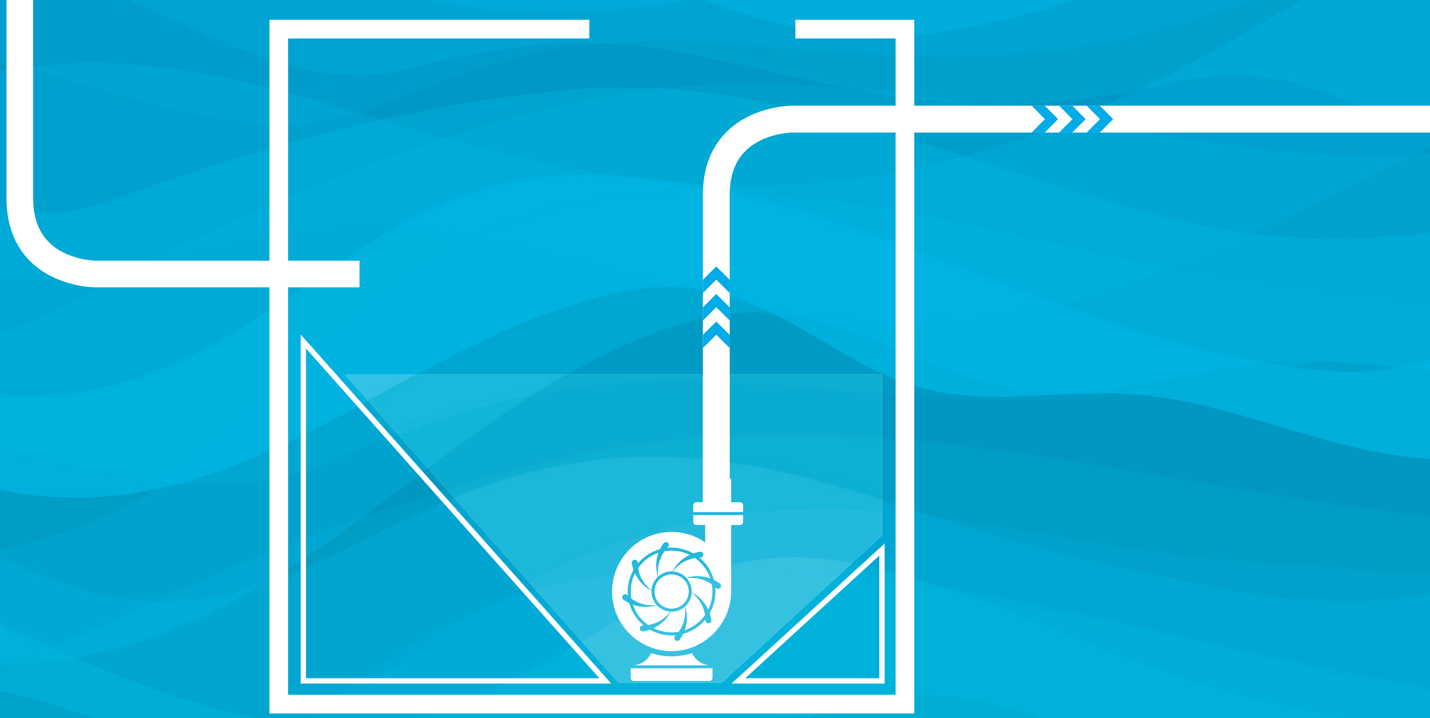
2019 Industry Report

Innovative technology reduces sewage pumping ownership costs by 15%



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Introduction

When wastewater pumps work harder to overcome debris, rags and fats, they put strain on their mechanical and electrical components, consume more energy and reduce their overall lifespan. This sub-optimal running results in more maintenance (often emergency call outs) and higher costs through expensive repairs and replacements.

A solution is needed that can keep pumps working in optimal condition and as close as possible to their Best Efficiency Point. Currently, issues within pumps - particularly ones caused by partial blockages - are only identified during routine maintenance checkups, or when a problem becomes so severe the pump stops working.

