ICE PIGGING: A NEW APPROACH TO CLEANING PRESSURISED PIPELINES

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ABSTRACT

Ice Pigging is an innovative technique used for cleaning pressurised water and wastewater pipelines.

Ice pigging takes advantage of both the liquid and solid properties of an ice slurry. The ice acts as a liquid whilst being injected into the pipe, usually through an existing fitting such as a hydrant or air valve. Once the ice has been pumped in, the pipe is pressurized causing the ice to act as a solid pig. It is then pushed along the pipe with the cleaning power of a solid whilst still navigating bends, fittings and changes in diameter. It is these properties that allow Ice Pigging to be used, so successfully, in the cleaning of water mains and sewer rising mains.

This paper outlines both the Ice Pigging process and the many advantages to the technique. Further to this it will look in detail at several Ice Pigging projects undertaken by Suez that demonstrate these economic, operational and reduced customer impact benefits.

- Ice Pigging the entire potable water network in Blackwater, QLD, a town that experienced such severe discoloured water problems, prior to our cleaning project, Council was required to hold monthly meeting with its customers to ameliorate their concerns.

- Ice Pigging a sewer rising main in Nambucca, NSW. This rising main suffered from low flows and was so fragile it was believed that it could not be cleaned. Ice Pigging the line significantly increased flow and the pipe suffered no damage.

Ice Pigging has been in use, Australia wide, for over five years now. This gives us the advantage of being able to introduce a tried and tested product to the New Zealand market.

KEYWORDS

Ice Pigging: Pressurised Pipelines: Water Systems: Wastewater Systems: Operations:

PRESENTER PROFILE

Graeme is the Operations Manager for Ice Pigging in Australia and New Zealand. He is responsible for managing the ice pigging function within Suez.

He has 35 years' experience in the water industry and has worked for several different water utilities, including Sydney Water, Gosford City Council and Wingecarribee Shire Council

1 INTRODUCTION

Water and wastewater utilities are increasingly being asked to deliver a higher quality service to customers, whilst being faced with a shrinking budget. This is true for both operating and capital budgets. In water, staff members have the responsibility of delivering water to customers within a regulatory framework that demands strict adherence to quality standards. Systematic planned cleaning of the network will reduce callouts for water quality issues whilst giving a superior service to customers. In Waste Water, capital budgets are reduced by better maintaining existing assets; pumping stations and rising (pressurized) mains can have their lives significantly extended by unblocking sludge and debris, and increasing flow rates. To best meet these demands utilities are requires then to seek out new and innovative methods for maintaining and operating these systems.

So how can ice pigging help in this task. Ice pigging water mains is a system that will give cleaning result normally associated with Sponge Pigging without the need for costly excavation, installation of launchers and catchers and numerous customer disruptions. With wastewater lines, Ice Pigging can significantly improve flow rates by removing sludge, foreign objects and cleaning out sections that are known to become septic

To better understand the benefits of Ice Pigging for Water and Wastewater systems we first need to understand how the operations works.

Water: Ice Pigging is the process of inserting an ice slurry into the water main and once pressure is applied the slurry turns into a solid pig allowing for the main to then be cleaned. The ice pig progresses through the main as a solid plug, but its properties as a two-phase material allow it to flow around solid obstacles such as partially closed valve gates, bends, constrictions and even tubercles on cast iron mains. A further benefit of this two-phase characteristic is that the pig does not "bulldoze" the sediment in front of it; rather it lifts the sediment from the pipe walls and carries it in suspension between the ice particles,

Firstly, the section of main to be cleaned is isolated from mains pressure but kept full of water, the ice is then inserted at one end, whilst the displaced water is discharged from the other end. Once the insertion is complete, both insertion and discharge fittings are closed, and the upstream valve is fully opened, this compresses the ice to form a solid pig and provides the pressure which will propel the ice through the main. The discharge fitting is then opened to discharge the water allowing for the pig to move through the main. *see figure 1*.

At the discharge fitting, pressure; flow rate; conductivity; temperature and turbidity are monitored and recorded in real time. As the front of the pig nears the outlet, an increase in conductivity is seen, caused by the salt added to the ice during manufacture; this indicates that the arrival of the pig is imminent. Once discoloration of the effluent is observed the flow is diverted into waste tankers, ensuring all the sediment and salt within the main body of the pig is collected and disposed of safely.

