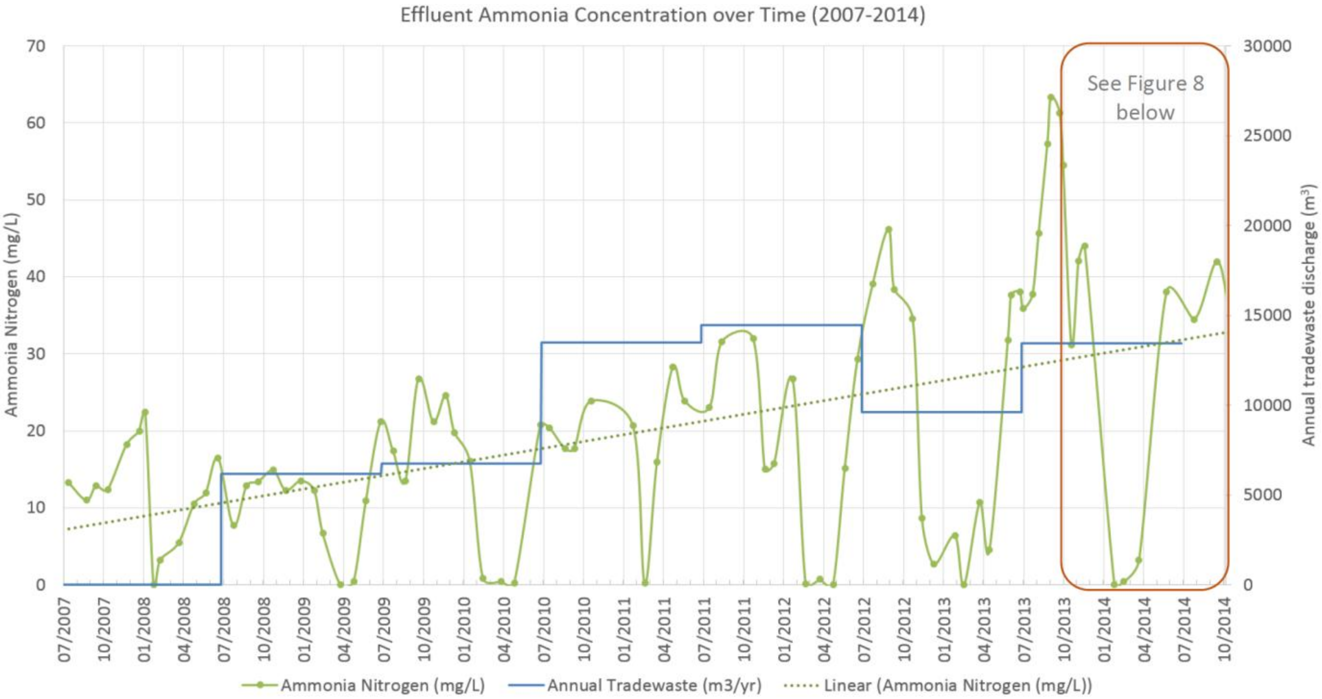
Particularly in a smaller WWTP, tradewaste discharges can have a significant, and sometimes highly variable or sporadic, effect.

A better understanding of local tradewaste dischargers can enable tradewaste agreements to be more applicable to the particular discharge and lead to fairer apportionment of WWTP operational and capital costs, as well as simply being able to design and operate the WWTP more appropriately to suit the particular circumstances.

For various reasons, often related to commercial sensitivities, tradewaste dischargers are not necessarily particularly forthcoming with their discharge data and future plans. Sometimes the first indication of a significant potential tradewaste change is actually a report in the media or simply that a Land Information Memorandum (LIM) for the property has been requested.

