Australian Government
Asbestos Safety and Eradication Agency

Asbestos-Cement Water and Sewer Pipe Management Case Studies

September 2022

Contents

1. Introduction

The case studies in this report highlight practices used by a variety of water and/or sewerage service providers (referred to as 'water agencies') to manage and remove asbestos-cement water and sewer pipes (AC pipes) in Australia.

The case studies complement the *Asbestos-Cement Water and Sewer Pipe Management Guidelines* (the Guidelines) that were developed to assist water agencies eliminate or minimise the risk of exposure to asbestos fibres being released from AC pipes. Exposure to airborne asbestos fibres can cause life-threatening diseases like cancer.

AC pipes become hazardous when the asbestos fibres are no longer bonded securely with cement and are instead released into the air or soil. This can occur when AC pipes deteriorate due to age or when they are disturbed or damaged, for example during maintenance work.

Australia began using AC pipes in 1926, with the practice peaking between 1957 and 1966, and finally ending in the 1980s. With an estimated lifespan of 60 to 75 years, most AC pipes that remain in use in Australia are now coming to the end of their product lifecycle.

In 2020, it was estimated that between 6.1 to 7.5 million tonnes of asbestos containing materials (ACMs) remained in the built environment in Australia. Of that, it was estimated that over half was AC pipes.

Earlier research, by the Water Services Association of Australia (WSAA), estimated that in 2013 there was about 40,000 km of AC water mains, and a further 5,000 km of AC pressure and gravity sewer mains in situ across Australia.

The management of ageing AC pipes remains an ongoing issue for many Australian water agencies. There is no 'one size fits all' approach. Water agencies differ in size, resourcing and the amount of AC pipe they manage. The factors they must consider in deciding how to eliminate or minimise asbestos exposure risks include the location and condition of AC pipes, the practicality of different management methods, and the availability of asbestos removalists and asbestos disposal facilities.

The case studies in this report were provided by water agencies in Queensland, New South Wales and Victoria.[1]

Some of these case studies were previously published in a 2018 report *Case studies of asbestos water pipe management practices*. The recommendation[2] in that report led to the development of the Guidelines.

[1] If you have an additional case study you would like included, please contact enquiries@asbestossafety.gov.au

[2] This report recommended that, '…there is some uncertainty about how (or if) future changes in the interpretation of national asbestos regulations may impact AC pipe rehabilitation programs in Australia. Given the significant potential cost exposure and likely flow on impacts to water consumers, the industry and governments should work closely with regulators to define which practices are allowed and which are not. This is particularly important in Victoria as some 70% of all AC pipes constructed in Australia between 1926 to 1947 (which are those currently at the highest risk of failure) were installed in the state', at p. 3 of the *Case studies of asbestos water pipe management practices*.

During the development of the Guidelines new case studies were obtained which have been included in this report and are identified with this symbol:

The case studies featured in this report are:

Water agency	Location	Overview
Central Coast Council	**New South Wales**	**Central Coast Council has developed procedures for conducting condition assessments of AC pipes and predicting their remaining life in order to achieve safe, efficient and cost-effective management of AC pipes.**
South East Water	**Victoria**	**South East Water is taking a long-term strategic approach to ensure the safe, efficient and cost-effective management of failing AC pipes, as reflected in its Strategy for Renewal of Asbestos Cement Water Mains.**
Barwon Water	**Victoria**	**Barwon Water has an Asbestos Handling Policy that provides the framework for ensuring that the risks associated with AC pipe management are eliminated or minimised.**
Goulburn Valley Water	**Victoria**	**Goulburn Valley Water has standard criteria for assessing the condition of AC water pipes which ensures consistent assessments and management. The process involves the assessment of a failing AC water pipe, through to the planning phase, the construction phase and the post-construction phase.**
Shoalhaven Water	**New South Wales**	**Shoalhaven Water prioritises AC pipes for replacement based on failure rates and related factors. Two case studies for how Shoalhaven Water managed two separate ageing AC pipes are provided.**
Urban Utilities	**Queensland**	**Urban Utilities replaced 7.95km of AC water main pipelines constructed between 1927 and 1954 in 2015/16. It encountered and overcame a range of issues during this program of work.**
Riverina Water	**New South Wales**	**Riverina Water replaced 7km of 150mm AC water pipe installed in 1940 by**

		decommissioning and leaving the, AC pipe in situ and by-passing it with a new alignment.
UnityWater	**Queensland**	**UnityWater has developed an Asbestos Management Procedure to ensure that all activities involving ACM are identified and that controls are implemented to eliminate or minimise the risk of exposure to workers, visitors, public and others.**

2. Central Coast Council[3]

The issue

Central Coast Council (CCC), located between Sydney and Newcastle, provides water and sewerage services to approximately 120,000 properties. Approximately 35% of its water supply network mains and 22% of its sewer rising mains are AC pipe. To achieve safe, efficient and cost-effective management of these assets CCC has developed procedures for conducting condition assessments of AC pipes and predicting their remaining life.

Action taken

Condition assessments of AC pipes are generally conducted either opportunistically or proactively:

1. **An opportunistic condition assessment is commonly completed following pipe failure. Asset engineers are notified of each failure and can determine whether the retrieval of an AC pipe sample for condition assessment is desirable based on a failure response decision tree.**

   In general, a sample recovery will occur for the following AC mains:

   - **All sewer rising main failures**
   - **All water mains > DN200**
   - **Any water main that causes significant property damage / flooding**
   - **Any water main in high break frequency areas.**

2. **A proactive condition assessment involves the planned shutdown of an AC pipe and the exhumation of a sample specifically for the purpose of condition assessment. It may occur on high criticality mains or prior to pump upgrades at the sewage pump station (SPS) (e.g., increase in duty).**

Condition assessment options

There are numerous techniques used by CCC to assess the condition of AC pipes and predict remaining life. They are described below, in order from least to most confidence, generally, in the results.

New Zealand's *National Asbestos Cement Pressure Pipe Manual* (NZ Pipe Manual) is the primary source used to assist in determining a value for predicted remaining life.

Desktop Analysis

An estimate of condition grade and remaining life can be made using available information which includes:

- **installation date**
- **diameter**
- **pressure class**

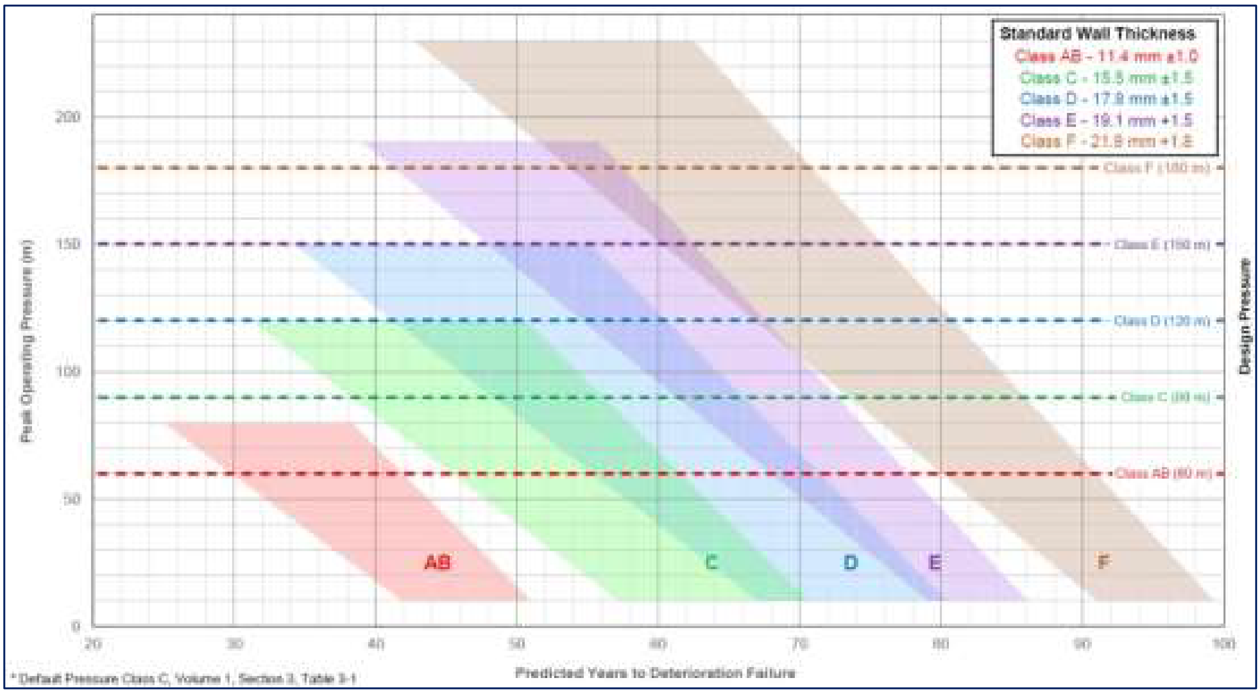
[3] Case study provided by Mark Lee, Asset Engineer, Central Coast Council.

- operating pressure
- failure history (optional).

In a desktop analysis, CCC uses failure history to decide which part of the relevant pressure band prediction is most appropriate.

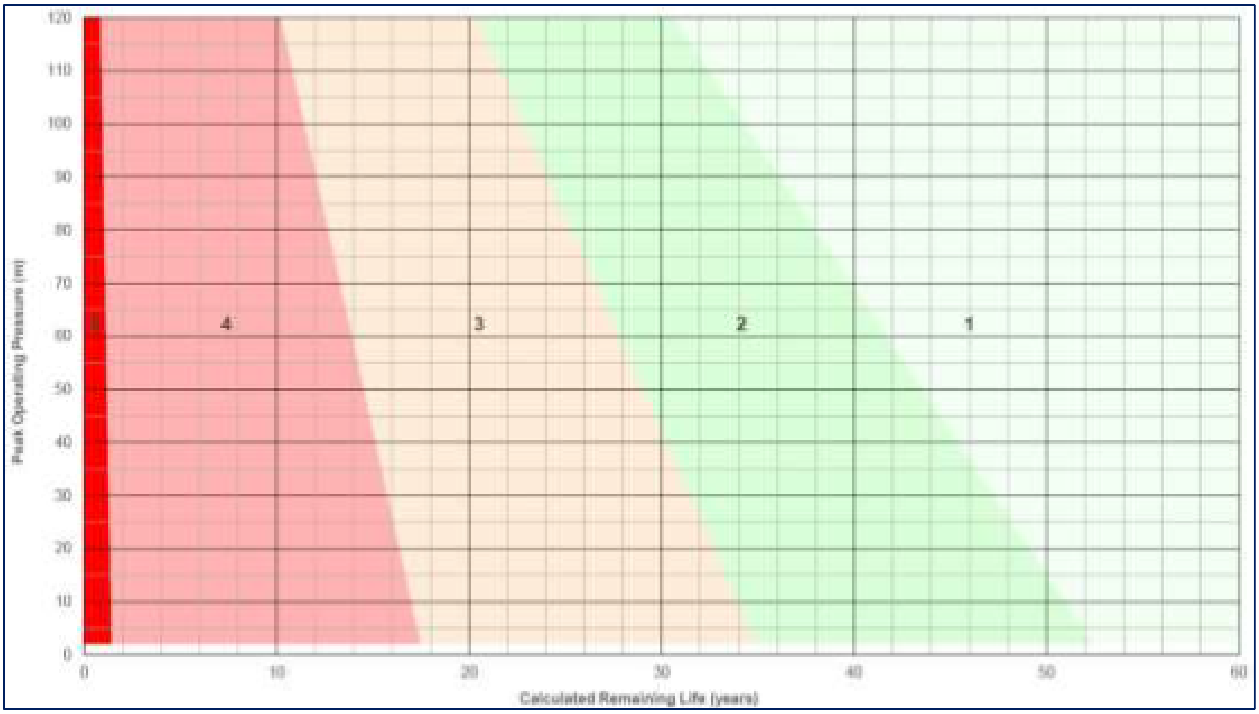
The NZ Pipe Manual clarifies that 'deterioration failure year' is intended to be the predicted year of first pressure related failure due to deterioration; it is not an indicator of a catastrophic failure event requiring full replacement of the pipe. Figures 2.1 and 2.4 show the charts used in a desktop analysis.