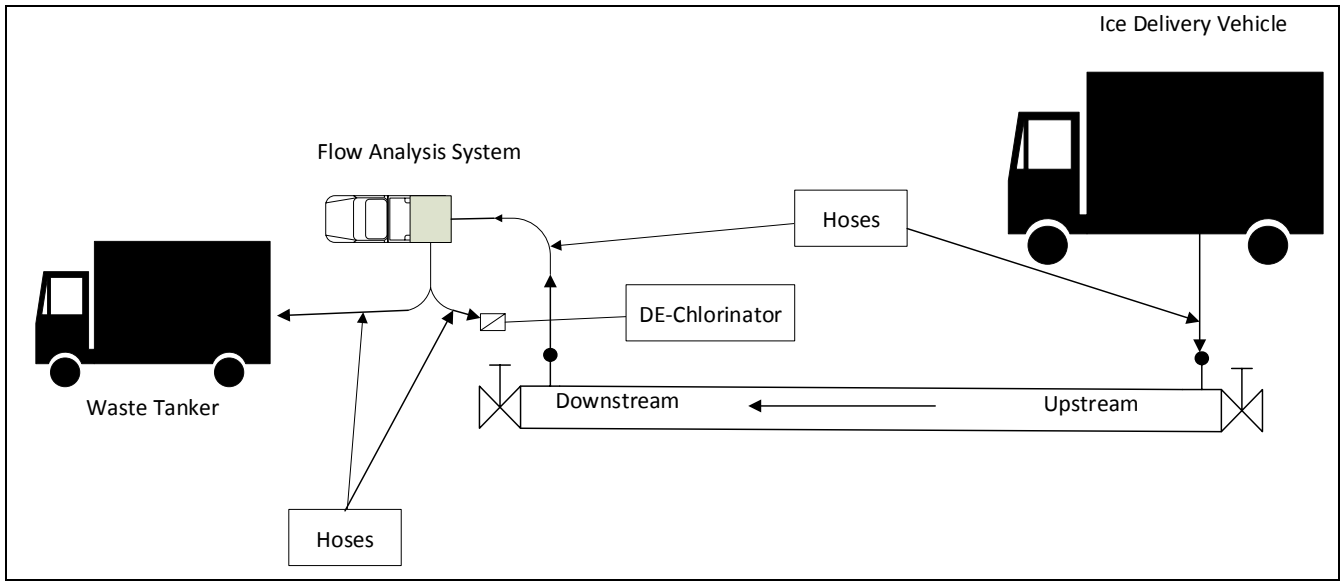


Figure 1: Ice Pigging Potable Water Reticulation System

As the ice pigging process relies on the physical force exerted from the ice crystals on the pipe walls, it uses lower flows (velocities) than other techniques, putting less stress on the assets whilst ensuring system is not stirred up upstream. It also provides the effectiveness of conventional foam pigging without the need for any excavation works saving on both preparation time and operation time. Typically, an operation takes less than 2 hours before the network is returned to normal service.

Ice Pigging uses far less water than other mains cleaning techniques, typically using only 1.5 pipe volumes of water. This accounts to approximately half the water used in flushing whilst give a far superior clean.

Wastewater: Wastewater rising mains are undertaken in a similar fashion. Ice is inserted via a surface fitting, reflux valve, air valve, scour line etc. Once the ice is inserted pressure is placed on the downstream end of the pig via the gravity head generated by the higher outlet point. Once the ice has had time to form into a solid pig it is then propelled through the main by use of the wet well pump, or if a greater flow/pressure is required water can be pumped into the system via the ice delivery pump. To monitor the progress of the ice pig we take temperature readings at the discharge manhole. Once the temperature begins to show a reduction, depending on the system involved, it can be collected using an educator or allowed to flow into the downstream gravity main, through to the treatment plant.

2 DISCUSSION

The two projects I intend to discuss within this paper are vastly different in their scope. One is the systematic water main cleaning of an entire town for Central Highlands Regional Council (QLD). The other is cleaning a single sewer rising main for Nambucca Shire Council (NSW). However despite the differences, both jobs show that the use of the ice pigging technology can have a long-lasting benefit to system operation and customer satisfaction.