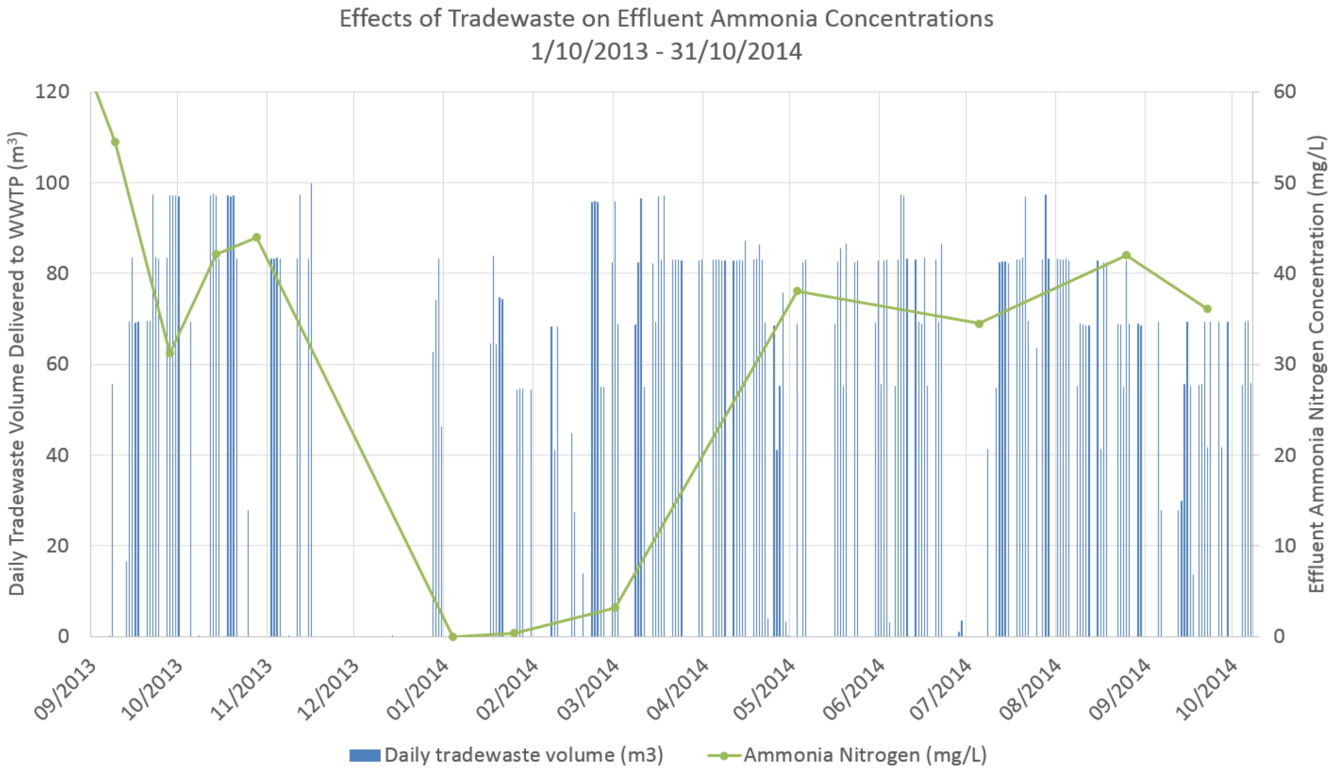
Compared with domestic wastewater, tradewaste can be very unpredictable in terms of both flow and load. It is important to understand the size and likely timing of these variations in order to use the appropriate data for the task. For example, Figure 7 provides an indication of how the effluent ammonia levels from a WWTP are trending over time, as the annual volume of tradewaste discharged into the upstream sewer system increases.

Figure 7: The effect of tradewaste on WWTP effluent ammonia concentrations over time