Figure 2.1: Lifetime prediction chart – DN150 (Water)[4]



[4] Figure reproduced with permission, from Water New Zealand's National Asbestos Cement Pressure Pipe Manual.

Figure 2.2: Condition Grading DN150 Class C (Water)[5]



Core Samples

Core samples can be taken from a pipe, to be used for assessing the condition and remaining life of an AC pipe, without taking a pipeline out of service. They can be retrieved through under pressure drilling, essentially the same method as a large diameter water service tapping would occur.

Core samples can then be tested using phenolphthalein staining or sent away for CT scanning to determine the external and internal deterioration extent. It is noted that CT scanning has benefits over phenolphthalein staining, including reduced work health and safety (WHS) risks and greater accuracy in measurement.

The main drawback of testing core samples is that it only provides a limited snapshot of a pipeline's deterioration. The core may not be a representative sample of other axial locations at that chainage on the main (i.e., deterioration can vary from obvert to invert), it may also not be representative of other locations along the length of the pipeline, particularly if ground conditions are variable.

However, this method gives more confidence than a desktop-only estimate and in some cases the cost and customer impact of taking main out of service for a larger sample makes it a practical option.

Pipe Samples

Taking a pipe sample is the most detailed, and accurate method – and therefore the preferred method - for assessing condition and making a remaining life prediction for an AC pipe.

Pipe samples can be tested using phenolphthalein staining or CT scanning. However, the difference in density between structurally sound parts of the pipe wall and

[5] Figure reproduced with permission, from Water New Zealand's National Asbestos Cement Pressure Pipe Manual.

deteriorated parts can be displayed more clearly, and therefore be measured more accurately, using CT scanning. CT scanning also has many benefits including reduced WHS risks, greater accuracy in measurement and significantly more data snapshots of the pipe cross-section.

Figures 2.3 and 2.4 show CT scan images of AC pipe samples.

Figure 2.3 - CT image of a DN150 sewer rising main

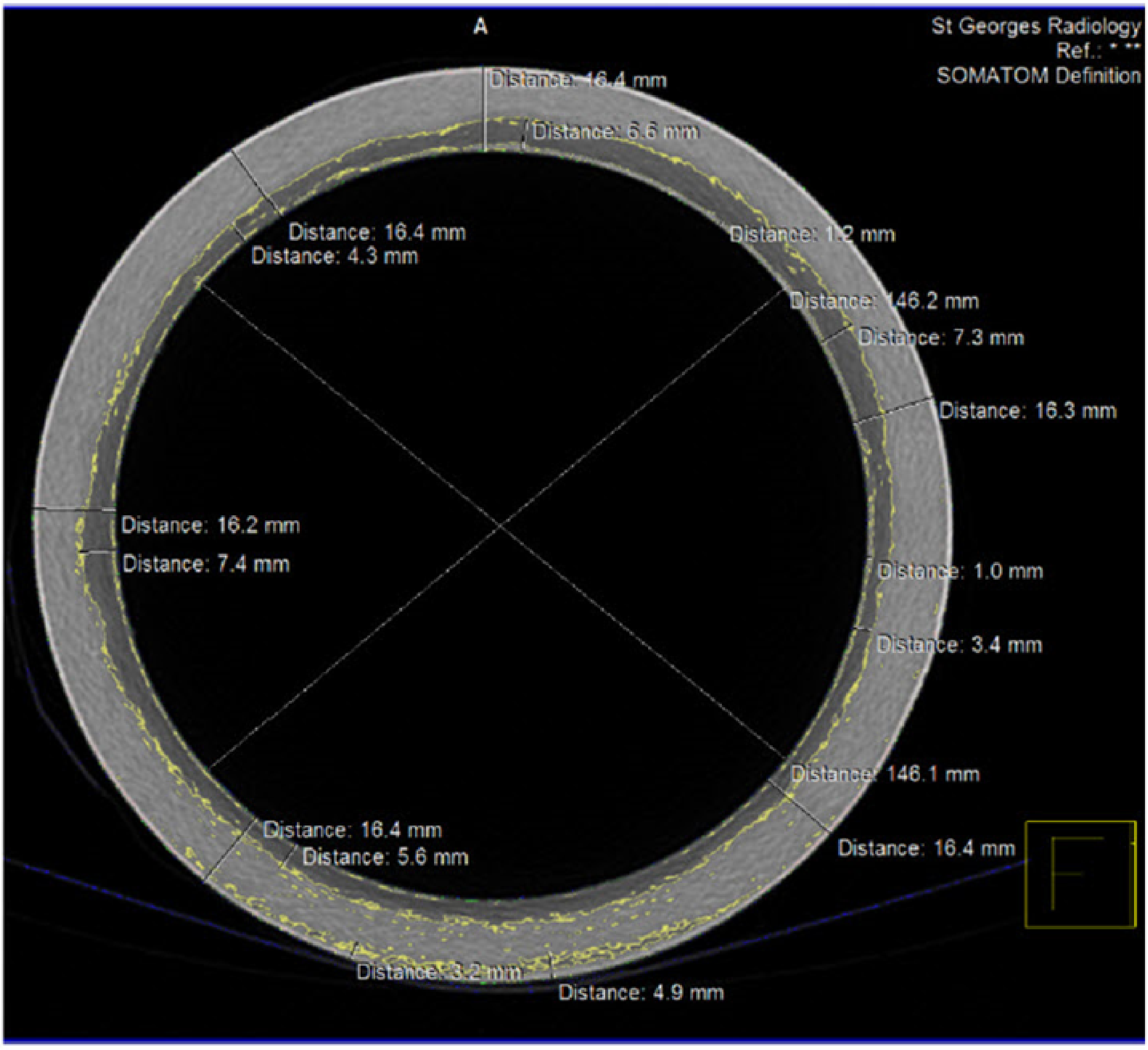
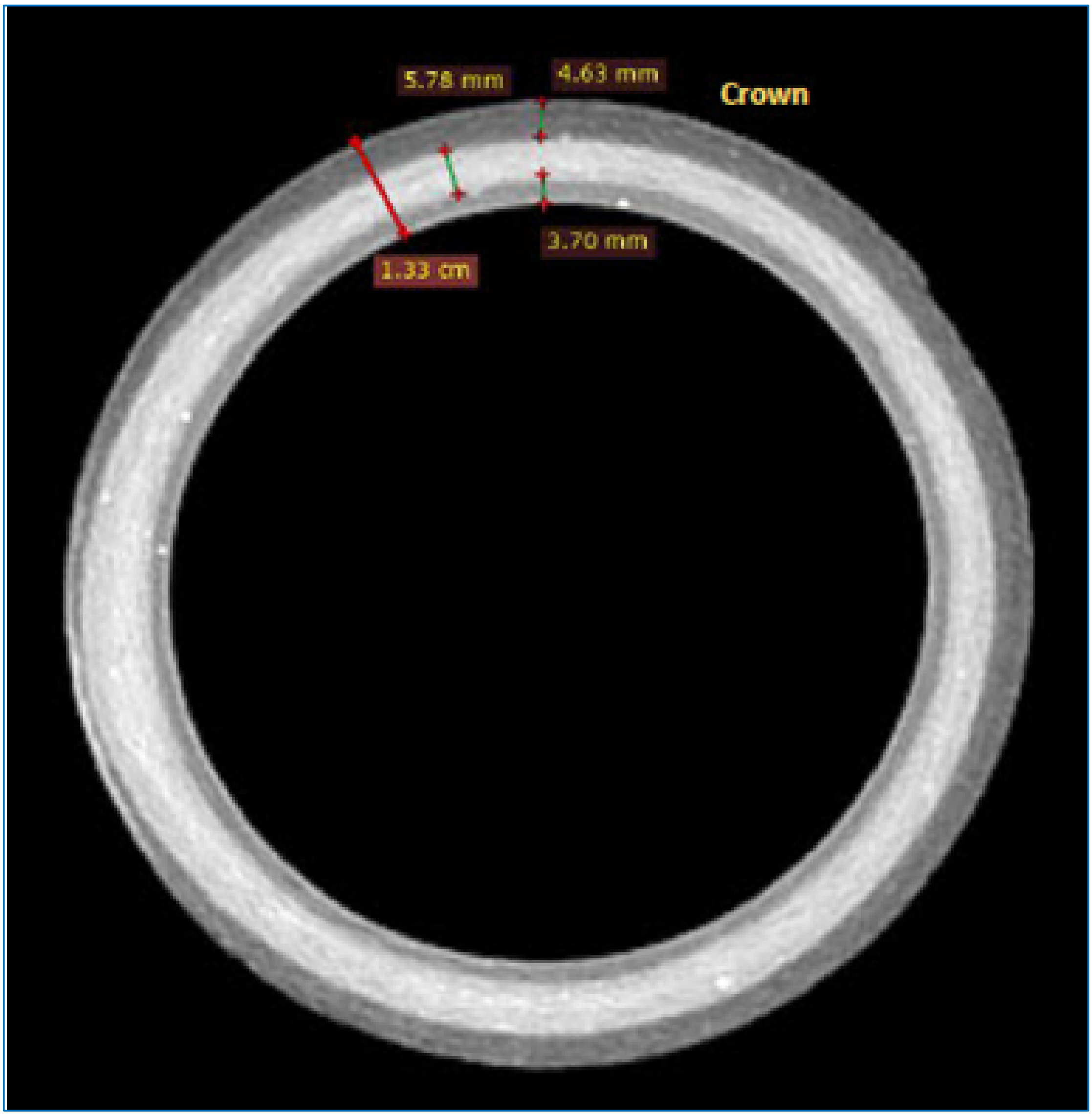


Figure 2.4 - CT image of a DN100 water main



The following data from a pipe or core sample is required to estimate remaining asset life using the Water New Zealand Deterioration Calculator[6]:

- **diameter**
- **use (e.g., water, sewage)**
- **installation year**
- **condition assessment year**
- **operating pressure**
- **mean pipe outside diameter (OD)**
- **minimum measured wall thickness**
- **maximum measured external deterioration**
- **maximum measured internal deterioration**

[6] https://12240-console.memberconnex.com/Attachment?Action=Download&Attachment_id=2084

Condition assessment of an AC sewer rising main in Wamberal

A 2015 condition assessment report for a DN150 AC sewer rising main in Wamberal is presented in Appendix A. This rising main had experienced two prior failures (2008 and 2011) and a decision was needed regarding whether it should be renewed. A pressure transient review of the rising main indicated that pressure surges could be reduced with replacement of the reflux valves at the pump station.