For potable water jobs we measure the effectiveness of the ice pigging operations; turbidity readings were taken before and after the operation as well as sediment samples collected and analysed for total suspended solids (TSS). These samples were then compared with the flow rate to give an estimate on how much sediment was removed in the process.

Effectiveness of work involving wastewater is measured by a number of tests; flow rate before and after, odour complains before and after and how soon, or if, the issue returns.

2.1 CENTRAL HIGHLANDS REGIONAL COUNCIL, BLACKWATER, QLD

Central Highlands Regional Council services some 30,000 residents with the largest town being Emerald. It is located approximately 500km inland in far north Queensland. Just prior to our arrival a new water treatment plant had been brought online. Largely this was to feed the towns of Blackwater and Bluff. Blackwater had been experiencing a large number of customer complaints regarding discoloured water. This was caused by a build up of sediment throughout the system, the result of unfiltered water being fed into Blackwater prior to the treatment plant being constructed. This issue was of such concern to residents as to warrant a monthly town meeting to discuss status and possible solutions. To mitigate these issues Ice Pigging was approached to access our ability to permanently resolve the situation. Our recommendation was a top down clean program covering all the affected area.

2.1.1 TARGETED ANALYSIS OF OUTCOMES, WATER.

Ice Pigging was used to clean the entire Blackwater reticulation system, of which approximately 70% was asbestos cement (AC) lines. To better show the outcomes we achieved, the following will look at a single ice Pigging run.

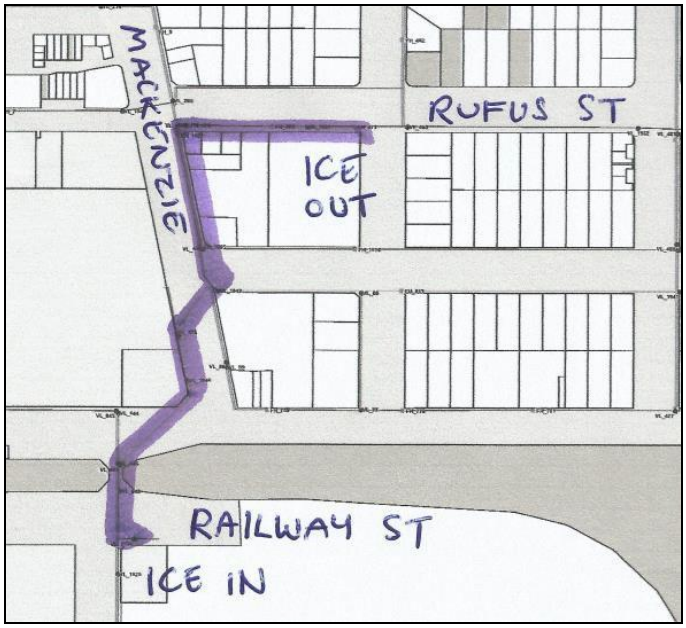


Figure 2: Operation (approx. 500m of 375-250mm)

The pipeline is isolated and readied for cleaning. Ice is injected into a Hydrant, once the correct amount of ice has been inserted the upstream valve is opened to repressurise the line to form the pig. The downstream valve located on the flow analysis system is opened and the pig moves through the line, *see figure 1.* At the outlet we measure pressure, temperature, turbidity, and conductivity, salt in the ice.

Once we see the conductivity rising we know the pig is almost arrived. It is at this stage we take timed sample for latter analysis.

Photograph 1: Samples taken for Operation 1.

As can be seen by the samples above, removal of sediment for this run was substantial. However, this was not an isolated main and the sample are on average consistent with what we found across the system. The samples are then dried out and weighed to give an average amount of sediment per kilometer, allowing the client to get a holistic picture of the condition of the network. As part of the final report we supply the customer with the following type of information*, refer table 1.*

