STASTICAL PROCESS CONROL
FOR IMPROVED WATER QUALITY OUTCOMES

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ABSTRACT

While critical control limits and licence limits are set following a rigorous process involving all stakeholders, control limits are typically arbitrarily set. This can cause data to be above the control limits too many or too few times. Both these limit the ability of the control limits to assist operators to continuously improve their processes.

If the control limits are set too far above or below the data, they do not provide the tool to alert operators and unusual trends or unstable control can be missed

Setting the control limits two or three standard deviations from the mean ensures they are a more useful tool to operators. This statistical approach limits the number of events that the operator has to focus on improving.

Using rolling statistics, the control lines will narrow over time as the process becomes more in control and the variability reduces.

1.0 INTRODUCTION

Most water utilities use some form of control chart to monitor their drinking water and treated sewage quality. These control charts help operators to keep their treatment processes in control and typically consist of critical limits and control or adjustment limits as shown in Figure 1.

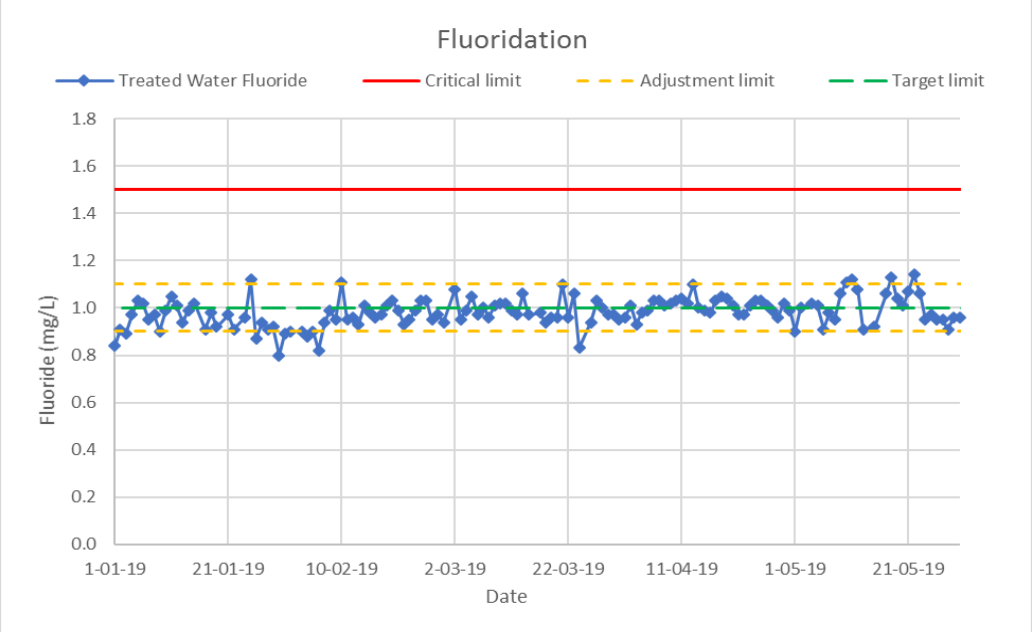

Figure 1: Typical control chart

Compliance limits are usually set by regulator such as limits in Environmental Protection Licences (EPL) or are Critical Control Points (CCPs) for drinking or recycled water systems.

Control limits provide early warning to operators that the parameter is trending unfavourably and out of control. This gives the operator time to take action to prevent a breach of the critical limit.

Control limits are often set arbitrarily based on standard numbers or operational experience. This method of setting control limits can cause the following problems.

- If control limits are too close, most of the data will be outside the limits causing overwhelm for the operators and confusion on which incidents require further investigation
- If control limits are too wide, by the time they are reached there may be insufficient time for operators to take action to prevent breach of the critical limits.
- Setting arbitrary control limits does not allow for changes in process performance over time due to seasonal impacts or improved operation.

2.0 DISCUSSION

2.1 Statistical Process Control

Statistical process control began in the manufacturing industry in the 1950s as part of LEAN manufacturing and Six Sigma. The use of control charts with statistical control limits was based on the theory that 99.999666% of a set of data will fall withing three standard deviations either side of the mean. This approach allowed industries such as car manufacturing to reduce the variability in their processes and therefore reduce the amount of component reject.

The use of three standard deviations to set control limits is valid for data such as machine component tolerances that are evenly distributed around the mean. Most water quality parameters are skewed to one side of the mean as the lower limit is the limit of detection. Nevertheless, the principle of setting control limits statistically is still valid and can provide opportunity for focussed root cause analysis and continuous improvement.

2.2 Example of control limits too wide

When control limits are set too far from the mean there is a risk that an unfavourable trend of instability may not be noticed until it is too late to prevent breach or high maintenance costs.

The example shown in Figure 2 shows an example from a recycled water plant where the reverse osmosis conductivity continued to rise to four times the average without reaching the upper control limit. Once the operators noticed the trend the membranes were replaced and the conductivity returned to normal.