Through in-depth research conducted in partnership with a major European Water Utility and using an innovative new pump performance sensing technology, Jacobs have determined that the scale of sub-optimal pump running is a more extensive problem than previously understood and one that affects much of the asset fleet. This new insight shines a light on the cost impact of sub-optimal running to the industry and also highlights the need for the adoption of a new breed of pump management solution.

From this collaborative research, it is also shown that the novel sensing technology tested can be successfully deployed as a solution for real-time asset management of the full wastewater pumping station (WWPS) portfolio. This technology results in the improved control of resources, reduction in spillage risk and cost savings of up to 15%.

The maintenance challenge

Operations and Maintenance teams typically have only limited visibility of emerging performance issues as, unlike other asset groups, wastewater lift stations are often poorly served with instrumentation, with most utilities reliant on a simple mix of telemetry or SCADA status and alarms. Usually teams are only alerted to an issue once a problem has become severe and a trip event occurs. There's a lack of visibility while the problem slowly builds. Due to this lack of awareness around how well the pumps are working day-to-day, many pumps are allowed to run while partially blocked. The size and scale of this issue has been one of the big unknowns in the industry to date. What impact does it have on cost and maintenance effort? How does it shape the risk of sewerage spillage?

Wastewater pumping in numbers

Labour Costs

Average **50 WWPS** per operator ≈ Equates to c. **650 staff** in **UK** and **Eire**.

80% of overtime is driven by pump blockages

50% of planned maintenance are simple WWPS inspections

15% of planned maintenance is vactor cleans

65% operator normal working hours spent on routine inspections Vs. **35% operator normal working hours** spent on reactive failures

Repairs and Maintenance

85% of maintenance team interventions are reactive ≈ **15%** of maintenance team interventions are preventative

30% 'Good' problem free stations

45% Occasional interventions

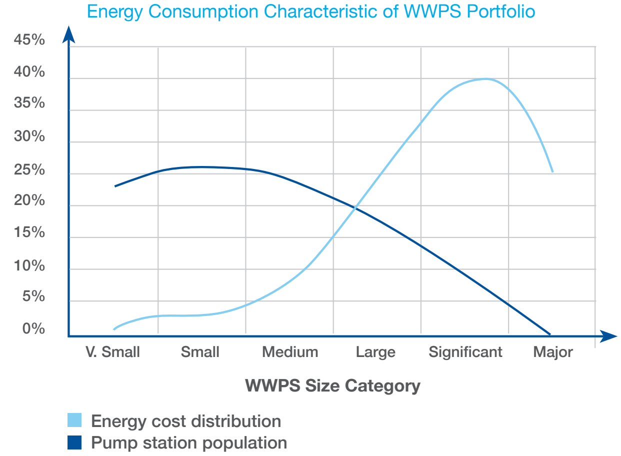
25% More frequent maintenance

50% of call outs are pump related Vs. **50%** of call outs are not pump related

Energy Costs

17% of a utility energy is wastewater pumping ≈ Equates to **£4,500 per WWPS** per annum in **UK** and **Eire**

Energy Consumption Characteristic of WWPS Portfolio



25% of largest pumps consume **87%** Energy

Data assimilated from over 4,000 WWPS in UK and Eire. The data outlined is an illustration of a large portfolio of WWPS. Note, there is significant variation between utilities and maintenance practices.

Wastewater pumping in numbers

Capital Maintenance

Average **£2K** per year per WWPS cost to refurbish, repair or replace ≈ Smaller pumps often cheaper to replace than repair or refurbish

24% Refurbish Asset

13% Repair Asset

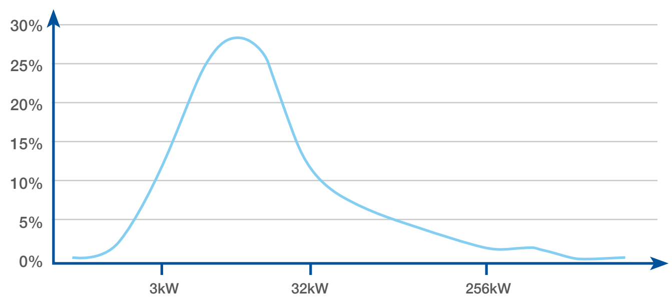
63% Replace Asset

Where reactive maintenance is prevalent compared to proactive ≈ **High number** of pumps in a poor state, leading to high replacement rates