Figure 2.5 – Deterioration modelling for pressure pipelines

Average Deterioration Rates (mm/year)	
Water	0.2344
Wastewater	0.3462
Stormwater	0.2344

					Data Required for Deterioration Modelling						
Sample #	DN	Class	Use	Location/Address/ Notes	Year installed	Year recovered	Operating pressure (m)	Mean Pipe OD (mm)	Min Wall Thickness (mm)	Max. Ext. Det'n	Max. Int Det'n
15.094AC	150	C	Wastewater	143 Ocean View Dr Wamberal	1978	2015	20.0	179.0	16.1	4.9	7.4

Variables			Results			
MPa	Surge Factor	National Det'n Rate	Sample Det'n Rate	Comparison to Nat. Avg.	Estimate Pipe Life	Est. Year of First Det'n Failure
23.5	1.5	0.3462	0.3324	4% slower	45	2023

Taking into account the consequence of failure, the failure history, the reduction in maximum surge pressure and the predicted remaining life of the main (estimated to be 2023) a decision was made not to include the main in the asset renewal program. The report suggests a 2030 renewal date may be appropriate which was accepted as reasonable.

Internal recommendations state that an additional failure of this rising main would likely result in it moving up to the next scheduled renewal program. The main has not experienced a failure since the report was issued in 2015.

Additional Testing Options

In conjunction with the pipe condition assessment discussed above, CCC also undertook the following testing of the AC sewer rising main in Wamberal—

- **Crush testing: The crush test results in the attached report (see Appendix A) identify that although the pipe is well into its useful life, it still exceeds the minimum requirement for a new pipe. In this specific example the test pipe demonstrated an ultimate strength 112% of the minimum requirement for an equivalent new AC pipe. Industry testing has found that this is not uncommon, even considering the degradation that has occurred.**
- **Soil Aggressivity Testing: CCC also undertook soil aggressivity testing in conjunction with pipe condition assessment to better understand the soil profile and the environmental conditions pipes are subject to in the LGA. This testing is perhaps more relevant to metallic pipes where aggressive soil and/or groundwater has a more observable relationship to corrosion and eventual pipe failure. However, knowing how deterioration is occurring (outside-in, inside-out, or both) and the various factors involved (pipe pressure, H_2S in rising mains,**

potable water aggressivity, soil/groundwater conditions, etc.) helps with understanding and management of pipe cohorts as a whole. Typical result outputs from soil aggressivity test are presented in Figure 2.6, below.

Figure 2.6 – Results from a soil sample collected along a sewer rising main in Forresters Beach

Bore	Depth (m)	Description	Concrete Structure				Steel Structures			
			pH	Sulfates (SO_4)		Chlorides in water (ppm)	pH	Chlorides (C)		Resistivity (ohm.cm)
				In soil (ppm)	In water (ppm)			In soil (ppm)	In water (ppm)	
2	1.4	Grey mottled red brown CLAY	6.1	110	-	-	6.1	350	-	2,800
2	-	GROUNDWATER	7.0	-	290	1700	7.0	-	1700	-

Non aggressive
Mildly aggressive
Moderately aggressive
Severely aggressive
Very severely aggressive
Not tested/ Not applicable

Note to Table: Scale of aggressivity based on threshold values given in AS 2159-2009 (Ref 1)

Key Learnings

A key challenge in assessing the condition and predicting the remaining life of AC pipes is the difficulty in securing suitable samples for testing. The current maximum pipe dimensions CCC's consultant can take for CT scanning is 1800mm long and 500mm outside diameter.

Difficulties arise as pipes are often exhumed as full 4m lengths after the collars are removed. This was previously overcome with wrapped samples transferred to a qualified Class A licence contractor who could set up a safe environment to prepare suitably sized samples. It is increasingly difficult to find companies that are qualified and available to do this work.

The availability of shorter samples can be easier following a failure, as the failure often splits the pipe, allowing the safe removal of the failed part in multiple smaller sections.

Australian WHS laws permit the transport of AC pipe samples for testing. Although the transportation exception to the WHS prohibition on the use of asbestos are written in relation to the disposal of asbestos waste, other exceptions permit the transportation and testing of AC pipe samples. In the case of condition assessment, the AC pipe sampling and transportation is permitted as a necessary component of maintenance work on AC pipes or as genuine research or analysis.

There is an opportunity for Australian water agencies to share the data obtained from condition assessments to build on the dataset that has been used to develop average deterioration rates in the *National Asbestos Cement Pressure Pipe Manual*. The water main data comes from 790 samples while the sewer rising main data comes from 89 samples, recovered between 2003 and 2016.

3. South East Water

The issue

South East Water (SE Water) provides water to residents and businesses in a large region south-east of Melbourne in Victoria. SE Water owns and manages over 24,000 kilometres of pipeline, spread across an area of approximately 3,600 square kilometres.

SE Water has around 1,600 kilometres of AC pipe remaining in its network, constituting around 7% of its entire pipeline. In recent years, some 400 kilometres of AC water mains have been removed due to breakage and pipe degradation or through scheduled upgrade works. These AC mains were installed between the 1920s and 1970s, and they make up around 4% of the estimated 40,000 kilometres of AC pipeline in Australia.

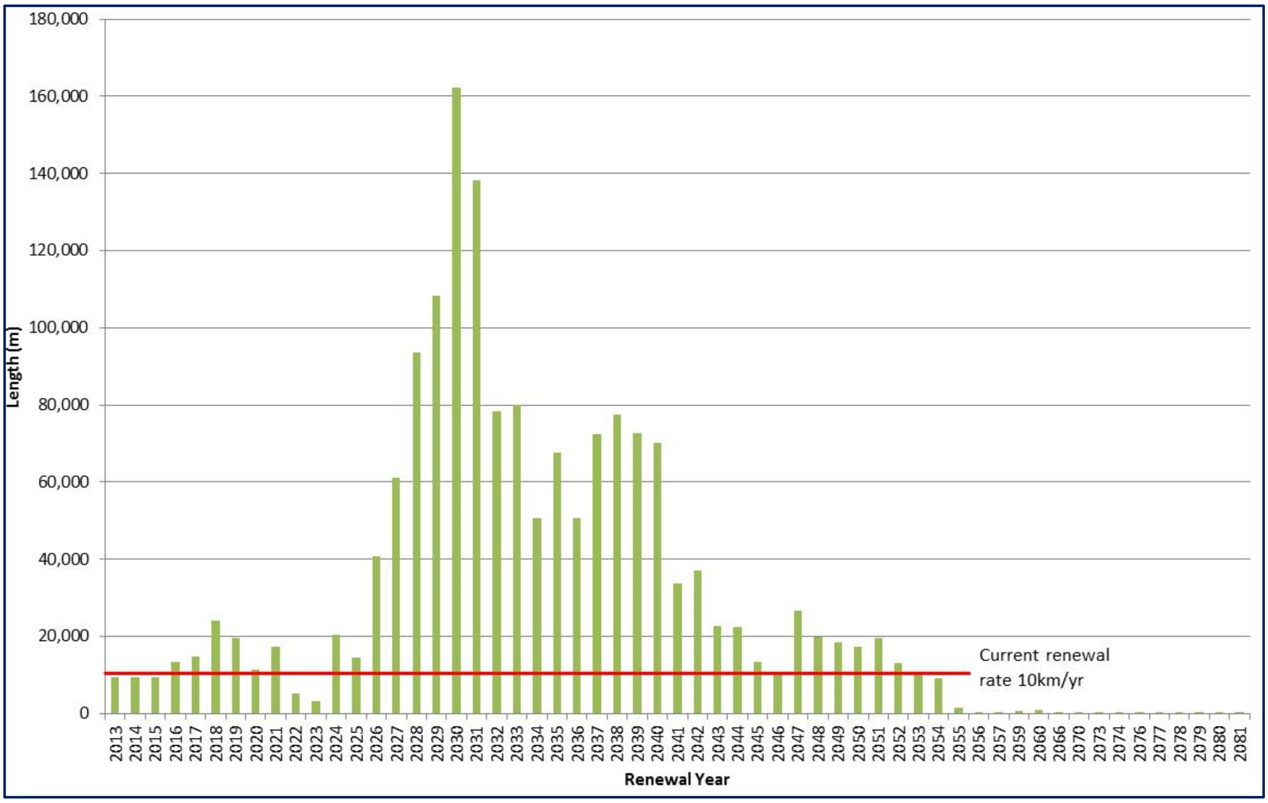
SE Water is taking a long-term strategic approach to ensure the safe, efficient and cost-effective management of failing AC pipes, reflected in SE Water's Strategy for Renewal of Asbestos Cement Water Mains.

Action taken

Predicting failure rates

SE Water is currently renewing around 10 kilometres of AC pipes per annum, which aligns with current pipe failure rates. Projection modelling is used to predict future failure rates which indicates that AC pipe failure is likely to increase significantly from 2026 to a peak of approximately 160 kilometres per annum by 2030. It is estimated that failure and renewal rates will remain significantly higher than the current rate until about 2053.

Figure 3.1: Estimated Failure Profiles for AC water mains in SE Water



Comparison of methods for managing deteriorating AC pipe

SE Water has trialled the following methods for managing deteriorating AC pipes:

- **slip-lining: inserting a smaller pipe into the deteriorating AC main,**
- **realign and leave: construction of a new alignment and leaving the disused AC main in situ,**
- **remove and replace: the AC main is removed, and a new pipe is laid in the same trench,**
- **pipe cracking/bursting: a cracking head which is pulled through the host AC water main with a new high-density polyethylene (HDPE) pipe attached. This method has the advantage of not undertaking any surface reinstatement, reducing inconvenience to the community. Prior to 2015, SE Water had renewed approximately 150 kilometres of AC pipe using this method.**

SE Water considered the risks and benefits of each method, as well as compliance with WHS and environment protection laws. They also estimated and compared the cost over 5 years of adopting either AC pipe bursting, by-passing and construction of a new alignment, or remove and replace.

