International Public Works Conference

25 - 29 August 2019

Stormwater pipe condition assessments - if only animals could talk

C Campbell[1]

[1] *Moreton Bay Regional Council, Strathpine, QLD*

ABSTRACT: *Moreton Bay Regional Council (Council) has nearly 250,000 stormwater assets valued at around 2.0 billion dollars. The large majority of these assets are buried underground and form part of a network, making them very difficult to inspect. To combat this, Council utilises CCTV technology to inspect their buried stormwater assets.*

Council invested in their own van and camera unit to conduct inspections of stormwater pipes in 2015 and added a second in 2017. The data from these inspections was used to support the creation of a five million dollar per annum renewal program, as well as informing the ongoing maintenance program.

Council has come across some interesting issues over the years, including:

- *A pipe with CCTV before and after a service had been built through it*
- *Two adjacent networks whose inverts had been corroded away*
- *A collapsed network that could not be located even with CCTV, ground penetrating radar, potholing, and excavation*
- *A damaged pipe suspiciously located under a recent road rehabilitation*
- *Twin box culverts in private property severely blocked by tree roots with no access for 50 metres either side*

Council has also learnt some invaluable lessons since acquiring the vans, including:

- *The importance of accurate asset records*
- *The difficulty with training and retaining CCTV operators*
- *Ideas for improved inspection techniques and improving the quality of the data*
- *The common cause of failures in newer pipe networks*
- *The value of coordinating with other projects and organisations*
- *The need to budget for future issues not just known issues*

This paper will describe the history of Council's CCTV inspection, renewal, and maintenance programs, provide a number of examples of interesting projects Council has come across over the years, compare some of the alternative pipe inspection technologies, and discuss some of the lessons learnt; including that stormwater pipes are a favourite hideout for a myriad of animals.

KEYWORDS: stormwater, drainage, pipe network, CCTV, inspection, condition assessment, asset management

1 Introduction

Moreton Bay Regional Council (MBRC) is a local government area in southeast Queensland, situated between Brisbane and the Sunshine Coast. MBRC covers 2,000 square kilometres and is home to 460,000 residents, making it one of the largest local governments in Australia (MBRC 2019). The population is expected to increase to 645,000 by 2036, also making it one of the fastest developing regions in Australia [1].

Council's budget for the 2019/20 financial year is $655 million; of this $227 million is spent on the capital works program [2].

Council has nearly 250,000 stormwater assets which includes stormwater pipes, channels, and pits, as well as water quality assets such as basins and gross pollutant traps, and flood mitigation assets such as weirs, spillways, and levees. Nearly half of Council's stormwater assets are pipes. With a total length of over 2,400 kilometres, Council's stormwater pipe network is longer than the distance between Brisbane and Hobart.

2 Inspection, Renewal and Maintenance Programs

Council has been using CCTV technology to proactively inspect our stormwater network for over 10 years. Up until 2014, Council engaged external contractors to complete large sections of our network. Since 2015, we have used our own internal staff and equipment.

In 2014, the historic CCTV data was turned into a number of renewal projects totalling $1M for delivery in 2015/16. This project was turned into a program which has been increasing by $250k each year.

Inspection Program

There were a couple of positives when it came to using contractors to complete our inspections, including not having to manage the CCTV staff or equipment. However, there were also some negatives, including difficulties in supplying them the data they needed, inconsistencies between the different contractors, and problems post-processing the data because of the other two issues.

Each of Council's CCTV vans has a crew leader and a labourer, and (in theory) a backup operator. In addition to the CCTV crew, there are Asset Management (one full-time position) and Drainage (one full-time position) resources that are required to keep the inspection program going.

There are three main sources of training for the CCTV crew:

- 1 day of training with the camera and 1 day of training with the WinCan software provided by the supplier
- 5-day training for operators called Inspect Conduit & Report on Condition & Features
- 1 to 2-hour information sessions on the context for the CCTV inspections and how to score defects to suit Practice Note 5

There are a number of sources of CCTV requests, including:

- Customer Requests e.g. a resident complaining of a blocked pipe
- Internal Requests e.g. a staff member noticing a pothole above a pipe
- Catchment Inspections e.g. our long-term goal to inspect the entire network
- Capital Projects e.g. pipes under an upcoming road rehabilitation
- As Constructed Inspections e.g. handover condition of new pipes

The most important aspects of the inspection data are:

- Ensuring the stormwater network in the asset register is as correct as possible prior to the inspection.
- Supplying the crew with ArcReader maps and a button that automatically populates the relevant attributes in WinCan
- Ensuring it is easy to process (via the above two items) and available to everyone within Council.

