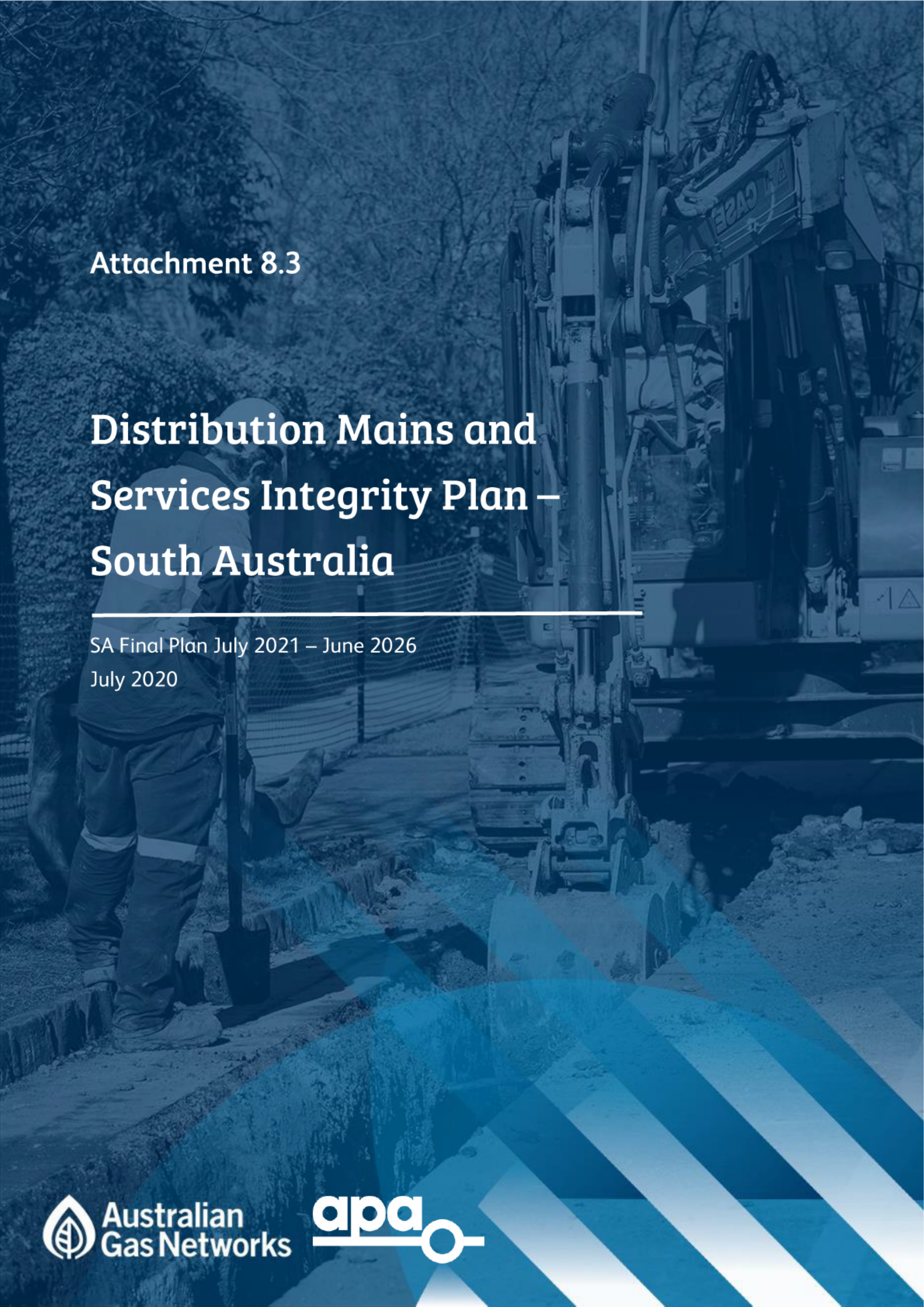

Attachment 8.3

Distribution Mains and Services Integrity Plan – South Australia

SA Final Plan July 2021 – June 2026

July 2020

Australian Gas Networks

apa

Prepared by	
Keith Lenghaus	Acting Manager, Asset Strategy and Planning

Reviewed by	
Martijn Vlught	Manager, Asset Planning

Approved by	
Craig Bonar	Head of Engineering and Planning, APA
Mark Beech	General Manager Network Operations, AGN

Contribution from	
Robin Gray	State Operations Manager
Jason Morony	Capital Delivery Manager
Troy Praag	Head of Strategy and Planning, AGN
Brooke Palmer	Senior Regulatory Advisor, AGN

Distribution list	
Edwin DePrinse	Group General Manager Networks, APA
Craig de Laine	General Manager People and Strategy, AGN
Ben Wilson	Chief Executive Officer, AGN

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1. Executive Summary

The Distribution Mains and Services Integrity Plan (DMSIP) for our South Australia distribution network (our Network) outlines the program of work we undertake to manage network performance and integrity on a rolling five-year basis. Within the DMSIP work program, there are four programs of work. The largest of these is commonly referred to as our mains replacement program (MRP). The others are our inline camera inspection, multi user service replacement and condition and performance monitoring.[1]

We will invest $264 million[2] (direct, unescalated $2019/20) in our DMSIP work program for the next Access Arrangement (AA) period (1 July 2021 to 30 June 2026) to undertake:

- 870 kilometres of block and piecemeal mains replacement;
- 457 service replacements at multi user service (MUS) sites;
- 316 kilometres of inline camera inspections and reinforcement of mains;
- 2,450 reactive service replacements that are forecast to be required separate to the annual mains replacement program (non-AMRP service replacement); and
- Continued monitoring of the condition and performance of all other mains to determine the need for replacement into the future.

This DMSIP work program follows on from a similar work program which will be delivered in the current AA period (1 July 2016 to 30 June 2021) at a total forecast investment of $272 million[3] (direct, real $2019/20) and includes:

- 1,059 kilometres of block and piecemeal mains replacement;
- 233 service replacements at MUS sites;
- 310 kilometres of inline camera inspections and reinforcement of mains;
- 2,749 reactive service replacements that have been required separate to the annual mains replacement program; and
- Continued monitoring of the condition and performance of all other mains.

1.1. The DMSIP captures our processes and commitments to managing our Network

The DMSIP is used to document our commitment to act in accordance with accepted good industry practice to maintain and improve the safety of gas distribution services at the lowest sustainable cost.