Pipe bursting

Advantages

Lower upfront costs, although costs of managing WHS risk, including whether they are grossly disproportionate to the risk, may only be considered after assessing the risk and other available ways of eliminating or minimising the risk.

No need to initially excavate a larger area (may be necessary for removal of waste).

Disadvantages
Does not comply with WHS asbestos disposal requirements so an exemption would be needed from the WHS regulator.
May not eliminate or minimise risks of exposure to asbestos fibres so far as reasonably practicable.
Results in AC pipe fragments in the surrounding soil. WHS laws require the removal of all fragments which necessitates extensive clean up.
May result in asbestos contaminated soil, triggering notification requirements under environment protection laws.

By-passing with new alignment

Advantages
Lower short-term costs, although costs of managing WHS risk, including whether they are grossly disproportionate to the risk, may only be considered after assessing the risk and other available ways of eliminating or minimising the risk

Disadvantages
Minimises risk but does not eliminate risk of exposure to asbestos fibres.
Ongoing costs and resources to manage disused AC pipe that remains in situ.
May result in asbestos contaminated soil, triggering notification requirements under environment protection laws.

Remove and replace

Advantages
Complete removal of AC pipe from the ground and consequently the elimination of any costs of managing a disused AC pipe in situ (for example, maintaining an asbestos register and risks of future asbestos exposure).

Disadvantages
Highest upfront cost due to increased time on site, use of heavy machinery for excavation and the WHS controls for managing the risk of asbestos exposure during the process.

Given the above factors, SE Water's preferred method for managing deteriorating AC pipe for now is the conventional 'removal and replacement', also often referred to as lift and relay. However, SE Water's strategic approach to AC water pipe renewal includes consideration of new and emerging techniques that may be safer and more cost effective.

Photos: South East Water using the realign and leave method for pipe renewal.

New and emerging techniques

The new and emerging techniques presented in photos below include:

- Non-structural liners, where an organic polymer is sprayed on the internal pipe wall. This can span gaps and prevent leakage.
- Semi-Structural Spray on linings, which is a thicker layer of organic polymer that provides some structural properties.
- Cured in place semi-structural liners, where an inflated hose is placed in the pipe and cured or sealed in place using steam/hot air.
- Cured in place structural liners, which is the same as the cured in place semi-structural liners, but the lining is reinforced with fibreglass to provide structural strength (the liner does not rely on the host pipe).[7]

Photo (left): Exhumed cured in place samples that were extracted to be laboratory tested.
Photo (right): Cured in place break test apparatus being tested.

[7] Comparison of methods sourced from the *Strategy for Renewal of Asbestos Cement Water Mains, South East Water, 2016.*

Key advantages of these over conventional methods for managing AC pipes include:

- **host pipe remains intact**
- **significant reduction in leakage from the host pipe**
- **reduction of internal corrosion**
- **same day return to service (in the case of spray lining methods), and**
- **minimal reduction in hydraulic capacity.**

There are also disadvantages that need to be considered with these new methods, such as:

- **there are currently no commonly accepted standards or testing requirements that would allow a water agency to have confidence in the expected useful service life of the liner**
- **current testing is limited as laboratories are reluctant to handle asbestos, and**
- **there is a lack of established markets in Australia for these products, which means there are limited experienced contractors available and high costs for installation.**

In addition to the disadvantages highlighted above, these new and emerging leave the AC pipe in the ground requiring ongoing management (in compliance with WHS laws and environment protection laws) and potential removal in the future, for example if the risk of asbestos exposure is too great and/or projects are carried out at the site that require excavation.

Key Learnings	Given the high level of uncertainty with the new products, the bypass and leave method continues to be adopted by SE Water. SE Water believes that further research is needed in the industry to enable: 1. a better understanding of deterioration rates and future renewal 2. a more comprehensive evaluation method of all AC pipe renewal options 3. quantification of risk exposure during rehabilitation works and future community risks, and 4. decision support tools for AC pipe rehabilitation.
	SE Water continues to implement its own further research and development programs, which include the following elements: **Material Testing** with a local university to assess the feasibility of developing a testing facility for AC pipes and associated rehabilitation products. **Industry collaboration** with the Water Services Association of Australia (WSAA) and industry to develop a product specification for lining products for use with AC pipes that can be used to evaluate lining products. **Improve pipe network understanding,** where SE Water will undertake studies to understand where sufficient hydraulic capacity may be available to allow slip-lining of AC pipe to occur. **Knowledge building**, from an international context, through attending relevant conferences from across the globe and reviewing international research in this space.

4. Barwon Water

The issue

Barwon Water provides water, recycled water and sewerage services to almost 300,000 residents across an area of 8,000 square kilometres in Geelong, Victoria. The organisation operates around 6,600 kilometres of pipes, including approximately 1,270 kilometres of AC pipes which are assumed to be wrapped in asbestos lining, until proven otherwise.

Barwon Water replaces around 20 kilometres of AC water pipes each year at an annual cost of approximately $4 million (approximately $200 per metre).

Barwon Water currently outsources maintenance services on AC pipes and ensures that strict processes are followed to ensure the safety of staff, surrounding businesses and residents.

Action taken

AC pipe maintenance

Maintenance and renewal of AC pipes as they burst, or crack is an ongoing task for Barwon Water. When AC pipes fail, Barwon Water generally follows the 'remove and replace' method, which involves removing the section of pipe with asbestos, disposing it in a licenced landfill, and replacing it with a non-asbestos section of pipe.

This work is performed in accordance with Barwon Water's Asbestos Handling Policy that provides the framework to ensure the risks associated with AC pipe management are eliminated or minimised. It requires:

- **Training: Anyone required to cut or handle AC products and asbestos wrapping must receive appropriate training in respect of the hazards and risks associated with asbestos, in accordance with WHS laws.**
- **Licences: If the asbestos wrapping is partially or fully deteriorated when uncovered, the asbestos is deemed as friable. Friable asbestos must be removed by a Class A asbestos removalist. More than 10m2 of non-friable asbestos must be removed by a Class B asbestos removalist or a Class A asbestos removalist.**
- **Personal Protective Equipment (PPE): The operator and anyone assisting with the cutting or in the vicinity of the cutting operation must:**
  - **Wear appropriate respiratory protective equipment, protective clothing and/or safety equipment.**
  - **Wear approved waterproof trousers, waterproof jackets, shower cap, or disposable overalls, rubber boots and rubber gloves taped to the outside of the jacket / overalls.**
  - **Wear a respirator fitted with an approved respiratory P2 Filter**

Figure 4.1: PPE that must be worn, and special requirements that must be complied with, when cutting AC pipe or in the vicinity of cutting of AC pipe.

Special requirements:

- P2 Mask Respirator - Fit check before use.
- Disposable overalls - tight cuffs (or taped to gloves and boots) and fitted with hood. Legs of overalls must be outside of gum boots.
- Nylex gloves
- Safety glasses
- Safety signage

AC pipe removal

Prior to removal, the following steps are taken.

1. **Audit the site, assess risk and complete an Asbestos Management Plan and Control Plan.**
2. **Notify WorkSafe Victoria (using a Notification of Asbestos Removal form)**
    a. **For works less than 10m2 (about 18 lm of 150mm pipe), Barwon Water or the contractor notify WorkSafe Victoria at least 24 hours prior to works commencing.**
    b. **For removals in excess of 10m2, WorkSafe Victoria is notified at least 5 days prior to works commencing.**
3. **Complete a Safe Work Method Statement.**
4. **If work is near a business or businesses, send them an asbestos notification card.**
5. **Prepare for removal**
    a. **Pipes are replaced from fitting to fitting, gibault to gibault or socket-to-socket where possible. For all pipes up to and including 150mm diameter, gibaults must be pre-rasped (reamed).**
    b. **Pipes are to be exposed using a backhoe hydro excavation or hand tools. The damaged pipe can be lifted to the surface using the backhoe or manually.**

Asbestos Removal Procedure

After the preparation phase, the asbestos removal commences. The removal process is tailored to the type of pipe being removed, for example an AC main, or a MSCL pipe. Both processes are outlined below.

AC Main Pipe Removal

1. **Wear appropriate PPE**
2. **Excavate to the depth of pipe, expose length of pipe using hand dig methods.**
3. **Barricade area.**
4. **Where pipes must be cut, the removalists use a hand saw or chain cutters. If unable to cut, removalists place a wet rag around the collar, wet the area down and hit the collar with a mash hammer and chisel away the collar. Power tools are never used.**
5. **All cutting operations (including, grinding, bevelling, shaping, rasping and filing) on asbestos-cement materials must be kept continuously wetted down at the leading edge of the cutting tool, and at any other point where dust could be formed, to effectively suppress any dust. Sawing and grinding are only undertaken when it is not practicable to use other cutting operations.**
6. **Replace the pipe.**
7. **Wash down tools, equipment and PPE (if for re-use).**
8. **When complete, place PPE in AC disposal bag (see photo), which is taken to a licenced landfill.**

Photo: AC disposal bag, goose necked and sealed.

MSCL pipe removal

1. **The pipe is taken out of the ground and removalists coat the area on the pipe to be removed with a mix of water/PVA or water-based paint.**
2. **They then barricade the area and place a 200-micron sheet or bag under section of the pipe to be removed to capture waste as it is chipped away from the pipe.**
3. **The asbestos is then removed by chipping it away using a hammer and chisel (see photo below). If the wrapping is not totally removed from the pipe, the area is rasped to ensure all wrapping material is removed.**

Photo: The hammer and chisel method used to remove asbestos from MSCL pipes.

4. **The Class A removalist must ensure air monitoring occurs and the results are available to employees at the workplace. On the completion of any cutting operation, all equipment, overalls and boots must be thoroughly washed down.**
5. **Clean up and disposal**
   a. **All major sections of pipe and asbestos wrapping, any disposable protective apparel and respirators / filters are placed in heavy duty (200 micron) polyethylene plastic wrapping, with small amounts of broken pipe and asbestos wrapping cleared from the trench and added to the bags,**
   b. **These are disposed at a licensed landfill.**

Photos: AC pipe removalists undertaking removal works.

After removal

After the removal of AC pipe or MSCL asbestos pipe, asbestos supervisors conduct random site inspections of 10% of the completed jobs to validate that the work is being carried out in accordance with this procedure.

Key Learnings	
	Barwon Water ensures its contractors follow strict safety measures when removing AC pipes and there is follow up to ensure the work is carried out in accordance with policies and procedures.
	Forward planning, such as through the development of an asbestos handling policy, can assist in efficiency in dealing with the important task of the ongoing management of cracked AC pipe as it is identified.
	Key factors to effectively and safely managing AC pipe include training of workers, ensuring the correct asbestos removal licence holders are engaged to carry out work and ensure correct PPE is used.
	Assuming all suspect water and sewer pipe is AC pipe until proven otherwise assists in managing possible risks of airborne asbestos exposure and is consistent with WHS laws requirements.