The highest number of pipes were inspected in 2018, which was the first year both vans were fully operational. This equated to 3.4% of the network and means it would take 29 years to inspect Council's entire stormwater network.

The utilisation for the second half of 2018 (with both vans operational) was 60%, while the utilisation for the first half of 2019 (with only one van operational) was 38%.

The outputs of the inspection program are defects, pictures and videos that are uploaded to the asset register. The Drainage team then review the high priority structural defects, and the Operations team review the high priority service defects.

As at June 2019, Council had just over 50,000 defects across just under 9,500 assets in our asset register.

Renewal Program

The renewal projects are prioritised by pipe condition and criticality. The condition is calculated based on the number and severity of the structural defects, and the length of the pipe, while the criticality is based on the size and location of the pipe.

Council deliver 15 to 25 renewal projects each year in addition to the 15 to 20 other projects that absorb stormwater renewal works (for example, road rehabilitations or intersection upgrades that have pipes underneath them that are in poor condition).

The three main techniques we use for renewing our pipes are

- Patching where there is a point defect in a long length of pipe or in a location where it is difficult or expensive to trench

- Relining where there are multiple defects, other than displacements, along a length pipe where it would otherwise not be cost-effective to replace
- Replacement where there are multiple defects and where we do not consider relining appropriate

In 2018 Council started working with Unitywater on a protocol for resolving conflicts between MBRC stormwater pipes and Unitywater sewer and water mains. MBRC and Unitywater have resolved three conflicts so far. We hope to implement similar protocols for addressing conflicts with other service providers such as NBN, Optus, Telstra, etc.

Maintenance Program

The cleaning projects are prioritised by the number and severity of the service defects.

Council have a jetrodding trailer for cleaning pipes smaller than 375mm, and a jetrodding truck for cleaning all pipe sizes.

Future Direction

There are a number of things Council are investigating to try to make our stormwater pipe condition assessments quicker, more efficient, and more cost effective, including:

- Determining how to inspect permanently submerged pipes
- Prioritising the stormwater networks we inspect by pipe criticality
- Using alternative technologies to complete a first-pass inspection to identify major blockages or structural defects to prioritise detailed inspections
- Incorporating Artificial Intelligence and Machine Learning into inspections and reviews.

3 Case Studies

In the 10 years that Council has been getting regular CCTV inspections, and particularly in the last 5 years with our own CCTV crews, we have come across some interesting issues.

In Clontarf, we found a pipe that had a service built through it very recently. We were able to determine which service it was with CCTV, aerial imagery and Streetview, and have been in contact with them regarding the relocation of their asset and the replacement of ours.

In Elimbah, we found two adjacent networks whose inverts had been corroded away. Even after a thorough investigation, we were not able to find the cause of the failure, so had to replace all the pipes.

In Redcliffe, we found a collapsed pipe in a network, but could not locate the rest of that network even with CCTV, ground penetrating radar, potholing, and excavation. We decided to block off the upstream end of the network and address the collapse when it presented itself on the surface.

In Murrumba Downs, we found a damaged pipe suspiciously located under a recent road rehabilitation. Despite claiming the rehab had nothing to do with it, the contractor eventually had to pay for the repair after we found a subsoil drain near the broken stormwater pipe.

In Albany Creek, we found twin box culverts in private property severely blocked by tree roots with no access for 50 metres either side. We found the likely culprit (a fig tree) and decided to install a manhole over each box culvert to facilitate access to manually remove the roots.

Clontarf Service Conflict Investigation

Summary: A pipe with CCTV before and after a service had been built through it.

Background: In 2010 Council completed a routine inspection of the 300mm stormwater pipe and identified a break at one of the pipe joints. Sometime between late-2011 and mid-2012, Unitywater constructed a vent pole to the south of the pipe to connect to their existing sewer manhole to the north of the pipe. In 2017 Council reinspected the 300mm pipe in preparation for relining and discovered a service had been built through it.

Figure 1: Map showing the stormwater and sewer networks (pipe of interest shown in red and intruding service shown in yellow)

Issue: As the service was constructed through the pipe; slightly obstructing the pipe and pushing concrete and reinforcement into the pipe, relining was no longer a viable solution.

Outcome: Council are still working with Unitywater to get the service relocated and the stormwater pipe replaced.