The DMSIP outlines:

- The process undertaken to develop the DMSIP work program;

[1] Condition and performance monitoring is an operating expenditure activity, so all costs relating to this program are excluded from total (capital) expenditure noted within this document
[2] Note that within this total is an allowance for piecemeal replacement activity of $6 million, which is treated as an operating expense
[3] Note that within this total is an allowance for piecemeal replacement activity of $5 million, which is treated as an operating expense

- Our obligations and responsibilities under law and regulations;
- The program forecast to be delivered in the current AA period (1 July 2016 to 30 June 2021); and
- The program planned for the next AA period (1 July 2021 to 30 June 2026).

The objective of the DMSIP work program is to manage the integrity of our Network by minimising risk to public safety and reliability in a sustainably cost efficient manner, i.e. maintaining services at the lowest sustainable cost. Core activities within this program of work include:

- Block and piecemeal mains and service replacement;
- Inline camera inspections and reinforcement of mains; and
- Monitoring and inspection programs to assess the condition of mains and the need for replacement into the future.

The planning and prioritisation of these activities consider:

- Available condition and performance information including reports of leaks and leak repairs, other material failures, incidents of water in mains or Gas in Buildings (GIB), age and other mains specific data;
- Our capacity to efficiently deliver the required works; and
- The operational and financial impact of delivery.

This DMSIP covers a five-year period to (i) align with the regulatory cycle frequency and (ii) review the process for establishing service and outcome expectations and revenue. It is reviewed annually to ensure new information and experience, and associated modifications to the program, are captured. These annual updates are submitted to our safety regulator, the Office of the Technical Regulator (OTR) of South Australia.

Our proposed DMSIP work program for the next AA period continues the strong performance of the current AA period.

We will continue to focus on replacing the highest risk assets which remain in our Network in a manner that is consistent with the actions of a prudent and efficient service provider, best meets the National Gas Objective (NGO) as it addresses the inherent Network risk, using a combination of risk treatments that minimises asset replacement in the short term, and allows for prudent asset management over the long term.

Our customers will benefit from maintained safety of the network with minimal cost impact.

We will continue to focus on delivering for our customers, through improved technical and commercial outcomes supporting sustainable cost efficiency as we aim to be the leading gas infrastructure business in Australia by achieving top quartile performance on all of our key targets.

1.2. Our plan for the next AA period

A total of 870 kilometres of mains will be replaced in the next AA period. In addition to the replacement of mains we will continue the inline camera inspection and reinforcement of 316 kilometres of high density polyethylene (HDPE) mains and replace 457 of the highest priority MUS. We will also continue to monitor the condition and performance of all other mains and services to determine the need for replacement into the future.

The forecast cost of this program is $264 million dollars,[4] which is $8 million lower than the program delivered in the current AA period. The key reasons for this are:

- Lower total volumes of mains replacement, inline camera inspection and reactive service replacements, offset by;
  - Higher average costs of replacement across the program driven by new internal and external requirements (such as meter compliance and the requirements of other utilities when undertaking work near their assets) which have introduced additional costs to our mains replacement activities only experienced for the last year or so of the current AA period; and
  - A greater proportion of our smaller diameter HDPE in the next AA period will require direct bury replacement which is higher effort (an estimated 50% more labour required based on contracted prices) and more expensive per metre than insertion which we have been able to use for most of our mains replacement to date; and
- Higher total volumes of MUS replacement.

By June 2026, we will complete the replacement of all remaining high risk cast iron (CI), unprotected steel (UPS) and other low pressure mains in our South Australian distribution network, effectively removing LP from our Network.[5] This is a significant safety milestone for our business, modernising our Network to consist of steel and plastic mains has the added benefit of contributing to the readiness of our Network for hydrogen.[6]

Throughout this document, when we refer to CI/UPS - block, we are referring to a block replacement program primarily driven by risk reduction linked to CI and UPS materials.

Our commitment to deliver the most efficient and prudent mains replacement outcomes, in line with industry best practice, means we undertake our CI/UPS replacement on a block basis.

Although mains replacement is usually adopted to address a particular mains material type, with block replacement, other mains may also be replaced where they are interspersed or islanded as a result of prior repairs. This is more efficient and much less expensive than attempting multiple small lengths of replacement by direct burial (size for size) and, in some cases, the condition of the other mains may also warrant replacement. For example, when replacing CI and UPS mains, some adjoining PE may also be replaced to maintain or improve the integrity of the section being replaced.

Replacement of individual customer services, service risers, other material (polyethylene) sections and associated meter set rebuilds can all occur as part of this block program. This is consistent with prior periods.

The polyethylene sections included in our CI/UPS program are interspersed or islanded within the CI/UPS network so it would be inefficient not to undertake their replacement as part of the block replacement program.[7]

The DMSIP work program for the next AA period by asset category is presented in Table 1.

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[4] All cost estimates in this plan are direct costs (excluding overhead) presented in real dollars of December 2019 and do not include real cost escalation, unless otherwise stated. The methodology is described in Section 5 with additional information provided in Attachment 8.9 - Unit Rates Report

[5] The only remaining LP in our Network post 2026 will be the newly installed 7Kpa mains in the CBD

[6] For further information about our decarbonisation focus, please see our SA Final Plan July 2020

[7] Any identified variance in opening inventory or replacement totals for the CI/UPS block program can be reconciled to the multiple material types included in the block program.

Table 1: DMSIP work program proposed – next AA period (July 2021 to June 2026)

Asset Category	Untreated Risk[8]	Proposed Treatment	Opening inventory	Closing inventory	Treated Risk
Mains replacement					
CI/UPS - block (km)[9]	High	Replace	558	0	Low
HDPE 250 - remaining (km)	High	Replace	14	0	Low
HDPE 575 DN50 - HP (km) [10]	High	Inspect	57	0	Intermediate (ALARP)
HDPE 575 DN50 - MP (km)	Intermediate	Inspect	259	0	Intermediate (ALARP)
HDPE 575 DN40 (km)	Intermediate	Replace	447	159	Intermediate (ALARP)
Inline camera inspection					
HDPE 575 – inspected (km)	Intermediate	Monitor	310	626	Intermediate (ALARP)
Service replacement					
MUS replacement (units) [11]	High	Replace	457	0	Low

Note: 10 kilometres of reactive (piecemeal) mains replacement and 2,450 reactive service replacements are also forecast in the period.