Sample #	*Time (s)*	*Flow Rate (l/s)*	*Temp (° C)*	*Sample Mass (g)*	*Sediment Mass (g)*	*Sediment Conc. (g/l)*
1	14:23:00	13.2	19.6	323	0.3	0.93
2	14:24:00	13.1	17.4	326	0.3	0.92
3	14:25:00	13.1	13.4	337	0.3	0.89
4	14:26:00	13.3	8.8	350	0.4	1.14
5	14:27:00	13.2	5.6	320	0.5	1.56
6	14:28:00	13.3	3.5	339	0.9	2.65
7	14:29:00	13.3	2.2	308	2.7	8.77
8	14:30:00	13.4	-2	342	1.7	4.97
9	14:31:00	13.4	-2.8	376	2.4	6.38
10	14:32:00	13.4	-3.5	332	1.3	3.92
11	14:33:00	13.5	-3.4	326	1.2	3.68
12	14:34:00	13.5	-3.4	326	1	3.07
13	14:35:00	13.3	-3.3	326	0.7	2.15
14	14:36:00	13.5	-2.4	326	0.2	0.61
15	14:37:00	13.5	4.4	337	0.01	0.03
Sediment Removed (kg):			**33.39**	**Sediment Removed per km (kg):**		**66.78**

Table 1: Sample analysis showing sediment removal

As can be seen by the table above ice pigging works; the vast majority of the sediment is removed in the ice itself, when the temperature is below zero degrees. It removes built up sediment from water mains restoring the system to an "as new" quality. As part of our service we stay in contact our clients the work at Blackwater was undertaken in 2015 and to this day we are still getting positive feedback, with discoloured water complaints a thing of the past.

2.2 NAMBUCCA SHIRE COUNCIL, MACKSVILLE

Nambucca Shire Council services some 22,000 residents and is located on the north coast of New South Wales. The council is responsible for the maintenance and operation of the water and sewer system. Ice pigging was approached to undertake the cleaning of a sewer rising main in Macksville one of the towns with Nambucca Shire's area of operation. The sewer rising main had two major issues an extreme buildup of grit and sludge, and a fragile UPVC pipeline.

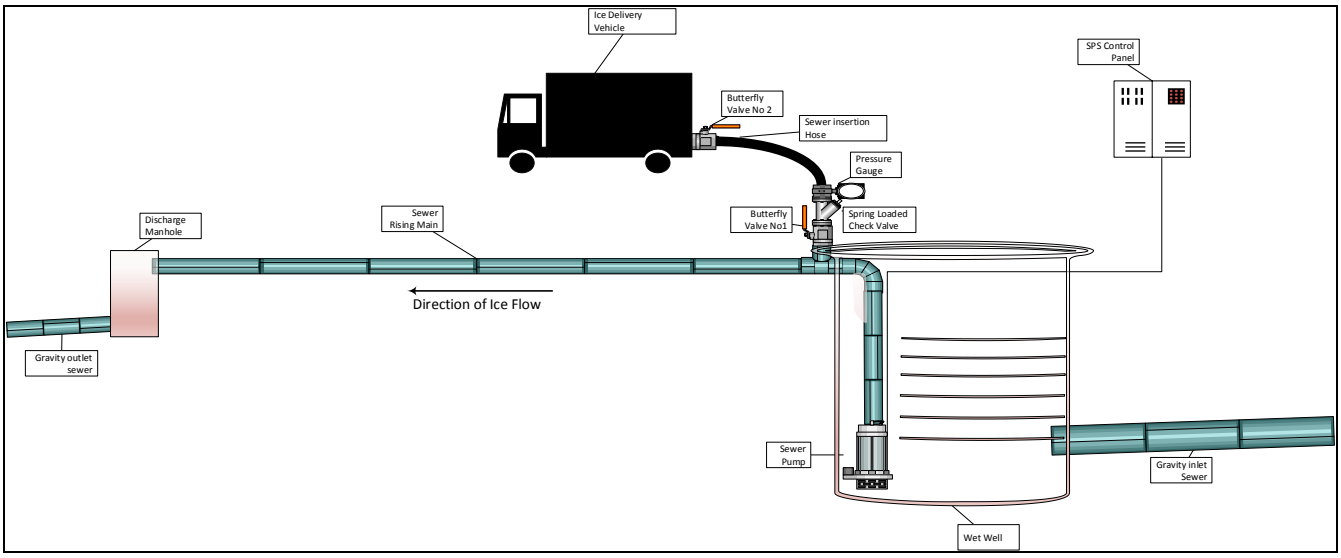
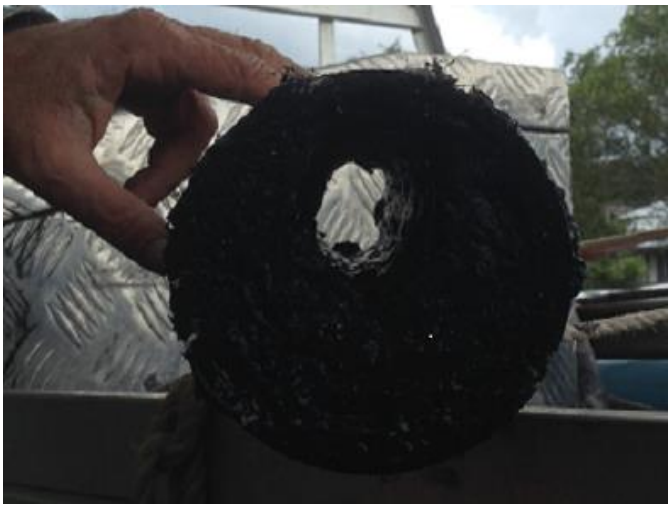


