THE INTERNET OF THINGS IS TRANSFORMING WASTEWATER COLLECTION SYSTEM MAINTENANCE

By **Jay Boyd**

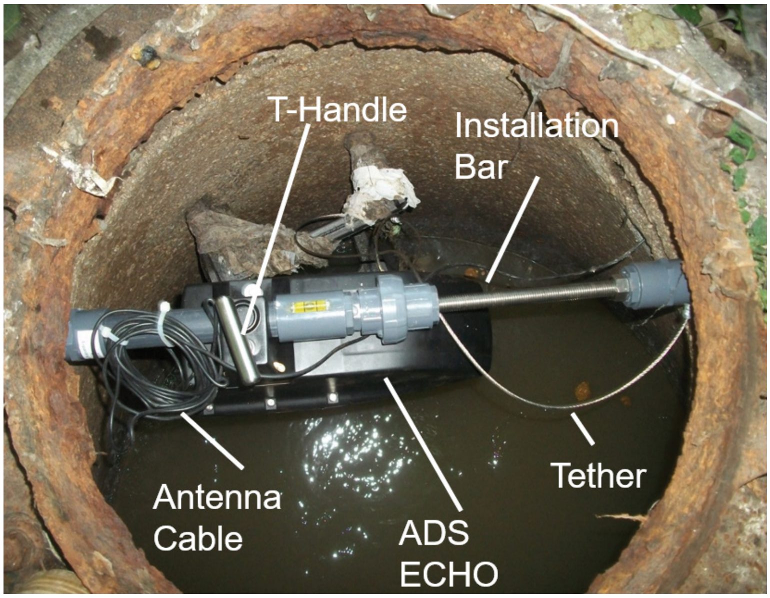
The capacity, management, operation and maintenance (CMOM) programs for collection systems have long established maintenance processes, including continuous, aggressive cleaning of the wastewater collection system.

Cleaning is considered preventative maintenance and is designed to keep sanitary sewers free of obstructions such as fats, oils and grease (FOG), roots, debris and sediment. All of these can reduce capacity and, worse, create blockages that cause sanitary sewer overflow (SSO)

It is quite common for utilities to have two concurrent approaches. The first is to clean the entire collection system on a regular cycle. Small collection systems may accomplish this annually, while large collection systems make take multiple years. The second element is to aggressively clean selected segments at high frequencies. Termed "high frequency segment cleaning" (HFSC), this approach is driven by a history of segments that have rapidly forming and/or excessive build up.

HFSC cleaning cycles can range from weekly to monthly to quarterly to semi-annually. Considered preventative maintenance, this aggressive approach is based on the historic build up behaviour of the segment where perhaps an overflow or series of overflows may have resulted. Cleaning is scheduled to "stay ahead" of that historic build up.

While the combination of system-wide and HFSC cleaning has demonstrated its effectiveness for reducing SSOs, it means ongoing costs. It is labour-intensive, requiring trained personnel to operate sophisticated equipment, such as combination trucks and specialized tools for the cleaning process. In addition, recurring costs, including insurance, equipment maintenance, consumables and more, form a significant portion of annual collection system maintenance budgets.



Typical installation of a remote site sensor system.

While annual budget planning accounts for these expenses, pressures from aging collection system infrastructure tend to increase costs all the more. Revenue increases are often difficult to realize due to rate payer resistance. As a result, maintenance operations are often forced to do more with little or no increase in resources.

BELOW THE SURFACE

Conventional cleaning processes do not use continuous real-time feedback. Maintenance crews are directed to HFSC sites based on a rote, schedule-driven routine. This process assumes a build up is an ongoing occurrence and therefore cleaning is required.

Sometimes, utilities will test their scheduled cleaning frequency assumptions and may do a video inspection, which gives real-time information. Effectively, it takes a snapshot of the segment's condition and enables the decision to clean, or not. While this approach is useful, additional personnel and equipment resources, e.g., CCTV, become impractical as an ongoing process.

In general, utilities must rely on historic information, not having access to real-time HFCS conditions. Veteran operators realize that there is a trade-off. They know that collection systems are dynamic. Build up may not occur with regularity, but instead in irregular patterns. Lacking ongoing knowledge of actual site conditions, scheduled cleaning can result in overcleaning.

Where utilities are short of staff, equipment and time, they must adjust their priorities such as scheduling, adding overtime, or delaying projects. These shifting priorities can contribute to organizational stress and increased expense.