1.3. Current AA period

A total of 1,059 kilometres of mains will have been replaced in the current AA period. This compares to 1,072 kilometres allowed in the AER's final decision in April 2016. The key reason for this minor variance is that the approved program included 20 kilometres of reactive replacement but we forecast to complete just 7 kilometres of reactive replacement in the period. In addition to the replacement of mains – which was the focus for the current AA period – a further 310 kilometres of mains will have been inspected with the use of an inline camera. 233 MUS will also be replaced.

The expected cost for the period is $272 million, which is $58 million (18%) less than the AER's final decision of $330 million (direct and inclusive of real cost escalation). The reduced cost is due to:

- Savings made by achieving lower than forecast unit rates for:

[8] Throughout this paper, the term 'untreated risk' refers to the current risk with all normal BAU controls (most notably inspections) but without the addition of other targeted risk mitigation programs

[9] Throughout this paper, the term 'CI/UPS – block' refers to all remaining mains in the LP network (to the specific exclusion of the new CBD LP mains) which includes mains of material other than CI/UPS

[10] Note that while high pressure HDPE 575 DN50s untreated risk is rated as high, the inspection and reinforcement treatment of these mains reduces this risk to intermediate. It is subsequently assessed as ALARP as the cost to further reduce the residual risk of these mains to low is not considered proportionate to the reduction in risk. This is discussed in more detail in Sections 3 and 4

[11] Note there are also Intermediate and Low risk MUS in our Network, but replacement of these is not proposed for the next AA period. They will remain at Intermediate and Low risk through to 2026, with Intermediate considered ALARP thanks to the introduction of additional controls.

- Block CI, UPS and other replacement in 2016/17;
- HDPE 250 replacement across all years to date;
- HDPE 575 replacement in 2017/18 and 2018/19; and
- Many of the CBD block replacement work packages in the current AA period to date, along with;

- Lower than forecast (and lower than historical average) volume of piecemeal replacement required.

The completion of the CBD replacement by the end of the current AA period will remove all extreme risk mains from our Network, with the last 8 kilometres of CBD mains due to be removed in 2020/21. This is a significant safety milestone for our business and delivers against our commitments made to the OTR and in our AA submission in 2016 to remove the highest risk rated assets in the Network, as a priority.

Table 2 provides a summary of the actual and allowed volume of mains replacement for the current AA period by asset category.

Table 2: Actual versus allowed volume – current AA period (kilometres)

Asset Category	Risk	Opening inventory	Actual volume	Allowed volume	Variance	Closing inventory
Mains replacement[12]						
CI/UPS CBD Mains (km)	Extreme	53	53	44	9	0
CI/UPS Trunk Mains (km)	Extreme	59	59	62	(3)	0
CI/UPS – LP (km)*	High	839	288	307	(19)	550
CI/UPS – MP (km)*	High	12	4	-	4	8
HDPE 250 (km)	High	305	291	180	111	14
HDPE 575 (km)	High	1,430	357	479	(119)	743[13]
Inline camera inspection						
HDPE 575 – inspected (km)	High	0	310	440	(130)	310
Service replacement						
MUS replacement (units)	High	633	176[14]	1,328	1,152	457

* Together these form "CI/UPS – block" and refer to all remaining mains in the LP network (to the specific exclusion of the new CBD LP mains replaced in the current AA period) which includes mains of material other than CI/UPS

[12] Note that 7 kilometres of reactive (piecemeal) mains replacement is also forecast in the period
[13] Note that 310 kilometres of these mains are now reflected in 'HDPE 575 – inspected' category
[14] Note that 233 MUS replacements were done in total, but 176 of those were priority group 1, High risk

1.4. We continually seek efficient and effective options to manage mains risk

We had a total of 8,140 kilometres of distribution mains in our Network as of July 2019. Our Network contains several different material types and pressures and was laid at varying times. We closely monitor the condition and performance of our mains to understand the risk they pose to public safety and reliability and take measures to reduce this risk to as low as reasonably practical (ALARP). Our MRP is one of the key risk mitigation activities we undertake.

We forecast that there will be 1,645 kilometres of high and intermediate risk mains remaining in our Network by 30 June 2021.

We will continue to prioritise the replacement and inline camera inspection and reinforcement (where it is technically feasible and an effective alternative to replacement) for our at risk mains. Our approach to prioritisation is discussed in Section 59.

The current AA period has been characterised by the effective use of inline inspection. This method involves inserting a camera in the mains to visually locate squeeze-off damage points to assess whether reinforcement with a stainless steel mechanical clip could be an effective alternative to replacement. This method has been shown to be effective to minimise gas release from Slow Crack Growth (SCG) in HDPE 575 mains with diameters of at least 50 millimetres deferring the need to replace these mains by an estimated 10 years. Therefore, the program for the next AA period will continue the use of this method to mitigate risk for HDPE 575 mains to achieve a risk that is ALARP.

The program for the next AA period is to include the replacement of 870 kilometres of mains at a cost of $244.2 million and the inspection and reinforcement of 316 kilometres of mains, at a cost of $8.2 million. This program is expected to eliminate all remaining high risk mains from our Network by the end of June 2026, leaving just 159 kilometres of intermediate risk mains to replace along with 626 kilometres of HDPE 575 DN50 mains that will have been inspected and reinforced to achieve a rating of ALARP. These HDPE DN50s are forecast for replacement from 2027 onwards.

1.5. We have revised our approach to improve our management of MUS risk

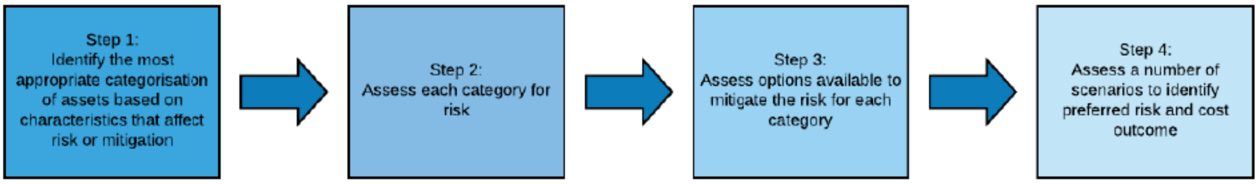
The plan for the current AA period was to replace 1,328 Low Pressure Multi User Services (LP MUS). This estimate was based on assumptions regarding the MRP undertaken in the 2004 to 2012 period. During this period, LP MUS were only replaced as part of the MRP if they failed a safety (pressure) test. As a result of this policy, 1,328 LP MUS remained in our Network. For the current AA period, these were identified as high risk based on a range of issues including age, condition, location and history of water ingress and replacement based on prioritisation of suburb was allowed.