Asset Depreciation

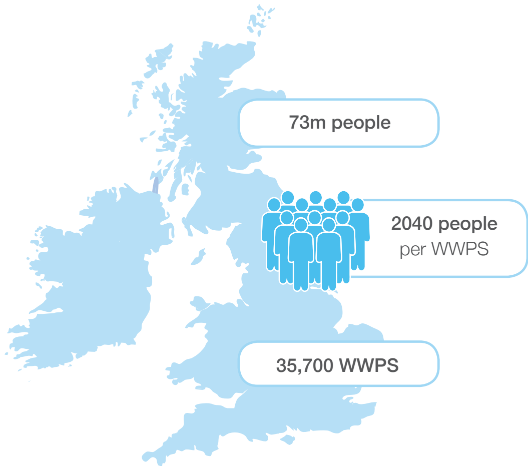
Average pump life **< 20** year design life ≈ Of the **25%** 'good' pumps, many suffer from hidden partial blockages

Population distribution by Pump Power Rating



85% Pumps in the 3KW to 32KW range

UK and Eire Asset Stock



80,000 blocked pump events per year

Estimated **£50m** to **£70m** per year to manage

Data assimilated from over 4,000 WWPS in UK and Eire. The data outlined is an illustration of a large portfolio of WWPS. Note, there is significant variation between utilities and maintenance practices.

Optimal running

The closer a pump runs to its Best Efficiency Point, the longer it lasts and the less maintenance it needs. Pumps that run close to their Best Efficiency Point see a smoother operation, marked reductions in vibration, noise and energy, and less risk of damage through cavitation, motor burn out, shaft or impeller failures, bearing failure, or mechanical seal failure. A clean running pump gives a good service life and maintenance can be optimised through sound asset management practice.

In contrast, a common issue most wastewater pumps face is they often deal with poor conditions as they are regularly impacted by debris which causes partial blockages, imbalanced running and resultant reduced pump performance – in other words, the pump transitions from a clean running state to a sub-optimal state as material entangles and interferes with clearances and components. Generally there's no way for the Operations team to be alerted or to know when sub-optimal running is occurring.

A pump running at or close to Best Efficiency Point experiences the following asset characteristics:

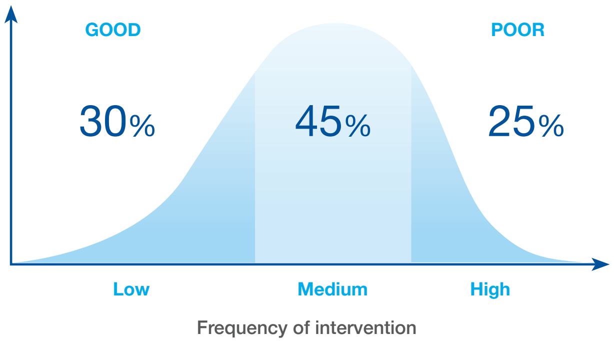
- Minimum vibration
- Minimum shaft radial deflection
- Minimum internal recirculation
- Smooth pump operation
- Reduced risk of cavitation damage
- Reduced noise
- Less bearing failure
- Less mechanical seal failure

The costs of running and maintaining pumping stations can be reduced by keeping all pumps working as close as possible to their Best Efficiency Point at all times. We've found through research with key water utilities that for many lift station operators, generally 30% of their portfolio runs without needing much attention from the Operations team. However, 45% require some occasional ongoing maintenance efforts to keep them running, while the remaining 25% encounter more issues and take up most of the Operations and Maintenance teams' attention, time, and effort.