The effects of overcleaning also create a progressive, unseen yet impactful effect on the collection system, with substantial financial implications. Cleaning with high pressure sprays can have a deleterious effect on pipes. Studies have shown that consistent and prolonged use of high-pressure sprays produces pipe wear, therefore shortening its lifespan.

In the case of high-risk pipes, already near the end of their useful life, high-pressure sprays may exacerbate this risk. The per kilometre capital cost for sewer pipe replacement is typically measured in millions of dollars. Thus, a reduction of asset life can have a severe impact on present and future capital budgets.

All in all, while aggressive high frequency cleaning has reduced the occurrence of SSOs, it has been achieved with reliance on scheduled overcleaning and the consequent impact on maintenance efficiency and asset wear.

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UTILITIES IN NEED OF TRANSFORMATIVE CHANGE

One very large utility which maintains more than 4,828 km of pipe, was challenged with retirement and the corresponding loss of highly experienced staff. This was coupled with increased maintenance demands from their aging infrastructure.

Replacing experienced staff proved to be difficult with increased competition from other utilities, as well as private industry. To offset this, the utility hired less experienced personnel, which created increased training demands, and lowered on-time performance for meeting the cleaning schedule. This in turn lowered the ability to recognize developing collection system issues. These circumstances resulted in a reversal of a seven-year decline in SSOs per 161 km of pipe. Over the next two years, the SSO rate doubled.

Another smaller utility maintains some 240 km of sanitary sewer and an additional 80 km of stormwater pipes. They had 100 HFSC sites. This unusually large number consumed more than 80% of all maintenance time. Budget constraints left them unable to expand staff. Even a single staff member's absence could be disruptive to their cleaning schedule.

Another utility was challenged with the demands of their schedule alone. Here, 100% of maintenance staff time was spent on HFSC sites, which meant no system-wide cleaning maintenance was being performed.

While these utilities' circumstances were different, there were commonalities:

- When crews arrived at an HFSC segment, they did not know actual segment conditions.
- The cleaning frequency for a given HFSC segment was predicated upon previous (historic) behaviours.
- Field observations regarding segment conditions subsequent to cleaning were largely subjective, unless video inspection followed; not possible in many cases.

IOT PROVIDES TRANSFORMATIVE RELIEF

To meet their challenges, these utilities sought out technology solutions, particularly with the Internet of things (IoT). Understanding that the core issue was that their maintenance staff was virtually blind to segment conditions, they saw the advantage of having remote site monitors utilizing inexpensive cellular communications and cloud-based software to provide ongoing real-time information. Moreover, they gained assurance that 24/7 on-site monitoring would also be a safeguard for preventing SSOs.

One supplier in particular offered software that had machine learning and the unique capability of identifying developing blockages predictively. It recognized distinct flow patterns and could distinguish a blockage from rain-induced level increases. This capability was accomplished through the software being "fed" more than a million days of human-reviewed and verified data.

The software made regular scans of all monitored sites and provided users with a dashboard summary prioritizing and grouping sites by high (red), medium (yellow) and no (green) urgency. Because the software was able to identify early developing patterns, utilities had days, and up to weeks, of time to plan and respond accordingly.

Although somewhat rare, should a fast-developing blockage occur between the regular predictive scans, the monitor was designed with five level alarms to detect flow level changes. Low flows were indicative of a potential upstream blockage while high flows indicated a potential downstream blockage.

The IoT technology provided utilities with ongoing visibility of remote sites and a new understanding of site behaviour. Based on its capability, utilities hypothesized that if they used continuous IoT technology and cleaned only as those conditions indicated, they would have an opportunity to reduce overcleaning. This effectively right-sizes cleaning frequency, while concurrently lowering SSO threats.

STUDY SET-UP, APPROACH AND RESULTS

Two of the three utilities cited performed pilot studies, while the third fully implemented IoT technology. They all first identified and targeted segments with the highest cleaning frequencies. These could yield the fastest return in terms of cleaning reductions. Additionally, consideration was given to segments where a SSO would have high impact, i.e., a waterway, and to locations that were hard to access.