During the current AA, we undertook a desktop review and site survey of all MUS (pre and post 2004) and selected a sample to be replaced, to inform the prioritisation of the MUS replacement program. This process revealed that replacing MUS by suburb would result in the unnecessary replacement of lower risk assets. The improved information supported the categorisation of MUS in to three risk based categories, prioritised for replacement depending on an assessment of age, public safety, supply security and compliance. We also introduced additional controls to monitor the priority groups 1 and 2 more closely until replacement is done. Our program for the next AA period will replace priority group 1 MUS at a cost of $6.8 million, with priority group 2 expected to be replaced in the subsequent period, and priority group 3 replacement remaining subject to monitoring.

1.6. Our program aims to achieve an appropriate risk reduction for the least cost to consumers

We have followed a similar four step approach to develop our DMSIP work program for the next AA period to that used in previous periods and for our other distribution networks as illustrated in Figure 1. The approach identifies and assesses different categories of assets based on risk drivers and mitigation options and then considers options to achieve the target level of risk at an efficient cost.

Figure 1: Our approach to developing our mains replacement program



1.6.1. Assessing and reducing risk for each category of asset

We have modified the categories of assets in developing the program for the next AA period to reflect better information on key characteristics which drive risk and management over the period.

For example, HDPE 575 mains have been split into different categories based on diameter, pressure and whether they have been subject to our in-line inspection program. The CI/UPS and HDPE mains are referred to as 'remaining' as those at highest risk were replaced in the current AA period.

Table 3 presents the categories of mains adopted for the next AA, the risk rating under AS/NZS 4645 and recommended risk treatment in the next AA period.

Table 3: Mains categories and associated risk and risk mitigation (treatment) in the next AA period

Mains category	Inventory July 2021 (km)	Untreated Risk	Treatment in next AA	Treated Risk
CI/UPS - block[15]	558	High	Replace – remove from Network	Low
HDPE 250 - remaining	14	High	Replace – remove from Network	Low
HDPE 575 DN50 - HP	57	High	Inspect and reinforce	Intermediate (ALARP)
HDPE 575 DN50 - MP	259	Intermediate	Inspect and reinforce	Intermediate (ALARP)

[15] As noted in Section 1.2, other LP materials such as HDPE 250, HDPE 575 and New PE are also included in this program

Mains category	Inventory July 2021 (km)	Untreated Risk	Treatment in next AA	Treated Risk
HDPE 575 DN40	447	Intermediate	Prioritised replacement – remove 288km from Network and monitor remaining 159km	Intermediate (ALARP)
HDPE 575 DN50 inspected	310	Intermediate (ALARP)	Monitor only	Intermediate (ALARP)

As outlined earlier, we have three categories of MUS based on the risk assessed priority for replacement.

Table 4 presents the categories, risk rating and proposed risk treatment in the next AA period.

Table 4: Multi User Site categories and associated risk and risk mitigation (treatment) in the next AA period

Service category	Inventory July 2021 (sites)	Untreated Risk	Treatment in next AA	Treated Risk
MUS - Priority group 1	457	High	Replacement	Low
MUS - Priority group 2	1,653	Intermediate (ALARP)	Continued additional monitoring and leak survey activities and awareness campaign	Intermediate (ALARP)
MUS - Priority group 3	361	Low	Monitor only	Low

The approach to rating the risk of each asset category is presented in Section 3.

1.6.2. Achieving the target risk at an efficient cost

To determine the program that achieves the targeted risk outcome at an efficient cost, we considered a number of scenarios of varying risk outcomes. Under all scenarios, regular inspection (e.g. leak survey) and reactive (piecemeal) replacement when required is assumed to continue. The scenarios assessed are as follows:

- Scenario A: Complete established programs only – this program replaces only the remaining CI/UPS block and HDPE 250 mains;
- Scenario B: Achieve low risk – this program removes all high and intermediate risk assets from our Network;
- Scenario C: Remove all high risk – this program removes all high risk mains and priority 1 MUS;
- Scenario D: Maintain ALARP for all mains and MUS – this program removes all high and intermediate risk mains unless they can, or have been, inspected through the inline inspection program and removes all priority group 1 MUS;
- Scenario E: Efficient ALARP for all mains and MUS – this program is the same as Scenario D except it takes a prioritised approach to replacing HDPE 575 DN40 mains, deferring the replacement of some of these mains until the subsequent AA period as the incremental cost of

replacing all these mains is not proportionate to the incremental reduction in risk. This is the recommended scenario.

The volume of assets to be replaced or inspected under the inline camera inspection program is shown in

Table 5 with the cost and residual risk for each scenario.

Table 5: Scenarios considered for next AA period

Asset Category	km in network	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E (preferred)
Mains replacement						
CI/UPS - block[16]	558	558	558	558	558	558
HDPE 250 - remaining	14	14	14	14	14	14
HDPE 575 DN50 - HP	57	-	57	57	-	-
HDPE 575 DN50 - MP	259	-	259	-	-	-
HDPE 575 DN40	447	-	447	-	447	288
HDPE 575 DN50 inspected	310	-	310	-	-	-
Piecemeal	-	60	10	40	10	10
Total km replaced		**632**	**1,655**	**669**	**1,029**	**870**
Inline camera inspection						
HDPE 575 – inspected (km)	310	-	-	-	316[17]	316
Total km inspected/reinforced		**-**	**-**	**-**	**316**	**316**
Service replacement						
MUS – Priority group 1	457	125	457	457	457	457
MUS – Priority group 2	1,653	-	1,653	-	-	-
MUS – Priority group 3	361	-	-	-	-	-
Total MUS replaced (sites)	**-**	**125**	**2,110**	**457**	**457**	**457**
Non AMRP MUS	470,000+	2,450	2,450	2,450	2,450	2,450
Risk at June 2026		High	Low	Intermediate	Intermediate (ALARP)	Intermediate (ALARP)
Total capex ($ million)[18]		**$197.1**	**$467.4**	**$203.7**	**$300.6**	**$259.1**
Cost to customers ($ million)[19]		**$14.3**	**$33.1**	**$14.8**	**$21.0**	**$18.3**

[16] As noted in Section 1.2, other LP materials such as HDPE 250, HDPE 575 and New PE are also included in this program

[17] 316km = 57km of HDPE 575 DN50 HP + 259km of HDPE 575 DN50 MP

[18] Note there is no inclusion of non AMRP in these capex totals as their cost and impact is unchanged across all scenarios.