To further understand how pumps are currently working and what more could be done to improve efficiency of all pumps, we investigated a mix of sites considered 'poor' and 'good'.

We found the sites that were considered 'good' were still running at far less than optimal efficiency. While these pumps still ran, they had problems caused by partial ragging. The issues weren't severe enough to trigger an alert to the Operations or Maintenance teams to fix, but they were still bad enough that they reduced pump performance, limiting pump outflow and pushing up pump run times and in consequence reducing the pump's overall life.

Failure characteristic of WWPS portfolio



The technology

The industry is currently exploring a couple of different options to find a solution to the issue of pumps blocking due to excessive ragging and eventual pump choking.

Some pump manufacturers are integrating variable frequency drives into pumps. These can help maintain an optimal running state by continually adjusting the operating parameters using proactive performance control. Potential barriers to this solution include:

- Pumps and control panels need to change or be modified to accommodate this new pump design, effectively requiring a station remodel, which can often be complicated and expensive.
- The remaining residual useful life of the existing conventional pump assets is lost, and potentially useful assets are discarded.
- The capital costs of these new types of pumps are much higher compared to conventional pumps, meaning that potential savings are longer to realise.

Another solution to proactive pump management technology is one that can be added to the existing conventional pump stock. This eliminates the need and cost of having to replace all pumps with completely new designs, although this does require the pump station controller to be changed and still incurs some complexity to implement. These solutions aim to keep the pumps in functional running condition by sensing when the pump is struggling to operate when experiencing the formation of a blockage and deploying a reversal to help dislodge the debris and clean the pumps. Products employing this technology commonly use high current monitoring to sense the buildup of blockage material through increased stressing of the motor, increasing current and power demand.

While this method can improve protection of the pump from choking, it doesn't prevent pumps from running when partially blocked. While this solution is an improvement in defending against clogging, it isn't suitable for ensuring pumps are kept running in an optimal condition closest to their Best Efficiency Point.

A more effective option that prevents sub-optimal running is real-time Dynamic Torque Waveform (DTW) analysis. This technology, whose benefits have not previously been widely recognised, is a highly sensitive way to detect even small deviations from a pump's optimal clean running state. Technology provider Clearwater Controls developed this technology originally to create their patented Deragger solution. It works to prevent the buildup of any debris in the pump through monitoring the variance in dynamic torque waveform using smart AI algorithms and triggers early cleaning of the pump at the onset of any debris related distortion.

The important differentiation from crude high current methods is that DTW:

- Prevents the development of sub-optimal running through early intervention
- Undertakes a carefully controlled pump reversal clean with the pumps in a clean state, as opposed to forcing a higher risk reversal on an already heavily choked pump as high current methods must deploy
- Can be deployed with almost any centrifugal pump, starter type or existing pump controller requiring minimal retrofit and negligible change to the existing station installation

To test the effectiveness of DTW technology Jacobs, in collaboration with a major European Water Utility have undertaken the first long-term (10 year) study into how this type of technology impacts the maintenance and asset life through preserving optimum operating conditions and how this can result in cost savings.

Case Study: Scottish Water

Scottish Water are leaders in innovation, making them a natural partner for us to work together on this innovative research. Pioneering the adoption of Clearwater Controls' Deragger since 2012, Scottish Water assimilated hard CMMS maintenance data for the continuous period 2009-2019. We collaborated to analyse this unique data set to establish the true cost impact of this technology.

This research is the first of its kind to use real world unbiased maintenance records, making it the largest and most extensive case study of pump station performance.

During this study, we compared the performance and maintenance histories of 40 lift stations before and after having the technology installed, amounting to 400 years worth of real-world maintenance data. We analysed long term maintenance characteristics prior to, and after technology deployment, across a representative sample of 'good' and 'bad' performing sites. This sample was chosen to reflect the makeup and characteristics of the 2,300 lift stations in the Scottish Water portfolio.