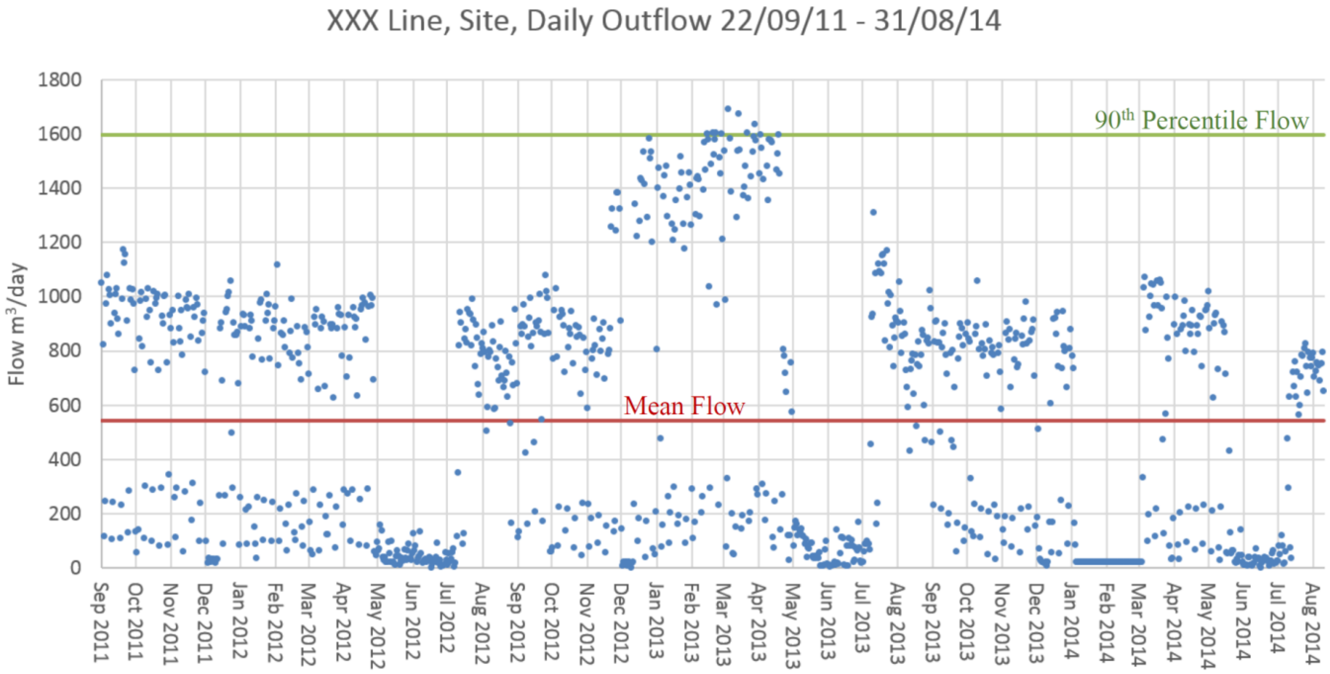
Clearly there are significant short term variations around this trend and these are likely to be associated with the temporal pattern of the tradewaste discharge to the sewer. Figure 8 provides details of the time period for which both detailed treatment plant flow and tradewaste logs are available concurrently. The December 2013 to February 2014 data, together with the regular low points in the Figure 7 plot, is strongly suggestive that, in the absence of significant loading from tradewaste, the WWTP is able to almost completely nitrify its effluent, given appropriate climatic conditions (with cooler temperatures slowing down the process) but heavy ammonia loading from the tradewaste causes problems.

Figure 8: A close-up look at the effect of tradewaste on WWTP effluent ammonia concentrations



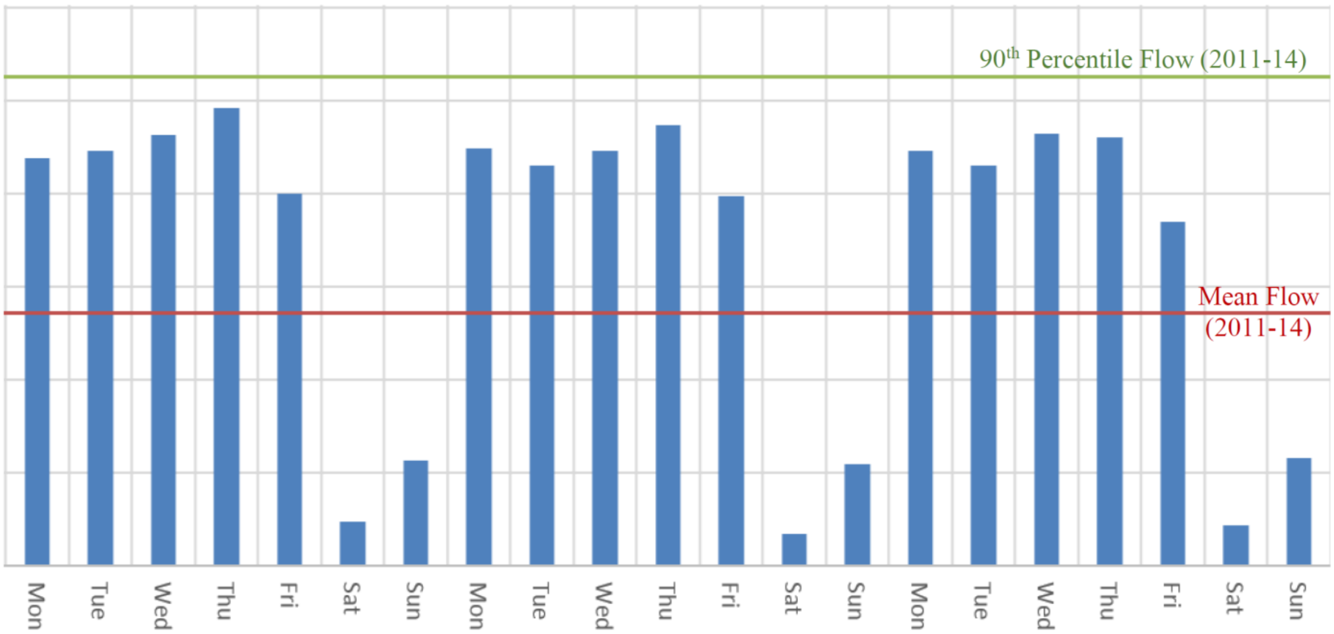
Understanding the patterns, and most importantly, the reasons behind these patterns, in tradewaste discharges is particularly important in order to know when to use which numbers. For example, there are times when using the mean flow and load would be appropriate and others when a peak is very important, such as the need to provide aeration to satisfy peak hour demands. A good understanding of variations in tradewaste discharges permits these variations to be considered in terms of treatment performance capability, sensitivity of the receiving environment, etc. For example, Figure 9, below, shows the daily outflow from a particular tradewaste discharger over a period of three years.