5. Goulburn Valley Water

The issue

Goulburn Valley Water (GVW) provides water and wastewater services to over 60,000 customers across 54 towns in central Victoria, from just north of Melbourne through to the northern Victoria border. GVW has 8,690 kilometres of AC mains, which comprises approximately 38% of its total water supply network. These AC pipes were installed between 1930 and 1980.

An AC water main in Cameron Avenue, Shepparton had failed on numerous occasions over a 20-year period, and each time had either had a repair band installed (at minimum disruption to residents), or a section had been replaced. The failure rate had been increasing. The AC pipe was constructed in the 1950s using a 150mm diameter AC material and lay along the entire street, with the pipe length a total of 715 metres. An assessment of the AC water main was conducted in October 2016 and subsequently renewed.

Action taken

Condition assessment

GVW has the following standard criteria for conducting a condition assessment of AC water pipes.

Criterion One – condition of water main

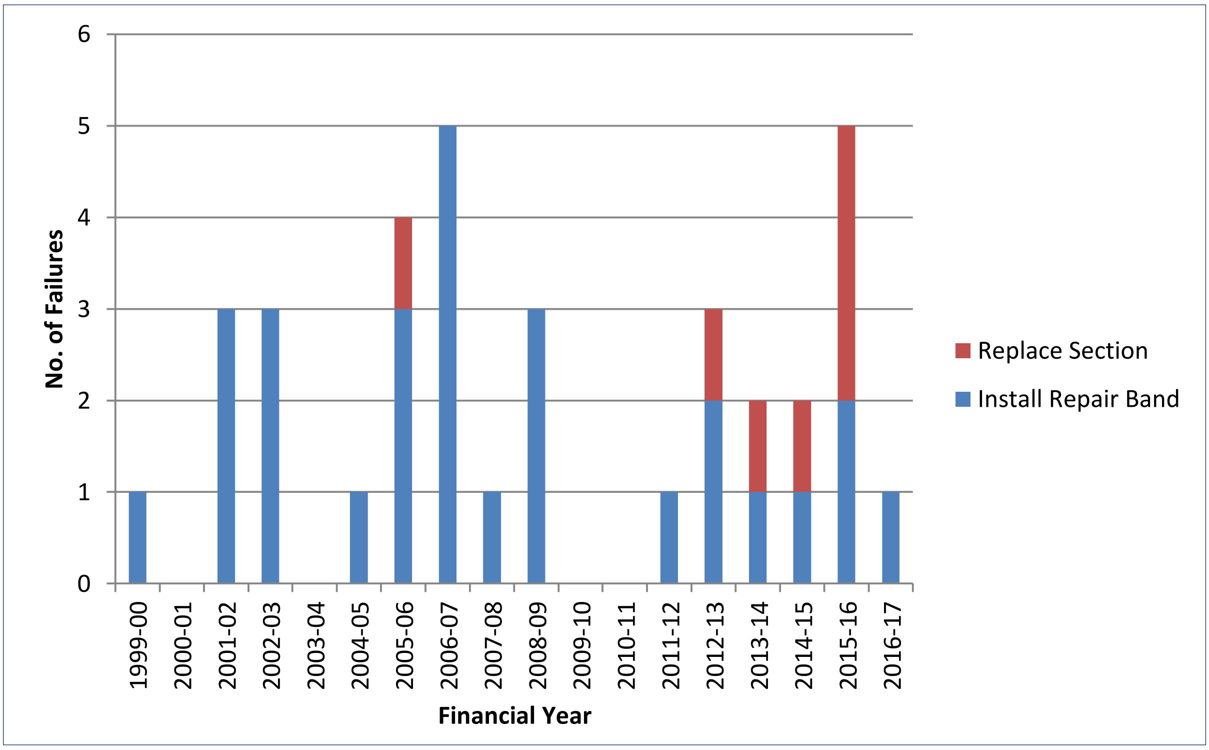
GVW uses a 0 to 5 structural condition grade to quantify the condition of the water main:

- **1 is the best condition, i.e., the pipeline has not failed since it was laid,**
- **5 is the worst condition, i.e., the pipeline has burst or leaked more than three times in the past year, or a detailed condition assessment indicates it has reached the end of its life, and**
- **0 means the pipe has been abandoned or no longer exists.**

As can be seen in Figure 5.1 below, the water main in Cameron Avenue had numerous failures from 1999/2000 to 2016/2017. There had also been an increase in the requirement to replace entire sections of pipeline from 2012/2013 to 2015/2016. As the AC pipe had more than three failures during 2015/2016, the Condition Rating was 5 (worst condition).

[8] Reported in ASEA, *Case studies of asbestos water pipe management practices*, 2018.

Figure 5.1: Failures of the Cameron Avenue Water Main by Financial Year from 1999-00 to 2016-17



Criterion Two – Water Main Criticality

The scoring system for water main criticality at GVW is based on the below factors:

1. **public health and safety (including of GVW employees)**
2. **risk of environmental pollution**
3. **degree of effect on residential and/or commercial customers**
4. **difficulty of repair, and**
5. **cost of repair.**

These factors are assessed, scored and weighted to give a point score, and placed into a criticality/ consequence rating.

These ratings range from:

- **small consequence – point score range between 3 and 8, indicating that if the asset failed it would not affect operational reliability,**

to

- **catastrophic – point score range between 30 and 36, indicating that if the asset failed it would cause disastrous consequences.**

Cameron Avenue's AC water main criticality score was 16, which is a ranking of 2—or minor—as the failure would have a minor impact on operational reliability.

Criterion Three - Combining the condition and criticality

The condition grade and criticality rating are combined and viewed in a decision matrix. In the case of the Cameron Avenue AC water main, with a structure condition

grade of 5 and a criticality/consequence rating of 2, it was placed into the 'Prioritise in Replacement Program'.

Other considerations

Other relevant factors are also considered in deciding the best approach for managing failing water mains. In this case, GVW residents were receiving financial rebates in response to numerous unplanned water supply interruptions on Cameron Avenue. Additionally, operations staff were concerned about the condition of the Cameron Avenue AC water main. These factors contributed to the decision to renew the Cameron Avenue AC water main.

Renewing the AC water main

Planning phase

GVW's water main replacement program is finalised by May for the following financial year, with flexibility where needed in response to changes that arise in the operating landscape, budget or unforeseen failures to a water main which can change replacement priorities.

Planning for renewal of the Cameron Avenue AC water main included notifying the local Council, undertaking site visits, developing a business case, and developing a detailed design for how to conduct the works.

The planning stage also included a comparison of the options for managing the AC pipe, set out in figure 5.2. For completeness, the options considered included not renewing the Cameron Avenue AC water main. As identified, a significant disadvantage of not renewing the main was the ongoing costs associated with continued failures.

Figure 5.2: GVW Options assessment for Cameron Avenue

	Description	Pros	Cons
1	Open trench/ horizontal boring replacement (by-passing and construction of new alignment)	• Proven replacement method • Removal of AC from service.	• Requires deviations in the alignment at each endpoint • Slow construction method means more disruption to community • New alignment would need to be in the road pavement.
2	Slip Line retired Sewer Rising Main, located across the other side of the road	• Limited trenching of the road pavement required less disruption to traffic • Reuse of a decommissioned asset.	• Requires deviations in the alignment at each endpoint • Large number of services would need to be transferred across the road • Initial cost estimates indicated this would be approx. $40,000 more than Option 1 (cost of construction per metre similar but cost to transfer services across the road high).

3	Do nothing	• No upfront cost	• OPEX costs will increase as main continues to fail • Adverse impact on GVW Performance • Potential Payments to residents for further disruptions • Reduced customer satisfaction with reliability of service.

Construction phase

After the planning phase was completed, GVW commenced the construction phase. Most work was conducted by a contractor, with GVW ensuring compliance and alignment with policies and procedures. For the Cameron Avenue AC water main, option 1 was selected – by-passing of the AC main and construction of a new alignment. The project following the below process:

1. Customers were notified that roadworks were to take place, and to expect traffic disruption.
2. Signage and barricades were erected, with a radius approximately 10 metres around the site.
3. New water main was laid on the agreed alignment, using Horizontal Directional Drilling, HDD8, method.
4. Swabbing and disinfecting of the new main was completed and water samples were taken for laboratory testing of water quality.
5. Customers were notified the date and time of that planned shutdowns.
6. Connections and transfer property service connections to the new water main were undertaken and the old service connection to the AC main was turned off.
7. The old main connection was cut out and a blank end gibbault was installed to cap the connection to the AC main. As it involved asbestos:
    - All workers wore appropriate PPE
    - Double plastic was prepared for disposal of the AC pipe.
    - The AC pipe was excavated, wet down and cut with non-powered tools. This included the use of reed cutters, chain cutters or hand saws.
    - A section of the AC pipe was removed from the trench, including all off-cuts, residue, contaminated soil and any collected dust.
    - The AC waste, including the AC pipe and all disposal PPE, was double wrapped in plastic sheeting. The double-wrapped AC waste was fully sealed with duct tape and labelled as containing asbestos before it was transported to GVW's depot. It was then transferred to an EPA approved Waste Disposal Site by an approved asbestos waste disposal contractor.
    - Non-disposal PPE, tools and equipment were decontaminated.
8. Disused above ground non-asbestos assets (e.g., valves and hydrants) were removed.

9. **The site was cleared and demobilised, with reinstatement works completed as required.**

Post-construction phase

A representative from GVW attended the site with the contractor to review clean-up activities and ensure that all reinstatement works were completed adequately. The location of the disused AC main, as well as the new alignment were recorded on the GVW geographic information system (GIS).

Key Learnings	
	A standard approach to grading the condition of AC pipes, combined with a standard approach to rating the criticality of AC mains, can assist a water agency in prioritising AC pipes for replacement.
	Flexibility within an AC pipe replacement program ensures that a water agency can adapt to unexpected events, such as pipe failures, as they occur.

6. Shoalhaven Water

The issue

Shoalhaven Water manages the water, sewer and water recycling systems for Shoalhaven City Council and is based in Nowra on the NSW south coast. The water agency provides services to 96,000 people but during peak holiday periods, this can increase to 300,000.

Shoalhaven Water manages AC pipes in both its water and sewer systems with the failure rate of AC water mains causing 52% of all water main failures. These are predominantly due to pressure with broken backs (crack-off) the main failures (40%). Shoalhaven Water intends to implement a program to replace ageing AC water pipes by 2027. Currently it selects water mains for replacement based on repetitive failures and other factors. The past action taken to manage two ageing AC pipes is outlined below.