[19] This reflects the cost to customer over the 5 years of the next AA period only and does not consider the impact over future periods.

Asset Category	km in network	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E (preferred)
Cost per customer per annum($)[20]		$5.94	$13.72	$6.13	$8.72	$7.57

The program for the next AA period reflects Scenario E. This program will achieve an intermediate risk rating at the end of the period that is considered ALARP because the cost of reducing the risk rating to low is disproportionate to the reduction in risk. Further, the cost of replacing the lower priority HDPE 575 DN40 mains within the period is not proportionate to the risk reduction achieved of replacing those remaining mains. This program achieves ALARP at an efficient cost to customers.

Scenario A and C do not achieve low or ALARP risk rating to comply with our obligations to manage identified risk on our Network. Scenario B achieves a low risk rating, but at a significant cost to the customer. Scenario D achieves ALARP but also at a higher cost than Scenario E.

As a result of the plan for the next AA period, we expect to reduce the risk associated with our at risk mains and services to low or intermediate (ALARP). This means the mains replacement program of the subsequent AA will complete the replacement of the remaining 159 kilometres of HDPE 575 DN40s not replaced in the next AA period and then move focus to the replacement of ageing mains consistent with their expected useful life, condition and performance, as well as the replacement of mains which have been inspected and reinforced in recent periods which will need to be replaced an estimated 10 years after reinforcement.

Our proposed DMSIP work program is consistent with the actions of a prudent and efficient service provider, acting in accordance with accepted good industry practice to maintain and improve the safety of gas distribution services at the lowest sustainable cost. The proposed program best meets the National Gas Objective (NGO) as it addresses the inherent Network risk, using a combination of risk treatments that minimises asset replacement in the short term, and allows for prudent asset management over the long term. Customers will benefit from maintained safety of the network with minimal cost impact.

The following sections provide further information as follows:

- Section 2 describes our mains and services in terms of condition and our approach to managing the condition of assets consistent with our obligations and requirements.
- Section 3 outlines our risk assessment approach and outcomes including the likelihood and consequence of an incident occurring for each category (and subcategory) of assets and risk mitigation options.
- Section 4 presents the options we assessed in terms to determine our plans for the next AA period that delivers an optimal balance of risk reduction and cost for customers.
- Section 5 presents our cost estimation methodology, comparisons with the work program delivered in the current AA period and the impact on our customers.

[20] This reflects the average cost to a customer each year over the 5 years of the next AA period.

2. Mains and services condition assessment and management options

This section identifies the inventory in our Network and provides a description of each mains category, the condition and mitigation options available to best manage each category and our obligations and responsibilities to manage the assets' condition.

2.1. Distribution mains

There were 8,140 kilometres of distribution mains in our Network as at July 2019. These mains consist of different material types, with diameters ranging from 15mm up to 900mm, which operate at different pressures.

As shown in Table 6, material types include cast iron (CI), unprotected steel (UPS), older high density polyethylene (HDPE 250, HDPE 575), new generation polyethylene (PE 100 and PE 80), protected steel (PS) and copper. Pressure varies from 2kPa to over 350kPa across our Low, Medium and High pressure networks, as shown:

- Low pressure (LP) – from 1.7kPa;
- Medium pressure (MP) – 80kPa;
- High pressure (HP) – 350kPa;

These material and pressure differences are the primary drivers of variability in condition and corresponding management activities over time.

Our mains inventory by material and pressure is shown in Table 6.

Table 6: Gas Mains Inventory by pressure and material at 1 July 2019

Network pressure	CI	UPS	HDPE 250	HDPE 575	HDPE 100	PE80	PS and copper	Total
Low	373	36	155	48	12	58	15	697
Medium	17	4	125	491	396	1,387	481	2,901
High	0	0	0	765	711	1,926	1,140	4,542
Total	**390**	**40**	**279**	**1,304**	**1,118**	**3,372**	**1,636**	**8,140**

Mains integrity issues can be addressed in different ways depending on characteristics such as material and diameter. To best manage the integrity and risk of our diverse portfolio of mains, their condition is monitored regularly.

Assessment of condition, and the most appropriate management of it, is based on information and evidence relating to key integrity indicators, including:

- leaks – leaks indicate a failure of pipe integrity. Leaks are detected by regular leak surveys or through public reporting. Leak numbers and leak rate (number of leaks per kilometre) provide an indicator of the integrity of mains;

- cracks and breaks – a sub-category of leaks. Cracks and breaks have been usually associated with CI mains, however HDPE (class 250 and 575) mains also have a propensity, albeit lower, to crack or break. Unlike small leaks from joints, these types of failures can result in a sudden and unpredictable release of gas which poses a greater risk to the public (when compared to smaller joint leaks);
- water in mains – water in main incidents are indicative of the integrity of LP networks. Water ingress occurs when ground water head (pressure) is greater than that of the pressure inside the pipe entering through corrosion pinholes, cracks, or poor sealing joints.
- Unaccounted for Gas (UAFG) – UAFG is the difference between gas metered entering the network and the metered volume delivered to customers. UAFG has a number of contributing factors, including metering accuracy, fugitive emissions (leaks from the network), administrative errors and theft. UAFG is sometimes used as a proxy measure for the network condition (how 'leak tight' the network is), but this is only valid where the level of UAFG is relatively high compared to industry norms.

We compare the performance and integrity indicators for different types of mains in order to understand contributors to risk and facilitate preventative action by identifying mains that may be prone to failure. All things being equal, increasing trends in these indicators are usually a sign of deterioration in the condition/integrity of the network.

The greatest risk associated with any gas network is the potential for assets to leak or fracture, (e.g. a loss of containment or fracture), where gas collects in sufficient quantities to become flammable (e.g. in or beneath a building) and ignites (i.e. explodes), leading to death or serious injury.

The most effective way of addressing the risk associated with any gas asset with a possibility of failure leading to a release of gas is to replace them.[21] However, there are often other options to address the risk or effectively monitor the assets to identify and rectify issues before they result in a failure. Therefore, although all mains will need to be replaced eventually (i.e. at the end of their useful life), a combination of qualitative and quantitative assessment is used throughout their lives to identify:

1. Mains that need to be replaced imminently (such as within an AA period);
2. Mains that can be monitored effectively so that issues are identified and rectified prior to failure; and
3. Mains that can remain safely in service.