Figure 9: Daily tradewaste discharge flows from a particular site over a three year period



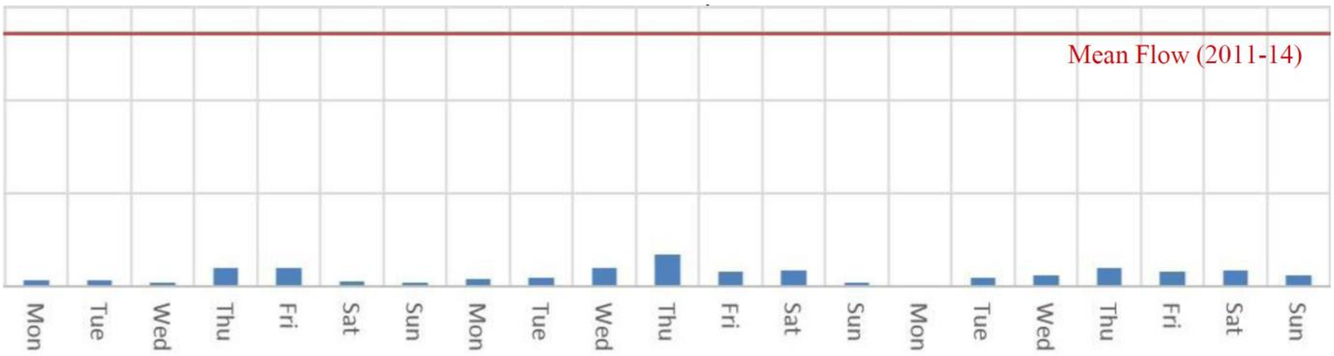
Upon closer examination, this data actually shows three distinct patterns each year, as shown in Figures 10 – 13 below.

Figure 10: A three week snapshot of the Figure 9 tradewaste discharge showing the typical flow pattern for most of the year