Figure 2: CCTV photo of intruding service

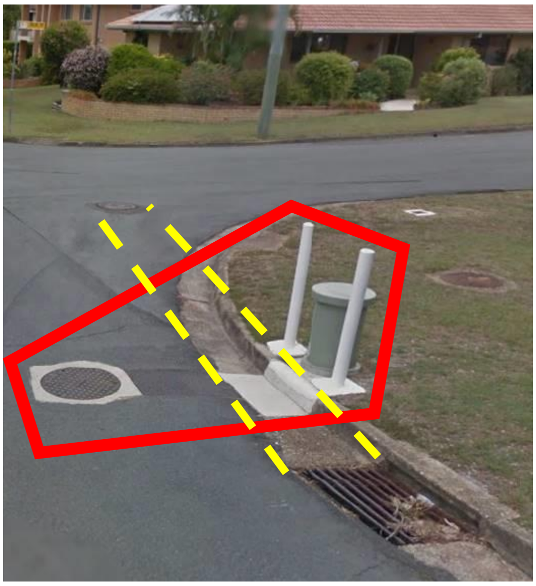

Figure 3: Streetview photo of intruding service

Elimbah Stormwater Network Renewal

Summary: Two adjacent networks whose inverts had been corroded away.

Background: The stormwater network was constructed in 1997. In 2012 Operations inspected and replaced a collapsed pipe in Leray Road. In early 2017 Operations patched a large pothole (located over the stormwater network) at the corner of Mifawny Road and Leray Road. In late 2017 Operations were called out to address a sinkhole (located behind a catchpit) in Mifawny Road. Operations requested CCTV of the affected pipe and pit. When the CCTV came back showing the invert of the pipe had disappeared and the top of the catchpit had collapsed, Drainage requested CCTV of the entire network in the area.

Figure 4: Map showing the stormwater pipe network (damaged network shown in red)

Issue: The 500 metres of FRC pipe ranging in size from 300mm to 750mm in diameter was in very poor condition due to invert corrosion, circumferential and longitudinal cracking and fracturing, and complex cracking and fracturing. The rural residential area had no evidence of anything that would cause failures of this nature, and Council did not want to risk replacing the network and having it fail within 20 years. Council engaged GHD to conduct a number of tests to determine the failure mechanism and recommend a replacement pipe material. GHD's investigation determined that acid attack from the inside of the pipe was the most likely cause of the deterioration, however were not able to determine the cause of the acid attack.

Outcome: In 2019 Council replaced all the affected FRC pipes with HDPE pipes and brought in imported backfill material.

Figure 5: CCTV photo of damaged network

Figure 6: Site photos above the damaged network

Redcliffe Stormwater Network Investigation

Summary: A collapsed pipe in a network that could not be located even with CCTV, ground penetrating radar, potholing, and excavation.

Background: In 2017 Council completed a routine inspection of a stormwater pipe in Marine Parade and Anzac Avenue and found it had collapsed. This pipe was not on Council's asset register and had no as-constructed plans. Council wanted to determine the location and condition of the rest of the pipe and network before replacing the section of damaged pipe, however encountered some barriers.

Figure 7: Map showing the stormwater pipe network (investigation area shown in red, unknown network shown in hatching, and collapsed pipe shown in yellow)

Issue: After all the investigation Council could reasonably do, the condition of the remaining 90% of the 450mm pipe was unknown. Another element that complicated any renewal was that the Department of Transport and Main Roads own Anzac Avenue, so any excavation within their road reserve would require a permit, a traffic management plan and significant traffic control.

Outcome: Council decided to abandon the 450mm pipe at the upstream manhole. This leaves the unknown network in place for any pipes connecting into it, however does not address the major defect. If the area above this defect does eventually collapse, Council will repair the defect and inspect the rest of the network.

Figure 8: CCTV photos of collapsed pipe

Figure 9: Site photo of excavation to try and locate the network

Murrumba Downs Stormwater Pipe Renewal

Summary: A damaged pipe suspiciously located under a recent road rehabilitation.

Background: In early 2016, Council completed a routine inspection of the upstream 2m of the pipe. This CCTV only covered a short length of pipe but suggested the rest of the pipe was in reasonable condition with no obstructions. In early 2017, a road rehabilitation of McClintock Road was finished. This included construction of kerb and channel near the pipe of interest. In mid-2017, Council completed a post-construction inspection of the downstream 5m of pipe. This CCTV showed a large break and void located roughly where the kerb and channel crossed the pipe.