Figure 3: Ice Pigging Sewer Rising Mains

2.2.1 TARGETED ANALYSIS OF OUTCOMES, WASTEWATER.

The sewer rising main in Macksville had been an issue for Nambucca Shire Council for some years due to the low flows within the rising main is had suffered from a buildup of material, this resulted in restricted flow from the pump station. The other issue they suffered from was the rising main was in poor condition. The usual methods employed to clean this main would have likely resulted in a break. Given how near the main was to several public waterways this was an untenable situation. They had already repaired a number of breaks and due to their speed in undertaking these repairs no environmental damage had been sustained.

Photograph 2: Red and white, denotes Sewer Rising Main.



Photograph 3: Section of rising main prior to cleaning

As you can see from photograph 3 the pipeline suffered from considerable blockage. The low flows caused by this only exacerbated the situation. We arrived on site and setup to inject the slush ice. As can be seen in photograph 2 there was a section of rising main that crossed Tilly Willy Creek, this was also of concern as the connection points either side of the bridge were made from older galvanized iron fitting. These were heavily corroded, and we decided to have a person station at the creek crossing in case of an incident. Nambucca Shire Council had put a crew on standby in case of a break.

A pressure gauge monitors our inlet pressure to make sure we didn't increase the head pressure inside the pipeline. Once we had injected all the ice we isolated butterfly valve 1, *see figure 3*. We then turned the wet well pump on and the ice began to move through the line. We monitored the outlet point and waited for the ice to arrive. When dealing with Waste Water we use a temperature probe to indicate when the pig is about to arrive. At this time, we can then use an educator to suck the ice and sludge from the discharge manhole.

Photograph 4: Ice and sludge arriving at the discharge manhole.

The ice continues to flow through the discharge manhole until is comes clean this shows that the rising main has been cleaned.

Photograph 4: Clean ice at the discharge manhole.

Perhaps the most telling point, is the increase in flow that was achieved. Prior to Ice Pigging the rising main had an average flow rate of **3.5L/s** post clean they achieved a **9L/s** flow rate almost 300% increase. Finally, this work was carried out in 2015 and we have had recent feedback that the line is still running well.

3 CONCLUSIONS

The two projects that I have outlined above clearly show that ice pigging, as a technology, works far better than other comparable methods. The following points also standout as benefits that cannot be overlooked when choosing a cleaning method.

1. Unlike sponge pigging, ice pigging requires no excavation and only requires one shutdown for each pipeline to perform the work.

2. Ice pigging is adaptable to the need of the client and can be used in any pressurised pipeline.

3. The two-phase property of an ice slurry allows single run cleaning of different size pipelines. *See Figure 2.*

4. Ice pigging offers a long-term solution to system issues, both examples above have not experienced a reoccurrence of the issues for 3 years.

5. Ice pigging can be used on fragile systems, we are able to tailor our pressures and flow to meet lines that would be uncleanable otherwise.

6. Ice pigging can be used on all types of pipe material including asbestos cement, AC, we have tested the ice from a number of AC cleans. This has conclusively show that cleaning using ice pigging does not remove any of the AC fibres.

7. The increase in flow from ice pigging sewer rising mains can extend the life of the wet well pumps, thus saving on capital expenditure.

8. Ice pigging uses significantly less water than other mains cleaning techniques.

Overall ice pigging can tailor a solution to numerous systemic issues currently plaguing the industry.

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