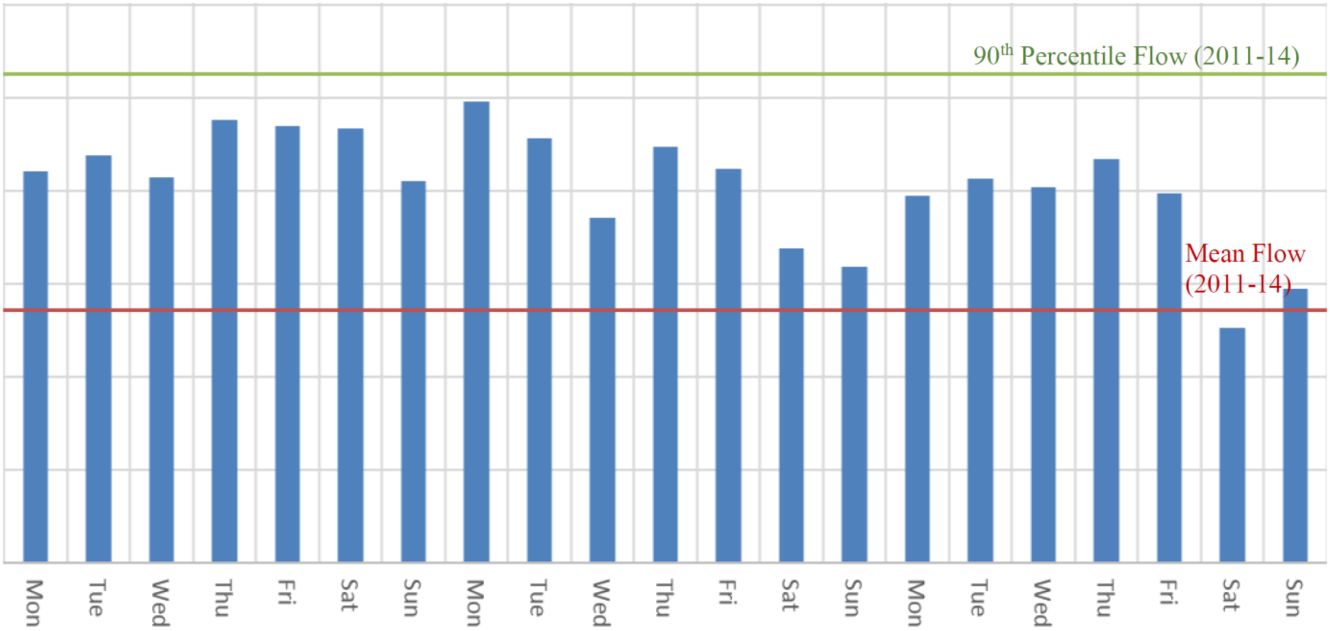
For most of the year, the Monday to Friday discharge is much larger than the weekend discharge, as shown in Figure 10. The Sunday discharge is higher than the Saturday discharge which suggests that perhaps there is some washdown or other preparation occuring on Sunday, in advance of operation resuming each Monday morning. Neither the 90th percentile or mean flows of the overall data set are representative of this typical flow pattern.

Figure 11:   A three week snapshot of the Figure 9 tradewaste discharge showing the typical flow pattern in June/July



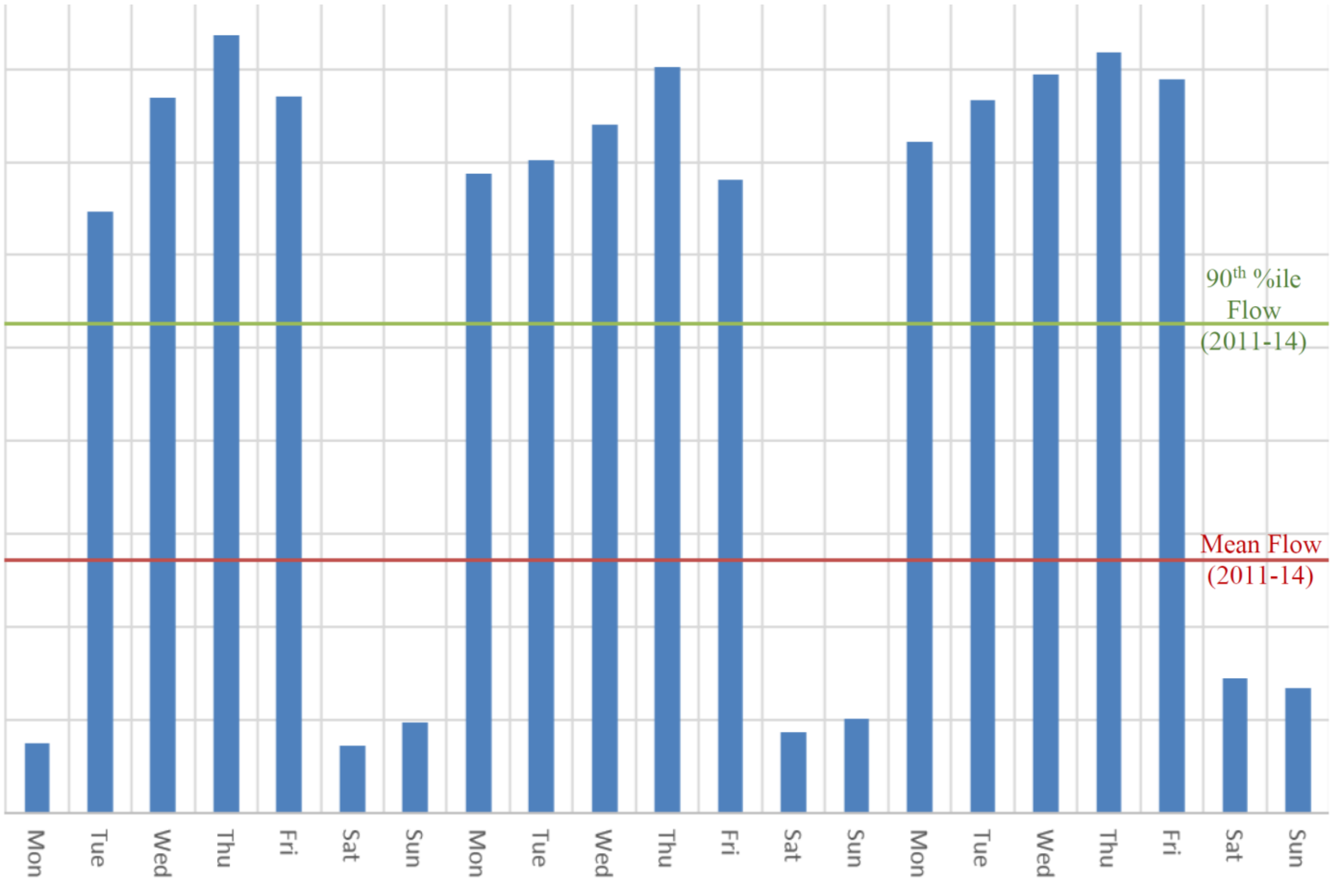
In June and July the plant shuts down and flows are very low, as shown in Figure 11. This shutdown corresponds with some of the coldest weather in the pond based treatment system.