Action taken

Removal due to rezoning of land

The construction of the Princess Highway by-pass of Berry resulted in some existing streets being closed off from interconnecting to the new highway. North Street was effectively cut by the highway with Council creating a cul-de-sac with a new lot over the previous street. The new lot was then earmarked for the construction site of new ambulance and fire stations, which further impacted on the existing duel 150mm and 200mm AC pipes.

The 150mm AC main was in relatively good condition but had failed 3 times in total and had once in the previous year. The planting of trees over the water main in North Street was identified as the main cause of the previous breaks.

Shoalhaven Water decided to replace 80 metre sections of the dual AC pipes with a single 250mm HDPE main and remove the decommissioned AC pipes. A new main was installed by open trenching on a new alignment, and once connected, both 80m sections of AC pipe were removed and disposed to a local licensed Council disposal facility. The project was completed at a cost of around $100,000.

The dual mains allowed for one to be isolated while construction occurred, ensuring water supply was retained. This prevented water supply for 20 customers from being disrupted and water pressure being reduced for the broader network.

Replacement due to high failure rate

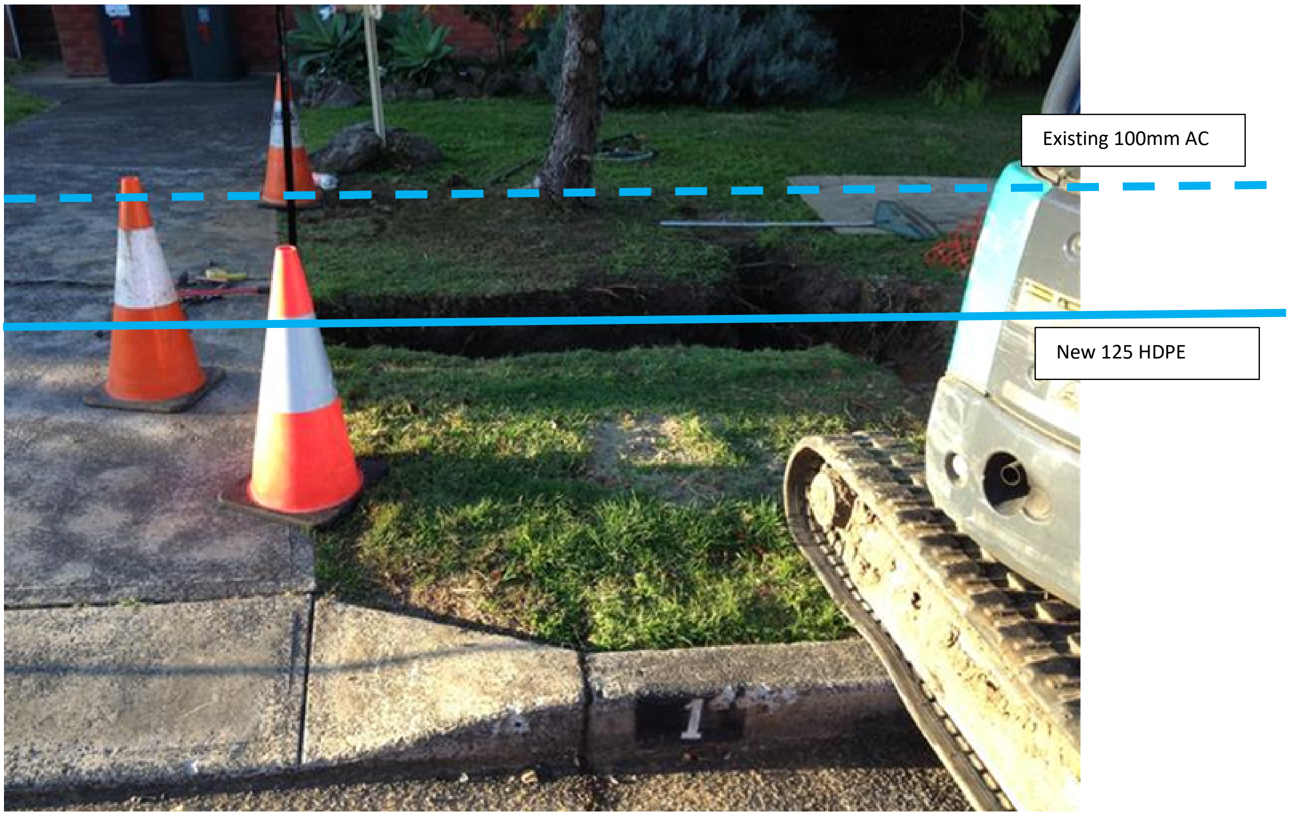
The planting of street trees over the top of the alignment of 100mm AC main constructed in 1961 in the median street of Walsh Crescent had contributed to recent failures of AC pipes, affecting supply to more than 20 customers.

To address the failure, a new 125mm HDPE water main was installed by boring on a new alignment and installing by-pass pipelines while works were undertaken. Services where then transferred from the old AC pipe to the new HDPE main, once it was commissioned. The existing AC water main had all surface fittings removed and was left in place, except at the connection points of the new and old main.

The primary issue during construction was encountering rock which caused difficulties in maintaining a constant alignment on the drilling head. Difficulties were also encountered removing the AC pipework at the connection point as it was located under a driveway.

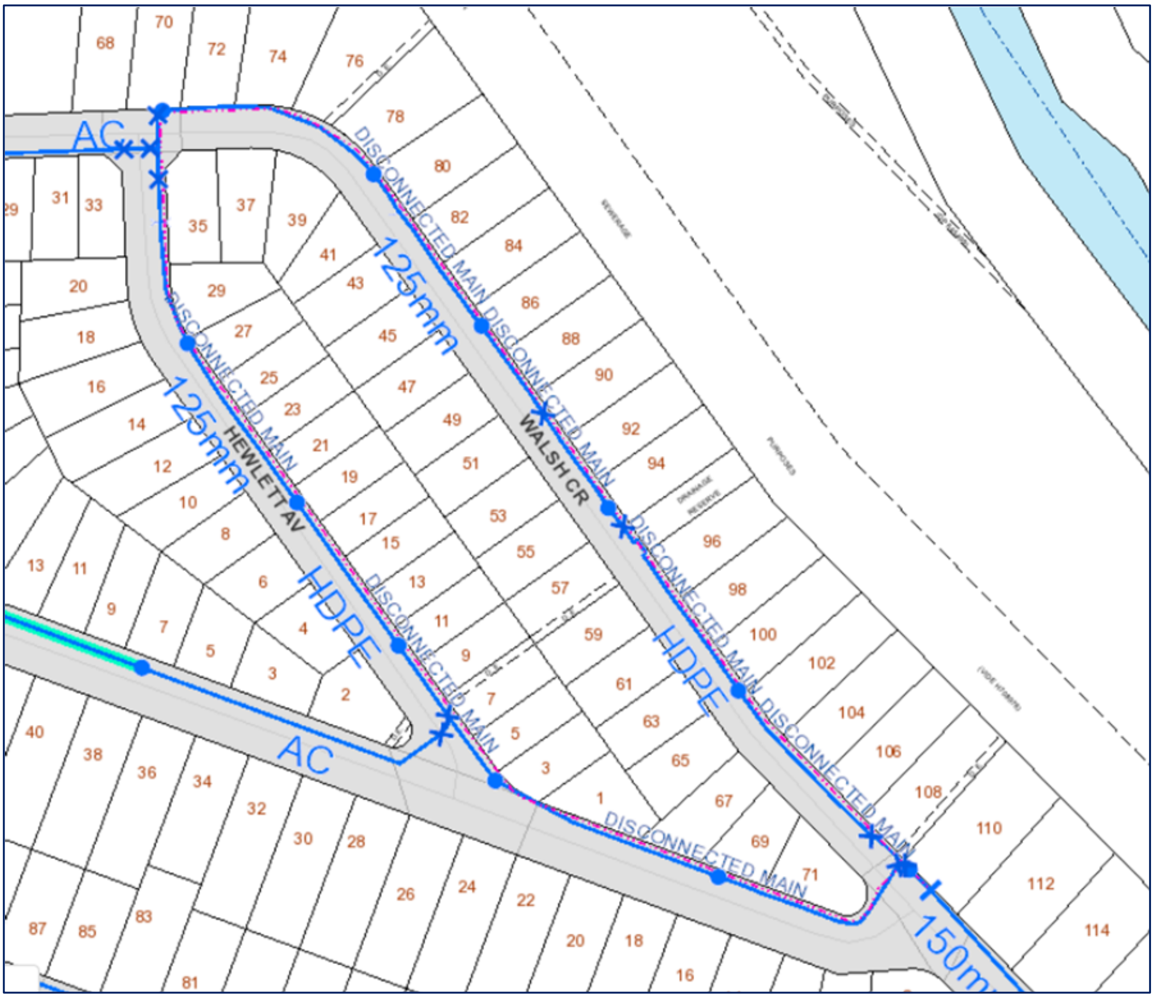
The GIS and asset information were updated to show both the new and disconnected main, as show in Figure 6.1.

Figure 6.1: Alignment of decommissioned AC pipe alongside the new alignment



Photos above: The worksite where Shoalhaven Water removed an AC pipe and replaced it with a new water main.

Figure 6.2: Updated GIS, showing the new main and decommissioned AC pipe in situ



Key Learnings	
	Removal of decommissioned AC mains in private land assists to reduce community risk
	Councils that are managing landfill may be able to provide reduced disposal costs for removed AC pipe
	Street trees planted over AC pipes contribute to an increase in water main failures as trees mature and grow Directional drilling can be made more difficult to control and complete due to rock
	Providing alternative water supply by temporary services minimizes impact to customers during construction of new alignment when replacing AC pipe
	All efforts must be made to remove broken and incomplete sections of AC pipe

7. Urban Utilities

The issue

Urban Utilities is a distributor and retailer of water and sewer services for the Councils of Brisbane, Ipswich, Lockyer Valley, Scenic Valley and Somerset in South East Queensland. It manages water supply and sewer reticulation systems for 1.4 million people, including 600,000 and 550,000 sewer connections. Of the 8800km of water mains it manages, 1320km are AC water mains that remain in operation.

Urban Utilities analysis of AC pipe failure history shows AC pipes installed prior to 1954 have a higher failure rate than those installed later.

In 2015/16 Urban Utilities replaced 7.95km of AC water main pipelines constructed between 1927 and 1954. These mains had 27 failures the previous year with 176 total failures which caused disruption to water supply and damage to driveways, verges and property.

Action taken

The Councils for the areas where Urban Utilities operates require AC pipe to be removed, limiting the water agency to using only the AC pipe removal and replacement method.