2.1.1. Cast Iron (CI) and Unprotected Steel (UPS)

CI and UPS were the first materials used to construct our Network and are our oldest mains. Because of their early installation, they are located in older suburbs, established as the city expanded. They previously also existed within the CBD itself, but have recently been replaced.

Though the likelihood of a gas explosion occurring is not high, (indeed, the likelihood has been assessed as unlikely under the AS/NZS 4645 risk framework), the potential consequences of an event are so severe (assessed as major), that we consider the overall risk assessment of these mains to be high. This assessment is influenced by age, propensity for failure and the type of failure as well as proximity to buildings and people.

[21] Consistent with the hierarchy of controls where the most effective control is to eliminate the hazard.

CI and UPS mains have a history of fracture and failure in gas distribution networks in Australia and overseas. In a 2016 report, Jacobs noted that:

"In the UK, policy makers determined that cast iron mains posed a 'societal risk' meaning a hazard that impacts society at large, such as a risk of multiple fatalities from a gas explosion. In both the [United States] US and the UK, the qualitative case was built from a detailed review of a series of incidents that have occurred on iron mains and from a review of frequency and nature of breaks, leaks, and corrosion (failure modes) found on iron networks that can, under the certain conditions, result in an incident."[22]

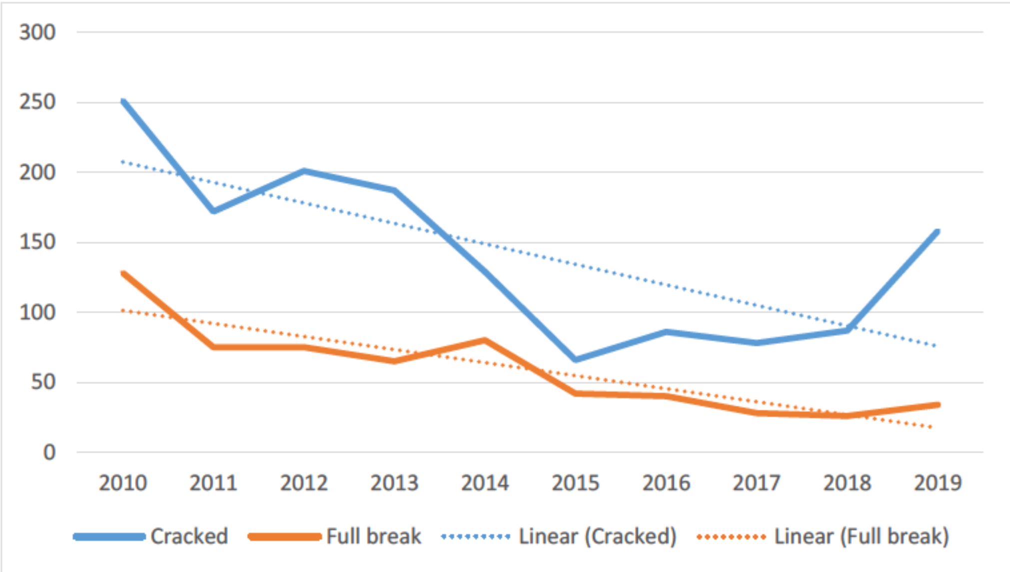
Table 7 CI/UPS Gas Mains overview

Asset Category	Pressure	Kilometres at July 2021	Untreated Risk
CI/UPS block[23]	Low	550	High
CI/UPS	Medium	8	High

The inherent risk of CI and UPS mains has been understood for a period of time, so we have prioritised a widespread replacement program to remove them from our Network. The highest risk mains in the CBD, as well as the medium pressure trunk mains will have been removed in full in the current AA period. All remaining CI and UPS block mains will have been replaced by the end of the next AA period. This will also result in the removal of the remaining LP mains in our Network, to the specific exception of the newly installed 7kPa mains in the CBD.

Figure 2 demonstrates the impact the CI and UPS replacement program has had on reducing the volume of cracks and breaks (which result in leaks) on our Network as highest risk mains have been removed, with a clear downward trend over the past decade.

Figure 2: Cast iron failure history over time

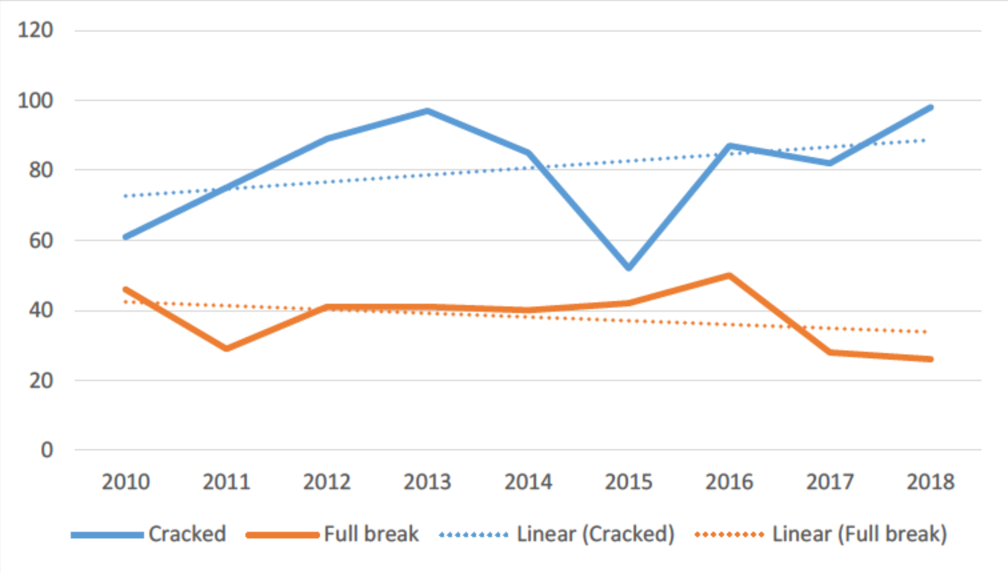


[22] Jacobs, "*Mains Replacement Program Review*", January 2016, pg. 9. Provided as Attachment 8.11 to AGN's Revised SA AA Proposal in 2016
[23] As noted in Section 1.2, other LP materials such as HDPE 250, HDPE 575 and New PE are also included in this program

Large decreases in cracks and breaks were seen in the early years of this replacement program, though it has slowed down more recently, as the mains which remain in our Network continue to deteriorate as they age.