Figure 12:   A three week snapshot of the Figure 9 tradewaste discharge showing the typical flow pattern in August/September



In August and September, production ramps up and runs seven days per week, as shown in Figure 12. However, even then, the 90th percentile and mean flows of the total data set are not representative.

Figure 13: A typical three week snapshot of the Figure 9 tradewaste discharge showing the flow pattern from 3 January 2013 - 10 May 2013 (this pattern was not repeated before or since this time period)



Between January and May 2013, the flow pattern was similar to the ‘typical’ pattern shown in Figure 10, but the weekday flows are significantly larger than were produced before or after this time period. These five months of data are skewing the 90th percentile and mean flows of the entire data set.

With this more detailed understanding of the tradewaste discharge it would be possible to firstly discuss historic, current and potential future operations with the particular tradewaste discharger and then use the appropriate figures for different purposes. Use of appropriate figures for different things can be particularly important in apportionning WWTP operational and capital costs between the tradewaste discharger and rate payer. The tradewaste discharger might even choose to discharge differently (pre-treat, blend or balance the discharge on its own site prior to discharge) in order to reduce its impact or to mitigate aggregate affects and hence reduce the resulting tradewaste charges.

9 PLANNING A DATA CAPTURE PROGRAMME

Although there is no universal ‘how to’ guide for WWTP sampling, the list below outlines some good questions to help get started:

- What events will lead to data capture programmes being required at my facility?
    - Demand growth
    - Upgrading for Level of Service or increased capacity
    - Asset manager wants to be well informed
    - Consent renewal
- When will different programmes be required?
- What minimum duration of data capture is reasonably required for each programme?

- What analytes need to be measured, where and at what frequency? Sometimes a long duration, less intensive programme, picking up growth and seasonal and weekly patterns will need to be supplemented by a short duration, high intensity programme to define, for example, diurnal patterns.
- What sample types are required for each analyte and at each process point?
  - Grab (essential for pathogen measurements): okay for some fully mixed, high hydraulic retention time processes
  - Time weighted composite (poor cousin to FWC): can be quickly set up using a sample bucket, solenoid valve and electronic timer.
  - Flow weighted composite (FWC): almost always the best choice, apart from for pathogens, but requires more set up and a more expensive sampler.
- What are my baseline monitoring programme requirements (e.g. from consents) and how will 'particular' programmes best fit in with these?
- Are my overall monitoring programme requirements such that I have sufficiently trained staff in-house or incumbent operations contractors to undertake the work, or should I be engaging a specialist monitoring contractor, with appropriate equipment, to supply staff and/or resources to manage special programmes?
- How much will the overall data capture programme for my assets cost, and when and how is it best to ensure that these costs are adequately identified and provided for in forward financial planning?