The removal and replacement method, also referred to as lift and relay, involves removing the existing AC alignment and replacing it with a new pipe. The main issues Urban Utilities encountered using this method to remove AC pips in 2015/16 were:

- **new driveways had to be cut in some instances to remove existing AC pipes,**
- **removing AC pipes without removing or damaging trees in the area, and**
- **impacts on water supply pressure if multiple streets were on by-pass at the same time potentially effecting the water supply for emergency services.**

To address these issues, the following actions were taken:

- **long by-pass lengths were often used**
- **Queensland Fire and Emergency Services were consulted to manage fire and water supply risks.**

At the completion of each AC pipe removal and replacement, the GIS was updated to reflect where the AC pipes were removed and the relay of the new pipes. If the GIS is a component of the asbestos register, this update would fulfil WHS requirements to keep the asbestos register up to date.

A benefit of being limited to the removal and replacement method of managing these AC pipes, was that it provided an opportunity for contractors to 'tool up' and become efficient and safe at removing the AC pipes and relaying the new pipes in a brownfield environment.

Key Learnings	Costs can be kept down by taking time to perfect the management method before carrying it out. Urban utilities estimated that costs were approximately only 30% above the cost of constructing a new pipeline on a new alignment.

8. Riverina Water

The Issue

Riverina Water County Council (Riverina Water) is a New South Wales local government utility based in Wagga Wagga, serving a population of approximately 78,000 people. Riverina Water manages water supply treatment plants, storages and reticulation with 24.8% of its operational pipeline network comprising AC pipes laid between 1935 and 1997.

Riverina Water doesn't have a specific AC pipe replacement program but includes them in its annual replacement program which uses a range of performance and condition criteria to determine priority of pipes for replacement.

The replacement program involves each water main being given a condition rating of 1 to 5, based on criteria including the number of pipe failures in the previous 12 months, pipe age, required maintenance and whether the pipe can meet demand capacity. Condition 1 water mains are in as new condition, whereas water mains in condition 5 are not in a serviceable condition (irreparable, not in service). Riverina Water does not have any active water mains in condition 5, so water mains in condition 4 are given the highest priority for replacement.

The Morven Reservoir to Morven Township water main (trunk main) was highlighted for replacement due to repeated pipe failures. The main supplies water to the Morven Township and surrounding rural properties which includes 79 water service connections. As this water main is the only trunk main feeding this area, every time this section of main failed, all the connected properties were without water supply for the duration of the failure and repair.

The project scope was to replace 7km of 150mm AC water main installed in 1940 and replace associated customer water supply service connections.

The AC water main was in both open farmland and bushland and had numerous road and creek crossings.

Action taken

By-passing with new alignment

After considering numerous options, by-passing and construction of a new alignment was selected. The new water main route would run adjacent to the old AC main (trying to maintain a consistent offset/alignment), except where established vegetation or structures were present. In these locations, a different alignment was selected to minimise environmental impacts.

The main issue with the project was dealing with multiple landowners regarding approval, access and maintaining safety for stock. Approval and access were handled through continual communication and consultation, whilst the safety of stock was achieved through coordination with the landowners, as well as ensuring open excavations were avoided or contained and barricaded appropriately.

All design and construction work was undertaken by Riverina Water's staff. During construction of the new water main, there was minimal interruption to the customers.

Most of the construction works were undertaken without any supply interruption. The only supply interruption was to cut-in the new mains (approx. 3 hours) and to transfer the services connected directly to this pipeline (14 services).

It was decided that the AC main was to be replaced using 150mm OPVC as a new pipeline on a new alignment, with the existing AC main to be left in ground. This decision was made due to cost, suitability, ease of installation and history. The road crossings were constructed in 150mm ductile iron cement lined pipes (DICL).

Due to the location and nature of the land, most of the new water main installation was done via trenching the new 150mm OPVC pipeline parallel to the existing AC main. This was a quick and efficient method of installation. The existing AC main was kept operating throughout construction, with the changeover completed once the new main was finished.

The road crossings were done via directional under-boring. This was to minimise the disturbance to the natural environment, and to minimise the interruption and inconvenience to residents by not impacting on the traffic flows or movements.

Riverina Water's policy relating to AC pipe is to leave any undisturbed material in the ground. Therefore, only 2 small sections (1 at either end) were removed (handled and disposed of appropriately), to make room for the cut-ins of the new main, and the remaining pipe has all been left in-situ. All exposed and broken sections of AC pipeline were removed by qualified and experienced staff, and later appropriately disposed of by authorised asbestos contractors.

The main approvals required were from the landowners of property where the water main was to be located. As the existing water main was located within private properties, there was no significant objection to the proposal for a new pipeline to be adjacent to the existing AC main, especially as the project would ultimately ensure a more reliable water supply and limit supply interruptions. Riverina Water also sought and gained approval from the local government authority (Greater Hume Council), to ensure the installation of the pipeline underneath/across the roadways was satisfactory and met with any specific standards or requirements.

The original budget for the project was $260,000. It was completed for $208,000, 20% under budget. This equates to $29.71 per metre to install 7 kilometres of 150mm oriented PCV pipe.

The only issue experienced upon completion of the project was to ensure that correct survey and capture of the pipeline and easement data was achieved. There was conflicting data around the location of existing easements, so extra work was required to reflect the new pipeline alignment and correct the easement locations at the same time.

Riverina Water completed the project under budget, on time, and improved the reliability of supply to customers. Riverina Water has not had any failures/incidents involving the new section of water main since the project was completed in early 2015.

Key Learnings	
	On rural land, AC mains (in use and decommissioned) can be managed in-situ if the location is recorded accurately on GIS and Asset Data, signage is installed on road crossings and fences along the route, and a suitable easement is created on private land to protect the alignment.
	Extensive stakeholder engagement and communication was required to ensure the project was delivered and completed to all parties' satisfaction. Communication with relevant agencies and customers was crucial to properly inform all stakeholders of the project, risk management, etc and gain necessary approvals and agreement.
	Cost effectiveness of Riverina Water's inhouse design and construction work practices assures affordability of provision of potable water to rural customers.

9. UnityWater

The Issue

UnityWater services an area spread over 9,275 km north of Brisbane, Queensland. The water agency provides water supply and sewerage services, including recycled water and trade waste disposal for approximately 16% of Queensland's population – a population of more than 829,000 people.

With a significant proportion of its water pipes being made of asbestos-cement (AC) – about 28% - UnityWater has developed an Asbestos Management Procedure to ensure that all activities involving ACM are identified and that controls are implemented to eliminate or minimise the risk of exposure to workers, visitors, public and others.

Action Taken

Implementation of an Asbestos Management Procedure

Key aspects of the Asbestos Management Procedure include:

Communication

Communication is an essential element of asbestos management practices at UnityWater. To keep the community informed about the management of asbestos water pipes, UnityWater uses a 'Working with Asbestos' Fact Sheet[9] as an engagement tool. The fact sheet provides relevant information and contact details to ensure that the community understands the protocols and practices being put in place.

Removal of damaged AC pipe

Where AC pipes are damaged in situ, UnityWater first considers whether removal is appropriate. If it is determined the AC pipe should be removed, UnityWater has trained workers with Class B asbestos removal licences who carry out the work. The removal of any AC pipe follows a methodological approach to ensure

Safe work practices

Working with asbestos

FACT SHEET

Unitywater's commitment

Our commitment to our customers is to safely provide water and sewerage services that continuously meet the needs of our growing communities.

Performing essential construction and maintenance works to ensure our networks are kept in a safe operating condition may involve handling material that contains Class B bonded asbestos. This class of asbestos does not pose a health risk to residents in proximity to our work sites.

In all our work with asbestos we comply with the compulsory safe work practices as set out by Workplace Health and Safety Queensland.

Protecting our community

We are committed to doing all that is reasonably practicable to eliminate or minimise risk for our workers and the community while maintaining our infrastructure in instances that involve asbestos. We:

- Establish an exclusion zone with a barrier around the asbestos removal area to prevent unauthorised entry;
- Erect appropriate signage on site; and
- Follow Queensland's Workplace Health and Safety Codes of Practice.

Contact us

- Visit www.unitywater.com
- Email ask.us@unitywater.com
- Phone Unitywater's Customer Service Centre on 1 300 0 UNITY (1 300 086 489) from a landline for the cost of a local call. Standard mobile phone call charges apply.

Safe work practices

Unitywater is fully compliant with Queensland's workplace health and safety laws for the handling of asbestos.

We enforce stringent safe work practices on all of our work sites:

- The Site Supervisor ensures all Occupational Health and Safety systems are in place and must have direct supervision at all times;
- Unitywater is licensed to remove B Class Asbestos and our employees are trained, experienced and follow the relevant safe work practices;
- Before handling any material that contains asbestos, it is thoroughly wetted down;
- The work site is barricaded to isolate it and prevent public access;
- Pipe work containing B Class Asbestos is manually broken up without cutting, to eliminate dust creation;
- All material is placed in the approved wrapping material for disposal; and
- Traffic management plans are implemented where necessary.

For further information:

- Call the Workplace Health and Safety Infoline on 1300 369 915
- Visit www.worksafe.qld.gov.au

Unitywater

[9] Available on Unity Water's website, Maintenance and renewal programs (unitywater.com).

all WHS requirements are complied with to ensure the risks of anyone being exposed to airborne asbestos fibres is minimised so far as is reasonably practical.

Alternative management methods where removal is not practicable

Removal of AC pipe is not always practicable, for example, in low-risk areas where ACMs are in good condition and the risk of asbestos exposure can be better managed by leaving the AC pipes in situ. In these instances, UnityWater will adopt alternative risk management methods after considering various factors including the condition of the asbestos, risks to health and safety, productivity and cost. These methods have included:

- enclosure: the creation of an airtight barrier around the asbestos which is subsequently documented in the Asbestos Management Plan.
- encapsulation or sealing: UnityWater treats encapsulation as an interim control measure which is supported through regular inspections by a competent person to identify if the asbestos requires removal due to damage or deterioration.

Sewer relining program

To extend the life of its sewerage infrastructure—which includes AC pipes—UnityWater invests in an ongoing sewer relining program, using ‘trenchless technology’. The process involves the use of technology to reline ageing sewer pipes to increase their structural integrity and reduce the risk of cracking and breakage. The non-destructive nature of this relining method means it is an appropriate method for rehabilitating AC pipes.

In the first instance, cameras are used to assess the sewer network, identifying areas of degradation that are subsequently targeted for relining. The remediation work is then undertaken across two phases. Firstly, manholes showing signs of deterioration are sprayed with a special coating to restore them to their prior level of performance. This method can be done directly into the manhole without the need for excavation and removal.

Secondly, pipe areas targeted through the camera investigation are repaired using innovative trenchless relining methods to correct faults, rather than being replaced. This is a ‘no-dig’ and cost-effective way of renewing the pipe. In most cases, the new pipes are formed on site by taking a continuous strip of profile and spirally winding it inside the damaged pipe, forming a new, watertight structural pipe within the host pipe.