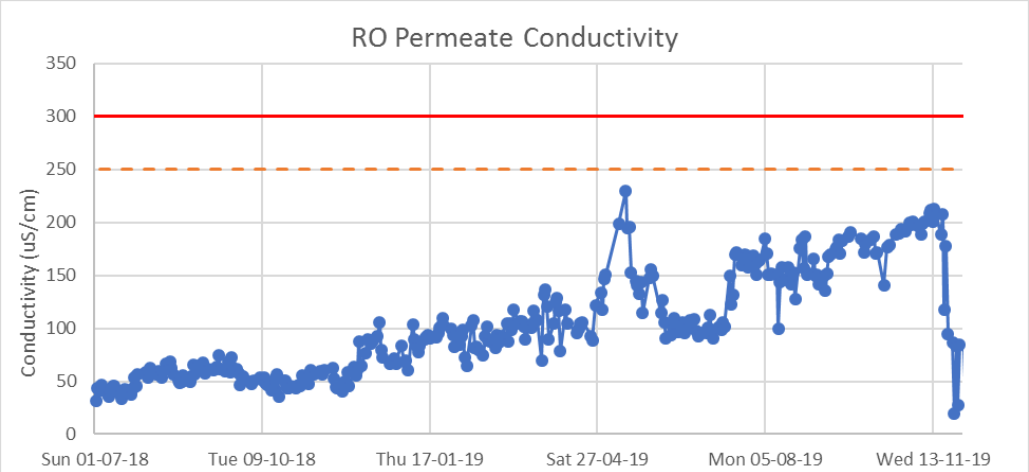

Figure 2: Control chart with limit too wide

Figure 3 shows the same data with the control limit changed to three standard deviations above the mean. With this statistical control limit, the rising trend could have been noticed nearly a year earlier and potentially membrane cleaning could have extended their life and saved maintenance costs.

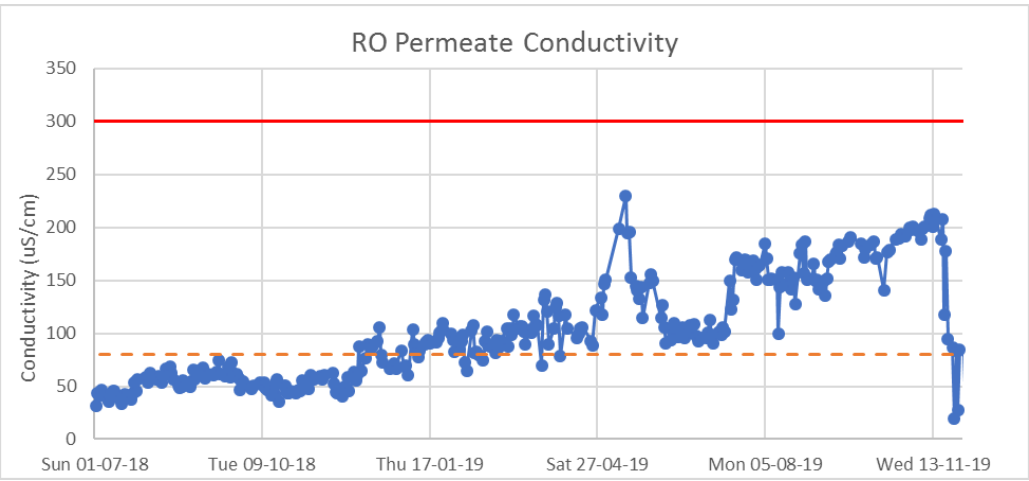

Figure 3: Control chart with control limit adjusted

2.3 Example of control limits too narrow

If the control limits are set too close to the mean, there can be so much data outside the limits that it is not possible for operators to what events to investigate. This can result in unfavourable trends or instability going unnoticed. It can also often result in operators losing confidence in the control charts as a tool for improving performance.

Figure 4 shows an example of recycled water free chlorine where the upper control limit is so low that nearly all the data is above the limit.

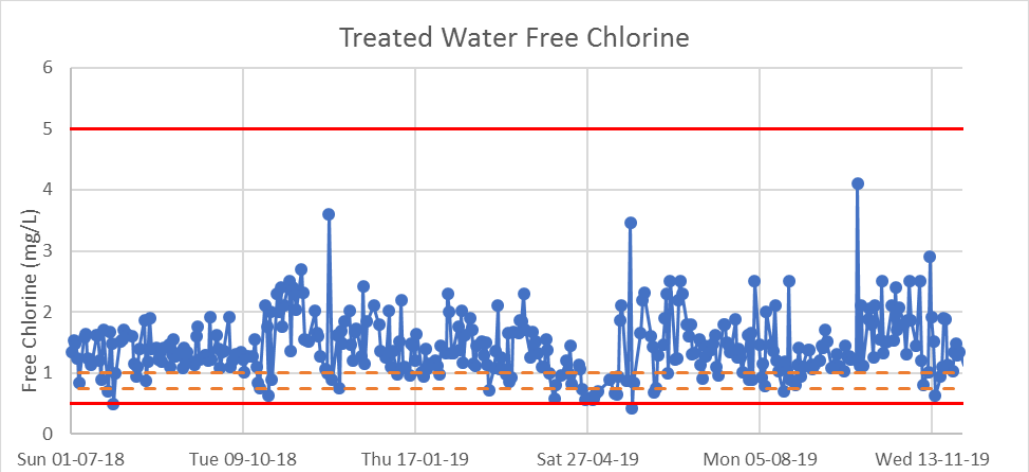

Figure 4: Control chart with limit too narrow

Figure 5 shows the same data with the upper limit adjusted to three standard deviations above the mean. This control chart now directs the operator to focus investigation on the highest peaks that are closest to the critical limit.