Once the monitoring systems were installed, operators were familiarized with the software, including appropriate alarm (level) settings and how to use the predictive software. Each utility determined their individual process for responding to the predictive blockage notifications, as well as responses to alarms should a fast-developing condition occur. In all

continued overleaf…

TABLE 1

CLEANING LOG	JUL-18	AUG-18	SEP-18	OCT-18	NOV-18	DEC-18	TOTAL
SITE	CLEAN	CLEAN	CLEAN	CLEAN	CLEAN	CLEAN	CLEAN
1	No	No	No	No	11/26/2018	No	1
2	No	No	No	No	11/26/2018	No	1
3	No	No	9/17/2018	No	11/26/2018	No	2
4	No	No	No	No	11/26/2018	No	1
5	No	No	9/11/2018	No	11/26/2018	No	2
6	No	No	No	No	11/26/2018	No	1
7	No	No	No	No	11/26/2018	No	1
8	No	No	No	No	11/26/2018	No	1
9	No	No	No	No	11/26/2018	No	1
10	No	No	No	No	11/26/2018	No	1
CLEANED-YES	0	0	2	0	10	0	12
CLEANED-NO	10	10	8	10	0	10	48

TABLE 2

Cost-Savings Analysis	Segments	Months	Cleaning Instances	Cost/ Segment	Value
Schedule-Driven (Old Process)	10	6	60	$ 400	$ 24,000
Site Condition-Driven (New, Smart Process)	10	6	12	$ 400	$ 4,800
Reductions (Savings) - Total Ten Segments			48	$ 400	**$ 19,200**
Cost of Implementation* - Total Ten Segments					$ 8,360
Net Productivity Savings - Ten Segments					$ 10,840
Net Productivity Savings- per Segment					$ 1,084
*Equipment, communications, software, installation, training, ongoing field services, warranty					

instances, the utility would clean based on segment conditions.

The duration of one study involving 10 pilot locations was six months. Each of these sites had been on monthly cleaning schedules. With their schedule-driven process they would have cleaned 60 times. Yet, during the six-month pilot and using the data-driven process, they cleaned only 12 times, for an 80% reduction. Of the 10 segment locations, two were cleaned twice, while the other eight were cleaned once. This frequency reduction indicated that the utility had been overcleaning all locations. (See Table 1.)

During the pilot, they also avoided a potential SSO at one site, receiving and responding to an alarm for a fast-forming blockage. The prevention of an SSO is an out-of-pocket savings, since an overflow carries with it a fine of undetermined value, depending on severity.

Through a thorough examination, the utility determined that the cost per segment cleaned was $400. This accounted for factors such as amortized truck cost, insurance, maintenance, fuel, tools and consumables, and the cost of labour for a two-person crew. Since they had eliminated cleaning 48 times at $400 per segment, this was the equivalent of saving $19,400. When utilities are being challenged by budget limitations and hiring is not possible, this solution can fill labour gaps. (See Table 2.)

In the second utility's four-month study, they realized an even more significant saving. It involved a mix of both weekly and monthly segments. Eight segments were being cleaned weekly and 12 were being cleaned monthly. With the schedule-driven cleaning process, weekly segments would have had 152 cleanings and the monthly segment 42 cleanings. Together the total would be 194.

Following the site-condition, data-driven process, a total of 185 cleaning instances were eliminated for a 95.4% reduction. Additionally, two developing SSOs were detected and prevented. The productivity cost of 185 reductions at $400 per segment totaled $74,000. They cleaned nine segments, reducing their cost to just $3,600. This meant that maintenance resources were now available for other projects.

The third utility has fully implemented IoT at more than 50 sites, distributed among monthly and some quarterly segments. The data shows they reduced cleaning by 87% at those segments. Moreover, their cost per segment cleaned is $595, which is higher than the other two utilities. This reduction translated into a $155,890 productivity cost saving.

DISCUSSION AND CONCLUSIONS

More than 20 years ago, it was considered best practice to plan and implement a rigorous and regular collection system cleaning program. Utilities developed schedules for cleaning their entire collection system, as well as targeting selected segments for high frequency cleaning. Consequently, SSO rates dropped.

Yet, utilities began to realize that they were "cleaning clean pipes". With the advent of the IoT technology, maintenance departments now have tools that can predictively assess remote conditions and provide indications when to clean. Moreover, SSO mitigation is elevated as monitored segments have continuous protection.

Yet, while there is a steady adoption rate, many utilities still lag and rely on the two-decade-old-plus method of scheduled cleaning. Why? One major obstacle to adoption is complacency. Often the response to robust data supporting an IoT optimized process is, "what I am doing today works. So, why change?"

In these circumstances, utilities would be better served to recognize that the old schedule-driven approach is not sustainable. Trends with retirement are affecting field staff experience levels and with that, efficiencies and effectiveness. As infrastructure ages, pressures on maintenance will continue to grow. Additionally, resistance to adoption often is rooted in the focus on the expense without deference to the return. However, if utilities take the holistic view of return-on-investment, they discover that the return is significant and fast, typically in less than a year.

In spite of these obstacles, IoT adoption continues, driven by proactive vision or necessity. ■

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References available on request.