Photo: Manholes, showing signs of deterioration, being repaired. A special coating is applied to restore them to original condition.

Photo: AC pipes being repaired via trenchless technology.

Key Learnings	
	An asbestos management policy can assist a water agency to ensure it is appropriately managing all AC water pipes.
	Open and proactive communication with the community is beneficial for a water agency is addressing concerns of the surrounding community.
	Using trenchless technology a no-dig, cost-saving pipe renewal process will help prolong the life of UnityWater's sewer network, defer the need for expensive infrastructure upgrades and minimise any inconvenience for customers.
	Relining pipes and rehabilitating manholes reduces the amount of groundwater infiltration entering the sewer via pipeline cracks or faulty joints, enabling UnityWater to better manage sewage flows, especially in times of extreme wet weather.

Appendix A: Central Coast Council Condition Assessment Report (2015)

Pipe Sample Condition Assessment Report

DN 150 Class C Asbestos Cement Pipe – Sewage Rising Main

Assessed Grade 4 – Poor Condition

Location:	143 Ocean View Drive, Wamberal, New South Wales	
GPS Co-ordinates:	E 355459, N 6300138 (Geocoded by Opus)	
Client Name:	Gosford City Council, C/o Detection Services	
Client Contact:	Steve Simmons (Detection Services)	
Sample Number:	15.094 AC	
Opus Reference:	3C1174.15 / 001CE	Client Asset ID: 3000437

Executive Summary

- The pipe sample assessed is a DN 150 Class C Asbestos Cement pipe
- This pipe sample is assessed as being at the upper end of **Grade 4 – Poor Condition**
- This pipe has a very low risk of pressure failure due to deterioration before 2023
- It is recommended that this sewage rising main is programmed for renewal in approximately 2030 or earlier if the consequences of failure are unacceptable
- We recommend that a pressure logger is installed for 12 to 24 hours (logging at 1 second intervals or less) to determine the peak surge pressures on pump start and stop. The results should be allowed for in the design of a new sewage rising main

General Description

Table 1 - Pipe and Service Details

Pipe Details		Service Details	
Pipe Material	Asbestos Cement	**Year of Installation**	Reported as 1978
Pipe Diameter (DN)	150	**Operating Pressure (m)**	Reported as 20 @ PSC12
Pipe Pressure Class	Class C	**% of Pressure Class**	~ 22 %
Pipe Manufacturer	Fibrolite (Assumed)	**Sample Extracted**	2015 (Assumed)
Pipe Purpose	Sewage Rising Main	**Pipe Jointing System**	Supertite (Assumed)
Sample Length (mm)	304	**Assessment Date**	10 / 2015
Comment: *Logged pumping pressure was not available for this assessment.*			

Table 2 - Cover and Bedding Details

Depth of Cover and Pipe Bedding Material		Observation / Comments
Depth of Cover (m)	≈ 1 m	*As per drawings provided. Pipe sampling site report not completed*
Bedding Material	Sand	*As per pipe sampling site report*
Ground Surface	Footpath	*As per pipe sampling site report and location plan*

Dimensional Compliance

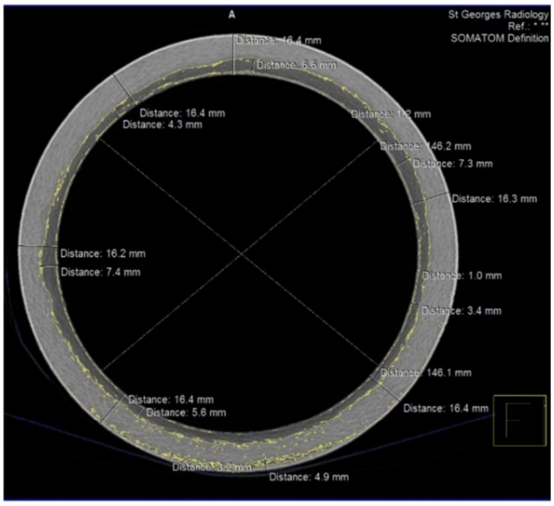
Table 3 – Dimensional Compliance

	Observed	AS 1711-1975 Class C	Comments
Mean OD (mm)	179.0	177.3 ± 3.0 (174.3 – 180.3)	*Within tolerance for a DN 150 Class C pipe*
Mean ID (mm)	146.2	146.3	*Within tolerance for a DN 150 Class C pipe*
Wall Thickness (mm)			
Mean	16.4	15.5	*Within tolerance for a DN 150 Class C pipe*
Range	16.1 – 16.9	≥ 15.5	
Standards Comment: *The pipe sample is dimensionally compliant with AS 1711-1975, for a DN 150 Class C Asbestos Cement pipe (design pressure of 90 m). Our measurements gave a mean wall thickness of 16.4 mm (6 measurements in total).*			

Deterioration Measurements

<u>Table 4 Pipe Wall Deterioration Measurements</u>

Scan Image 74



Pipe Wall Deterioration Measurements	
External Det'n Min – Max (mm)	0.0 – 4.9
Max External Det'n Rate (mm / yr)	0.132
Internal Det'n Min – Max (mm)	3.4 – 7.4
Max Internal Det'n Rate (mm / yr)	0.200
Combined Det'n (mm)	12.3
Max Yearly Rate of Deterioration (mm / yr.)	0.332
Comparison with NZ Average for AC Sewage Rising Mains (% Faster / Slower)	4 % Slower

Comments: *Top of pipe 'as laid' was not marked during pipe sample recovery. Both the external and internal deterioration on the pipe sample were highly variable.*

Condition Assessment Results and Interpretation

Assessed Pipe Class, Deterioration and Condition Grade:

This pipe sample has been assessed as a DN 150 Class C Asbestos Cement pipe. Class C pipe had a maximum recommended working pressure of 90 m head.

The CT scan shows exterior deterioration up to 4.9 mm. Interior surface deterioration varied between 3.4 mm and 7.4 mm with signs of possible future delamination at 1.0 mm – 1.2 mm.

The internal deterioration is significantly variable (>2.0 mm range) which is not uncommon for a sewage rising main and may be a result of hydrogen sulphide corrosion.

The AC pipe deterioration model has calculated (based on the reported installation year of 1978, reported operating pressure of 20 m, and a surge factor of 1.5) that the pipe could be at risk of first pressure failure due to deterioration from 2023. This pipe sample is assessed as being at the upper end of **Grade 4 – Poor Condition.**

Crush Test:

The pipe sample was tested for ultimate crushing strength using the method given in AS 1711-1975, Appendix D. The pipe sample was longer than the standard length of 300 mm by approximately 4 mm.

The lab test results are attached as Appendix A. Note that the Opus Christchurch laboratory is not formally accredited for this test, but the test was carried out in accordance with the requirement of the standard using calibrated testing equipment.

The ultimate crushing strength for this pipe sample was calculated at 58.1 MPa which is ~12 % greater than the minimum requirement for a new AC pressure pipe manufactured to AS 1711-1975.

This test serves to confirm that the material strength of the pipe (with respect to crushing) is greater than the minimum crushing requirements for a new pipe.

Pipe Sample Observations:

As received, the pipe sample was wet. A large gouge was present on the machined spigot. This was likely to have occurred during the recovery of the pipe sample.

The external surface was very hard and no manufacturer's marking were visible. The internal surface was also very hard with dark red-brown staining and a thick black deposit (which is common for sewage rising mains).

The observed roller pattern and pipe sample dimensions confirm that the pipe sample is a Fibrolite pressure pipe manufactured by James Hardie & Co.

The high value of the crushing strength of the sample, combined with the observed "hardness" of the pipe, serves to confirm that even the deteriorated part of the pipe wall has significant remaining strength.

Renewal Planning:

The consequences of failure for this sewerage rising main should be considered carefully and taken into account for the prioritisation of renewal works. Failure of a sewerage rising main within an urban area will usually attract media attention and early renewal is usually preferred compared to allowing the pipeline to run-to fail.

AC pipes can fail due to causes other than deterioration of the pipe wall matrix. Such causes of failure can include; extreme pressure surges, bending forces (due to earth movement e.g. expansive clays, subsidence, settlement, tree root growth or earthquake), surface loads (e.g. heavy traffic or construction equipment), third party activities or failure of pipe fittings.

As all pipes deteriorate, their strength diminishes and they become more susceptible to failure due to the loads applied to the pipe.

Conclusions and Recommendations

Our conclusions and recommendations are based on the assessed pipe sample's condition (deterioration) being a typical reflection of the pipes in this rising main.

Pipe Condition Assessment Conclusions:

- The pipe sample assessed is a DN 150 Class C Asbestos Cement pipe
- This pipe sample is assessed as being at the upper end of **Grade 4 – Poor Condition**
- This pipe has a very low risk of pressure failure due to deterioration before 2023

Renewals and Data Collection Recommendations:

- It is recommended that this sewage rising main is programmed for renewal in approximately 2030 or earlier if the consequences of failure are unacceptable
- We recommend that a pressure logger is installed for 12 to 24 hours (logging at 1 second intervals or less) to determine the peak surge pressures on pump start and stop. The results should be allowed for in the design of a new sewage rising main
- In future, consider the following as part of the pipe sample recovery:
    - Complete a "Site Report & Sampling Form" in full
    - Include a photograph and description of the pipe bedding material
    - Obtain GPS co-ordinates of the pipe sample's location
    - Mark the top of pipe 'as laid'. Options the contractor may consider include, though not limited to, are drilling a small hole of 5 - 6 mm in diameter, using spot / stripe of dazzle paint or use or a wax crayon if the pipe is wet
    - Take a photograph of the exposed pipe in the trench and forward the electronic file

Assessed By

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Reviewed By

JRBlack

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APPENDIX A: CRUSH TEST

AC Pipe Crush Test Report

Project	Pipe Condition Assessment 2015	**Project No.**	3C1174.15
Location	143 Ocean View Drive, Wamberal	**Sample #**	15.094 AC
Client	Gosford City Council		
Date sampled	2015 (Assumed)		
Sample description	DN 150 Class C AC pipe		

Test Results

Age at Recovery (yrs)	37		**GCC Ref**	3000437
Mean ID (mm)	146.2		**Year Installed**	1978
Mean OD (mm)	179			
Mean thickness (t) (mm)	16.4			
Length (L) (mm)	304			
Mean Radius (R) (mm)	81.3			
Crushing Load (W) (N)	30600	101 kN/m		
Ultimate Strength (f) (MPa)	58.1			
Standard Requirement (f) (MPa)	51.7	AS 1711-1975		
% of Minimum Requirement	112.3			

Comments

The failure was a brittle fracture and it failed with two distinct "bangs" as fractures occurred vertically and horizontally.

Test Method

Tensile Strength AS 1711-1975 (Appendix D) $f = (1.9 * R * W)/(L * t^2)$

Date Tested: 29/09/2015
Date Reported: 29/09/2015

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