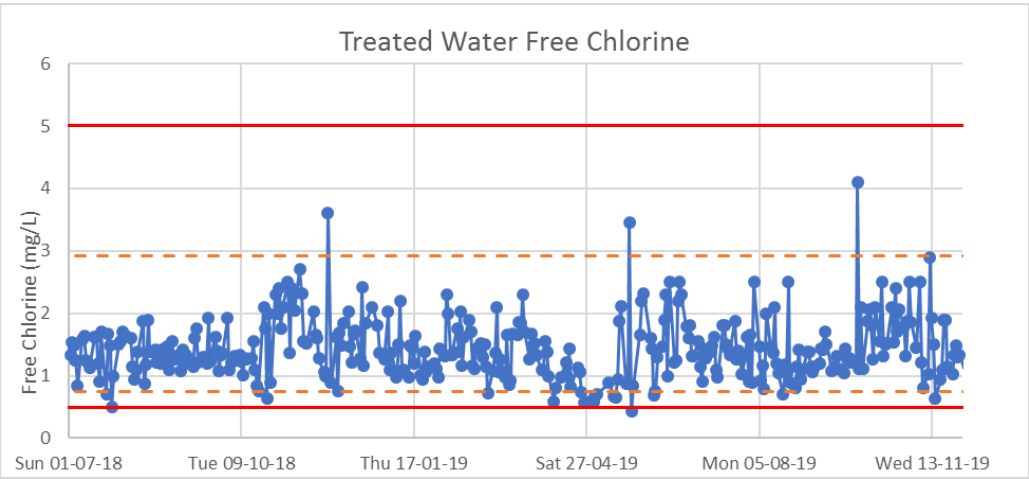

Figure 5: Control chart with adjusted upper control limit

2.4 Continuous Improvement

By using a statistical formula based on the latest data to set the control limits, they will automatically adjust as the performance of the process changes. Depending on the frequency of data collection and the rate of change, the mean and standard deviation typically based on the last one to three months.

If we look at the previous example of recycled water free chlorine and remove the peaks above the control limit, the limit drops from 2.9 mg/L to 2.5 mg/L automatically as the process becomes more in control (see Figure 6).

This automatic adjustment allows operators to focus on the most important data that will improve the reliability of their processes and improved water quality outcomes over time.

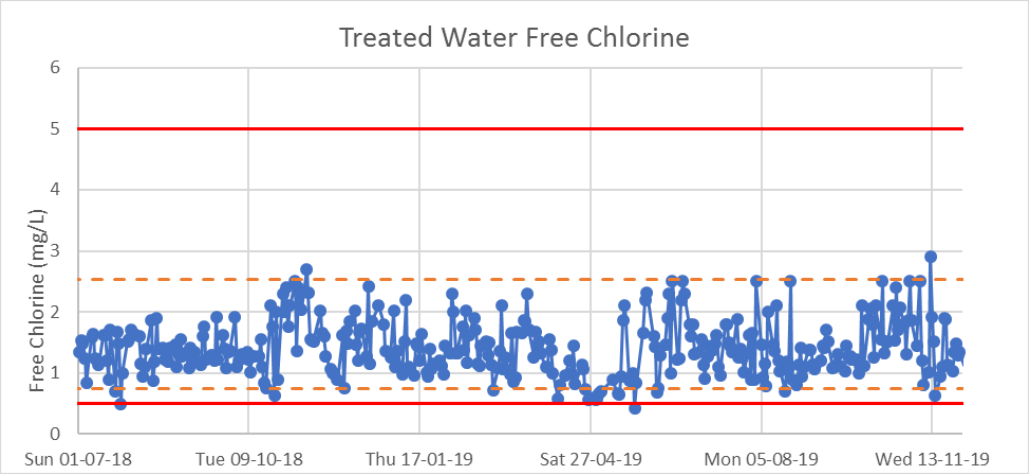

Figure 6: Automatic lowering of upper control limit as high values are removed

3.0 CONCLUSION

Control limits for water quality are often set arbitrarily and this can prevent operators from noticing and investigating incidents that have the greatest risk to compliance.

By setting these control limits using statistical methods, unfavourable trends and unstable control are clearly identified allowing operators to focus on the problems that are most important. The statistical control limits will also automatically adjust as the process changes ensuring operators are able to achieve continuous improvement in their water quality.

4.0 ACKNOWLEDGEMENTS

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5.0 REFERENCES

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