Figure 3 shows an increase in crack volumes for the remaining CI/UPS mains.

Figure 3: Historic breaks and cracks on cast iron mains remaining in our Network



2.1.2. High Density Polyethylene (HDPE) mains

HDPE mains were first installed in our Network in the 1970s. These older mains (first generation) are made up of HDPE 250 and HDPE 575 polymer types. It has been reported that some early products have an oxidised inner surface that predisposes the inner surface to experience cracks faster when certain stresses are applied. The resulting shortened crack initiation time leads to dramatically reduced overall pipeline longevity through a predominant failure mechanism known as slow crack growth (SCG).[24] Early squeeze off procedures adopted by the industry resulted in the "over-squeezing" of the first generation HDPE mains. This, coupled with no restrictions in release rates, resulted in significant damage to the structural integrity of the main from which SCG occurs. Subsequent failures at squeeze off locations has and will continue to occur years later depending on the extent of the damage and the operating conditions

All our HDPE mains have been squeezed off on average every 100 metres,[25] therefore all these mains pose a risk of SCG and should be removed in a prioritised manner.

[24] Jacobs, "*Mains Replacement Program Review*", January 2016, pg. 24. Provided as Attachment 8.11 to AGN's Revised SA AA Proposal in 2016

[25] Of the most recent 229km of HDPE 575 mains inspected, 2,258 squeeze off locations were located.

Figure 4: Image of a partial crack at an old squeeze-off location

HDPE mains have been a further focus in our DMSIP work program because of three gas in building (GIB) incidents since 2007 in the Adelaide metropolitan area that resulted in explosion, with one of these resulting in a life threatening injury.

Incident investigations found that the primary cause of these incidents was leakage associated with SCG failures, originating from squeeze off locations in older HDPE mains laid until the 1990's. Analysis of material behaviour concluded that there is a risk of further, sudden, indiscriminate failures that could lead to additional GIB incidents and the potential of further explosions.

The crack rates of HDPE are typically three times lower than CI. However, the risk of a major GIB incident on HDPE MP and HP networks has been calculated to be about three times higher than CI.

There are three core categories of HDPE mains:

1. HDPE 250;
2. HDPE 575 DN40; and
3. HDPE 575 DN50.

2.1.2.1. HDPE 250

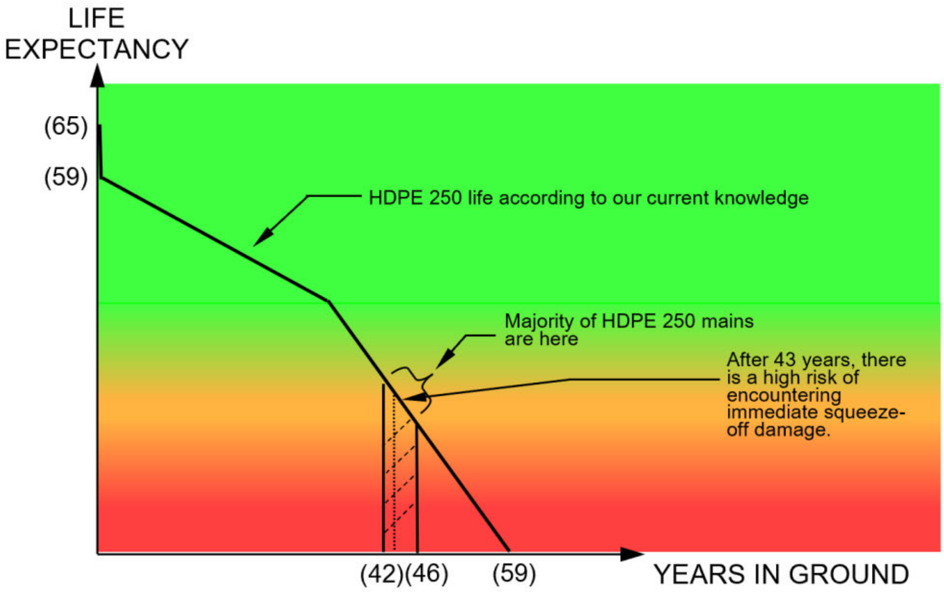
Laid in the 1970s, HDPE 250 mains are our oldest class of polyethylene. HDPE 250 mains are becoming increasingly brittle with age, which reduces their ability to withstand SCG induced at damaged sections of the main caused by previous squash-offs.

In our Mains Replacement Plan for the current period, we mentioned that "Further analysis of HDPE material behaviour, planned during the next regulatory period, will confirm the timing and volume of future HDPE replacement."[26]

In support of this, a material behaviour curve was developed which is shown in Figure 5. Once in the 'brittle' zone on the material behaviour curve, mains display significantly increased risk of crack failure in service or when squeeze offs are applied to repair, extend the main or connect new customers. This risk increases over time.

[26] Attachment 8.2, Mains Replacement Plan, 2016/17 to 2020/21

Figure 5: HDPE class 250 material behaviour curve



HDPE 250 mains have a history of leaks and SCG and are considered high risk and unmaintainable. The only effective risk mitigation option is to remove them from our Network, as documented in our PE Pipes Integrity Management Strategy report.

An independent report by Jacobs confirmed the appropriateness of a replacement program for this class of mains back in 2015, due to its age and the history in the US of Aldyl A PE pipe material (which is considered an equivalent material to our vintage HDPE mains). Aldyl A PE pipe material was shown to fail much more abruptly than other materials, such as steel. Failures on Aldyl A PE caused an incident in San Juan (Puerto Rico) which resulted in multiple fatalities and incidents in California which resulted in the California Public Utilities Commission identifying Aldyl A PE pipes as a major potential hazard that are not manageable by leak surveying.[27]

2.1.2.2. HDPE 575

Like HDPE 250, the HDPE 575 polymer has poor resistance and is susceptible to SCG resulting from damage inflicted by previous squeeze offs or other stress concentrators.

The program to replace HDPE 575 mains commenced in the current AA period, with higher priority given to those mains with a higher history of squeeze off failures. These are typically older mains, with more recently installed HDPE 575 benefitting from improved operational procedures for doing squeeze offs, resulting in reduced instances of over squeezing.

All HDPE 575 mains with a history of squeeze off failure will have been replaced by the end of the current AA period.