Figure 10: Map showing stormwater network and other services (pipe of interest shown in red and large break shown in yellow)

Issue: The original CCTV did not inspect the damaged section of pipe, however it did show that the pipe appeared to be intact. The new CCTV, when reviewed very closely, showed a subsoil pipe above the broken and displaced concrete and void. A review of the as-constructed plans showed no assets were constructed near the major defect, except for the kerb and channel. Council would normally replace a section of pipe with this type of defect, however did not want to damage brand new pavement or kerb and channel.

Outcome: In 2017 Council engaged Pipe Management Australia to cut back the concrete intruding into the pipe, patch the hole in the pipe, and address the void above the pipe by core-drilling a 100mm hole through the pavement and filling the void with flowable fill.

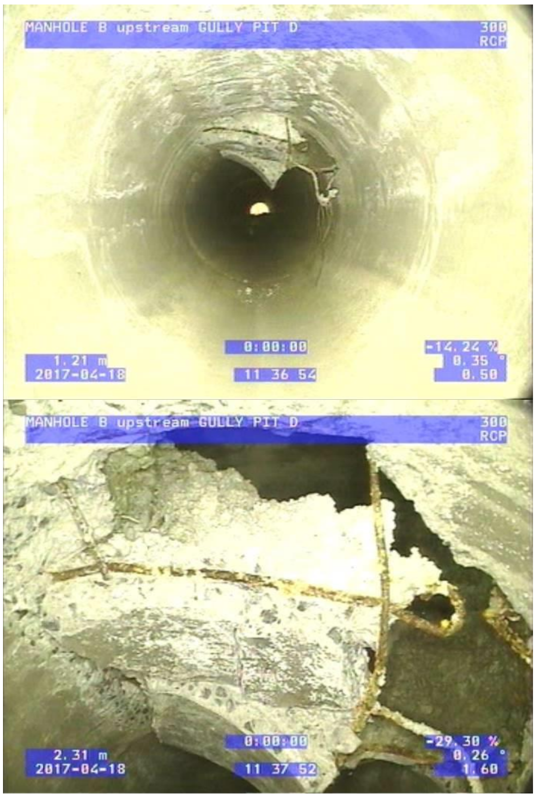

Figure 11: CCTV photos of broken pipe

Figure 12: Site photos of void above break

Albany Creek Root Blockage Investigation

Summary: Twin box culverts in private property severely blocked by tree roots with no access for 50 metres either side.

Background: In 2017 Council completed a routine inspection of the 1800x900mm twin box culverts running through an easement on private property on Albany Creek Road. These large box culverts were severely blocked with tree roots. A site inspection identified a large fig tree in an island in the carpark as the likely culprit.

Figure 13: Map showing the stormwater network (pipes of interest shown in red and root blockage shown in yellow)

Issue: The access points for the culverts were 45m upstream and 100m downstream from the blockage. This posed an issue when it came to confined space, particularly as the culverts, at 900mm high, were not a comfortable height to walk through. Council decided it would be safer, cheaper, and better in the long run to install a manhole where the blockages were. This would allow the blockages to be removed more quickly, safely, and cheaply, and would provide an access point in future. The property owner was supportive of Council removing the tree to install the manholes and unblock the culverts, with the understanding that the tree would not be reinstated in the easement.

Outcome: Council is still in the process of scheduling these works.

Figure 14: CCTV photo of root blockage

Figure 15: Site photos of fig tree and roots

4 Animals in CCTV

Figure 16: "Strange Animals"

Figure 17: Possum 1

Figure 18: Possum 2

Figure 19: Cat

Figure 20: Same Cat

Figure 21: Crab

Figure 22: Lizard

5 Alternative Technologies

There are a number of alternative technologies out there for inspecting stormwater pipes, and they all have their pros and cons. Each of the technologies below includes a qualitative rating for the cost, speed and quality of the data for each technology.

Handheld Camera

Description: Camera on pole that is held at pipe entrance and can take a video or picture of the pipe.

Cost: Low. **Speed**: High. **Data Quality**: Low.

Figure 23: SECA QuickView airHD

Push Camera

Description: Camera on a cable that is fed into pipe and provides video which can be turned into defects and images by an operator.

Cost: Med. **Speed**: Med. **Data Quality**: Low.

Figure 24: SECA SoloPro Plus

Drive Camera

Description: Camera on wheels that is driven into pipe and provides video which can be turned into defects and images by an operator.

Cost: High. **Speed:** Low. **Data Quality:** High.

Figure 25: SECA iPEK Rovion

Underwater Camera

Description: Underwater camera that swims into pipe and provides video which can be turned into defects and images by an operator.

Cost: Med. **Speed**: Low. **Data Quality**: Med.