Answering these questions in a systematic and structured manner may also be all that is required to constitute an 'in-house' business case to gain approval for a monitoring budget.

Additionally, the Wastewater Monitoring Guidelines (NZWERF, 2002) do provide a good risk-based framework with tools and techniques to assist in developing a sampling plan, although primarily focused on the monitoring required for resource consent conditions.

10 PAY OFF

The investment in a good sampling programme is small compared with the cost of the potential consequences of using erroneous or misleading data.

It is difficult to specifically determine what cost savings will be generated by a particular monitoring programme, however starting with good data means that other investment decisions will be made on a much more robust and defensible basis and that the risk of process under or over spend is significantly reduced. We have witnessed poor wastewater characterisation on a medium sized project leading to errors costing $2-5 million to correct, and in that context investing in a proper monitoring programme is very economical indeed.

There is also the risk that early decisions based on incorrect figures or assumptions could lead to selection of a treatment process which is more costly in the longterm. For example, something as basic as making a choice between a high capex, low opex option compared with a low capex, high opex option, based on preliminary, inaccurate flow and/or load data which is discovered to be incorrect when additional data is collected and analysed during the design phase.

Good monitoring data can also lead to cost savings through identifying operational efficiencies and by enabling timely fault finding. Finally, accurate and appropriate data enables a fairer apportionment of WWTP operational and capital costs between the council and tradewaste dischargers.

11 SUMMARY

A good WTP/WWTP monitoring and characterisation process is vital in order to determine the most appropriate processes (and sizing) for treating the water/wastewater and to operate each treatment process efficiently. In developing the characterisation it is important to consider sampling period, programme design, communications, sample collection, quality control and tradewaste discharges.

The first step is to develop an understanding of what data will be required, when and for what purpose, then to budget for that sampling and characterisation and, finally, to implement the sampling programme well **in advance** of consent renewal or capital work.

It is important to allow a **long enough sampling period** to identify patterns and, equally importantly, identify anomalies – not only anomalies in the data itself, but also anomalies in the environment producing the data. Analysing temporal patterns over the most recent two or three years can help to ensure that no particular season was anomalous and to see how plant performance is tracking as growth occurs.

In design of the sampling programme, **focus on getting the basics right**. Each community, WWTP and receiving environment is different and the monitoring programme needs to be individually tailored accordingly. Every sample costs money but missing something important can cost a whole lot more. An intensive trial sampling period can be used to initially sample more analytes at higher frequency in order to work out what needs to be sampled on an ongoing basis.

Good communication is vital. This includes not only clearly communicating the sampling requirements to operations staff, but also picking the operations team's brains for information about what is really happening at the plant. Speaking directly with the operations staff is invaluable and not only provides useful insight into the day to day reality of the plant, but can highlight real life issues with the data collection which cannot be detected on paper.

Sample collection, preservation, custody and testing must be rigorous. Accurate analysis of rubbish still produces rubbish, but it can give a false impression of accuracy. It is vital to sample the right stuff in the right spot. Conducting **audits of the sampling process** is recommended. Instruments need to be calibrated regularly and it is also very important to have the instrument data manipulation equations reviewed. It is always important to consider what is physically possible from the process or equipment.

Regular sanity checks, including graphing of data, are invaluable. It is much easier, and cheaper, to conduct sanity checks as the sampling progresses, rather than risk discovering problems later on which might invalidate all the work done and potentially create a critical situation in which there is insufficient time to collect sufficient correct data.

Particularly in a smaller WWTP, **tradewaste discharges** can have a significant, and sometimes highly variable or sporadic, effect. A better understanding of local tradewaste discharges can enable tradewaste agreements to be more applicable to the particular discharge and lead to fairer apportionment of WWTP operational and capital costs, as well as simply being able to design and operate the WWTP more appropriately to suit the particular circumstances.

Finally, starting with good data means that other investment decisions will be made on a much more robust and defensible basis and that the risk of process under or over spend is significantly reduced. The **investment** in a good sampling programme is small compared with the cost of the potential consequences of using erroneous or misleading data.

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