The findings show that pump-related maintenance fell significantly across all pumping stations; from the poor problem sites to the good low-maintenance sites. This is notable as it demonstrates that this type of solution can have a positive impact on all pumping stations, even the ones perceived to be performing better than average.

Across the 40 lift station sample, the average long-term cost per month to maintain the stations dropped by 15% at portfolio level. This saving was a combination of a reduction in callouts, reactive maintenance, repairs, parts replacements, and refurbishments.

By adopting DTW technology we clearly see a range of benefits to the operation and maintenance of the pumping station fleet and, based on the findings of the study, the technology can be assigned as an obvious contender for best practice in lift station asset management.

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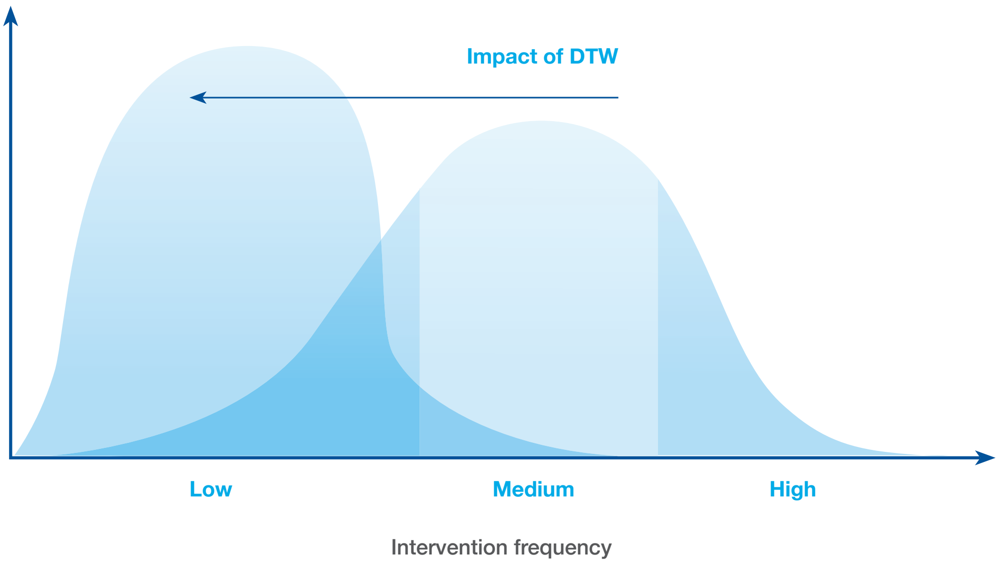
Change of failure characteristic of WWPS Portfolio

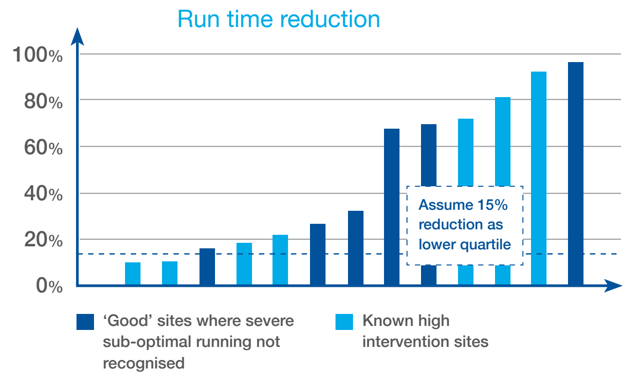


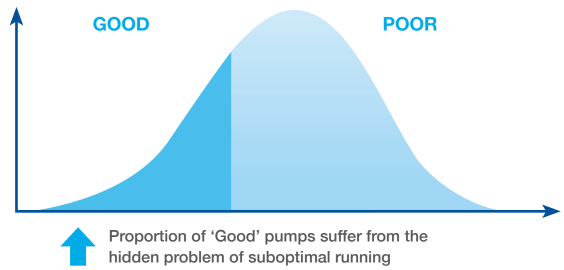
Proven benefits

Below we see where positive impacts are created through implementing DTW technology evidenced by the long-term data set. These include electrical and mechanical callouts, capital maintenance, electricity and energy consumption, and asset life. Our research found this technology has the ability to save 15% across the total cost of ownership of the pumping station asset stock. This saving is a combination of:

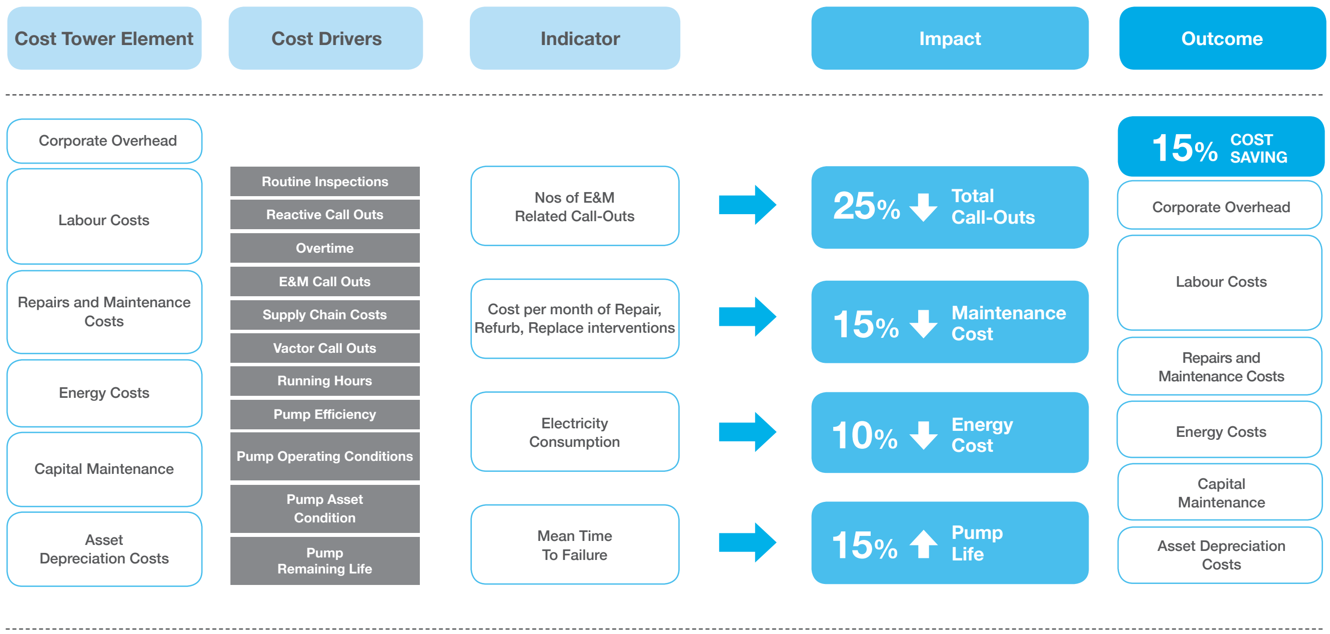
- 25% fewer mechanical and electrical callouts needed
- 10% reduction in energy consumption
- 15% lower pump run times (resulting in an increase in pump life)

Perhaps most surprising and important for the industry, is the finding that relates to the impact on pump stations seen by their operators as being 'good' stations – those stations that do not cause routine problems and as such are largely left alone on the assumption that all is well. Contrary to the assumed 'good' performance, the evidence suggests that many of these 'good' stations also suffer from continual and harmful impacts of partial blockages to the detriment of the performance and longevity of the pumps. Specifically, such stations run the risk of failing to deliver their design pump forward flow rates and hence are liable to greater risk of premature flooding than previously understood.





In summary, this study shows that applying DTW technology across the full portfolio offers both a reduction in total cost of ownership - typically paying for itself in less than two years – coupled with a remedy for the previously hidden blight of partially blocked and underperforming pumps. In this regard DTW technology can be viewed as a viable solution, or even a vaccine may be a better analogy, against the damage of sub-optimal pump operation.



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