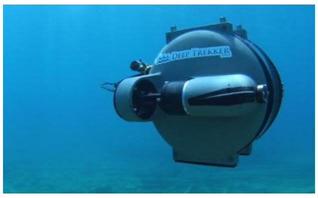

Figure 26: Deep Trekker ROV

Sound Waves

Description: Set up is held at pipe entrance and sends and receives sound waves that correlate to issues providing overall pipe condition.

Cost: Med. **Speed:** High. **Data Quality:** Low.

Figure 27: UVS Trenchless Technology SewerBatt

Electric Signals

Description: Set up on a cable that is fed into pipe that sends and receives electric signals that correlate to issues.

Cost: Low. **Speed:** Med. **Data Quality:** Low.

Figure 28: SECA Sewer Serpent

3D Laser Scanner

Description: Set up is lowered into structure (manhole, catchpit, etc.) and provides image and point cloud data.

Cost: Med. **Speed:** High. **Data Quality:** Med.

Figure 29: SECA CleverScan

6 Conclusions and Recommendations

Council have learnt some invaluable lessons since acquiring our own CCTV vans, leading to the following recommendations.

Asset Register

Ensure the asset register is as correct as possible. This not only makes the inspection easier, it makes the post-processing and future review of the CCTV easier.

Staff Training and Retention

CCTV operators are skilled positions and should be remunerated accordingly.

If experienced CCTV operators are available, let new staff work with them for 1 to 3 months to get experience with WinCan before completing the 5-day certification training.

In addition to the CCTV crew itself, there is a relative workload in preparing the data, processing the data, and reviewing and utilising the data. For two vans, we have two full-time positions in Asset Management and Drainage.

There is substantial value in having backup operators for the CCTV crew, however these staff must work with the crew regularly (a minimum of once per fortnight) to keep their skills up.

The operators should alternate (at least every other day) so they complete the computer side of the inspection (driving the camera, capturing the defects, etc.) as well as the labour side of the inspection (unloading and loading the camera, operating the reel, etc.).

Inspection Techniques and Equipment

Based on my experience at Council, I recommend the following inspection regime:

- Use a handheld camera to inspect the entire network with the aim of quickly identifying high priority service and structural defects. This camera can be easily incorporate into an existing crew.
- Use a push camera for small pipes or customer requests. Again, this camera can be easily incorporate into an existing crew.
- Use a drive camera for thorough inspections of high criticality assets or those with high priority structural defects. This is a good item to have completed by external contractors.

An internal CCTV crew comes with responsibility for damage to equipment, the resulting maintenance costs, as well as the associated down time.

Quality and Volume of Data

Create a WinCan template for external contractors to make post-processing easier.

For the CCTV crew during inspections, inspect upstream and downstream structures and inspect the pipe from both ends if unable to inspect the full length from one end. It is time consuming and unnecessary to inspect every joint (as per WSAA code). The crew should only inspect joints where a defect is identified.

Consider the benefit of manually rescoring defects to suit stormwater based on Practice Note 5. This process is time consuming for the CCTV crew and the scores differ between operators. It may be quicker and easier to use the automatic scoring from WinCan and rescore the affected defect types (e.g. those relating to exposed reinforcement, with or without spalling and corrosion) types following the inspections.

For CCTV completed by external contractors (for developments or capital projects), review every 1 in 10 inspections and compare to the Wincan report. A number of reports submitted to Council (and signed off by RPEQ's) have no defects other than the start and end node, despite the video containing minor defects.

Regularly review high priority defects (at least once per month) to keep them under control.

Cause of Failures

The most common cause of failures is poor construction practices, particularly relating to high compaction loads during construction.

Another common cause of failures is the pipe material not suiting the environment, for example normal-cover pipes in marine environments.

Coordinating with Other Projects and Organisations

Of the other projects we review CCTV for, at least 50% end up having to complete some amount of stormwater renewal work.

Due to how common service conflicts are, there is value in engaging with the respective service providers about the resulting renewals.

Renewal and Maintenance Budgets

Create renewal and maintenance programs early, and regularly update them based on defect information.

7 References

1. Moreton Bay Regional Council 2018, *Our Region,* viewed 28 April 2019 https://www.moretonbay.qld.gov.au/Council/Our-Region.
2. Moreton Bay Regional Council 2018, *Budget & Operational Plan 2018 – 2019,* viewed 28 April 2019, https://www.moretonbay.qld.gov.au/files/assets/public/services/budget/budget-2019-20/budget-2019-20.pdf