Prioritisation within and across asset categories is required to inform and support work program planning, as described in Section 5.3.2. The prioritisation of HDPE mains is developed by disaggregating the HDPE 575 mains population into approximately 2,000 segments, based on job pack and diameter. These are then ranked based on:

- Age, operating pressure and diameter

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[27] Jacobs, "*Mains Replacement Program Review*", January 2016, pg. 24. Provided as Attachment 8.11 to AGN's Revised SA AA Proposal in 2016

- Leak history by segment; and
- A deterioration factor for mains over 30 years.

This ranking revealed a higher instance of failures in older, high pressure HDPE 575.

A total of 249 squeeze off failure events occurred on the HDPE 575 network between 2005 and 2019, with 230 of those squeeze off failures experienced on HDPE 575 mains installed before 1993.

2.1.2.3. HDPE 575 risk mitigation

Our mains categories now distinguish between the larger diameter HDPE 575 DN50 and the smaller HDPE 575 DN40 because there is an alternative risk mitigation for the larger diameter HDPE 575 mains. HDPE 575 DN50 mains are large enough to allow inline camera insertion so they can be inspected and reinforced when required rather than being replaced.

It became apparent in the current AA period that inline camera inspection and reinforcement of the larger diameter HDPE 575 was an effective mitigation tool, reducing the risk of these assets from high to intermediate (ALARP) and extending their useful life by an estimated 10 years.

As part of our response to an incident in 2014[28], live camera inspection technology was introduced. The camera system is a useful element to mitigate PE risks but does have limitations, including but not limited to:

- Inability to detect non-squeeze-off SCG problems (e.g. butt joint SCG); and
- Inability to enter DN40 (48mm OD) or smaller pipes.[29]

Considering the camera system limitations and other factors related to SCG, the current strategy is to use the inspection and reinforcement system on mains that are expected to experience some squeeze-off failures but are not expected to experience other types of SCG failures over the next 10 years. Many of our HDPE 575 mains laid in the 1990s fit into this category.

The inline camera is used to inspect the inside of the pipe and identify squeeze off points, i.e. points on the main susceptible to sudden failure. Once identified, the pipe is clamped and reinforced with a stainless-steel clip. This provides protection to the weakened parts of the pipe wall caused by squeeze off and reduces/removes the event of squeeze off failures that would release gas. By reducing the likelihood of squeeze off as a source of failure, the overall risk of these pipes reduces to intermediate (ALARP) from high. This inspection and reinforcement option is only available for mains with a diameter of at least 50mm, as that is the size required to allow the camera access.

Inline camera inspection and reinforcement is a practical alternative to replacement for these mains and is now adopted as our primary management policy for mains where there is no history of squeeze off failure.

HDPE 575 DN50s are now separated in to three sub-categories, to recognise different operating pressure and inspection history which has influenced the priority for replacement during the current AA period.

HDPE 575 DN50 that has been inspected with squeeze off locations reinforced has been included as a separate category because this extends their useful life of these mains by an estimated 10

[28] Three such failures occurred on our Network between 2007 and 2014. All three resulted in an explosion and were a direct result of cracking in HDPE mains

[29] Investigation is ongoing to identify and evaluate a live camera system (or other technology) to send through APA Group's small diameter 48 mm ID and 37.6 mm ID HDPE pipes to detect squeeze off damage and potential cracking.

years. Due to no squeeze off failures having been recorded on any HDPE 575 DN50 mains which has been inspected and reinforced they are now considered intermediate (ALARP).

HDPE 575 DN40s have been included as a separate category because inline inspection and reinforcement is not available for these mains. Their size is not large enough to allow insertion of a camera. We are continuing to investigate and research the potential for in line inspections of these smaller diameter mains given the success of this risk mitigation method in larger diameter HDPE 575, but this has been unsuccessful to date. Therefore, as there is currently no option to inspect and reinforce these squeeze off locations, we believe the only prudent risk mitigation option available is to continue to replace these on a prioritised basis.

Figure 6 demonstrates the impact of replacement and inspection and reinforcement of HDPE 575.

The frequency of squeeze off failures has reduced over time, with the majority of mains with a history of squeeze offs already replaced.

We know that on our Network, there is a squeeze off approximately every 100 metres so the risk of squeeze off failures in the future remains. With DN50s, we can inspect and reinforce where a squeeze off location is identified. Currently, we do not have an inspection program option for DN40s, so replacement is the only way or removing this risk from our Network.

Figure 6: HDPE class 575 squeeze off failure history over time

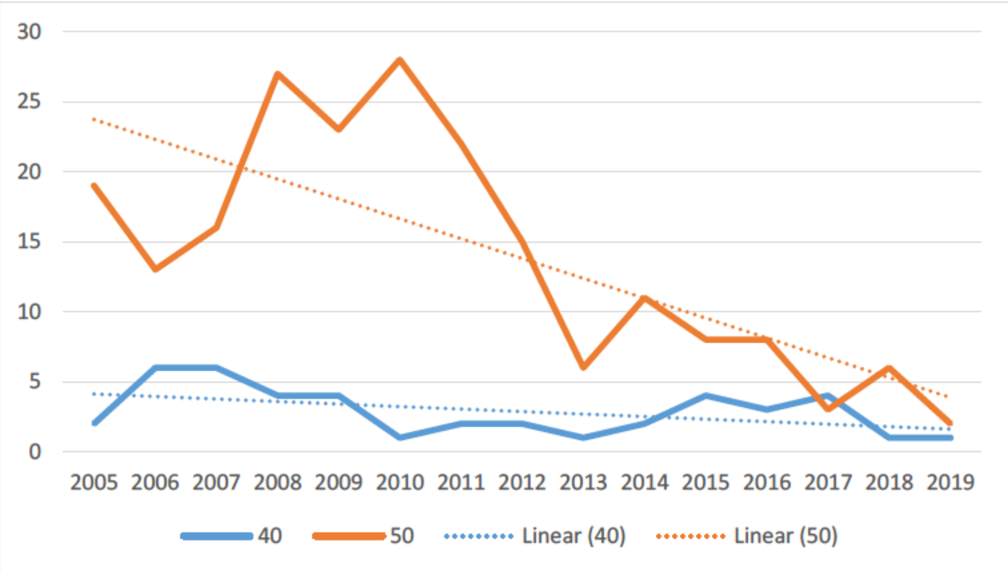


Figure 7 illustrates a downward trend in both squeeze off failures and cracks in HDPE 575 mains which were installed more recently. This information supports the effective use of prioritisation of replacement and/or inspection to manage risk associated with the remaining HDPE 575 mains.

Figure 7: HDPE class 575 squeeze off failure history over time

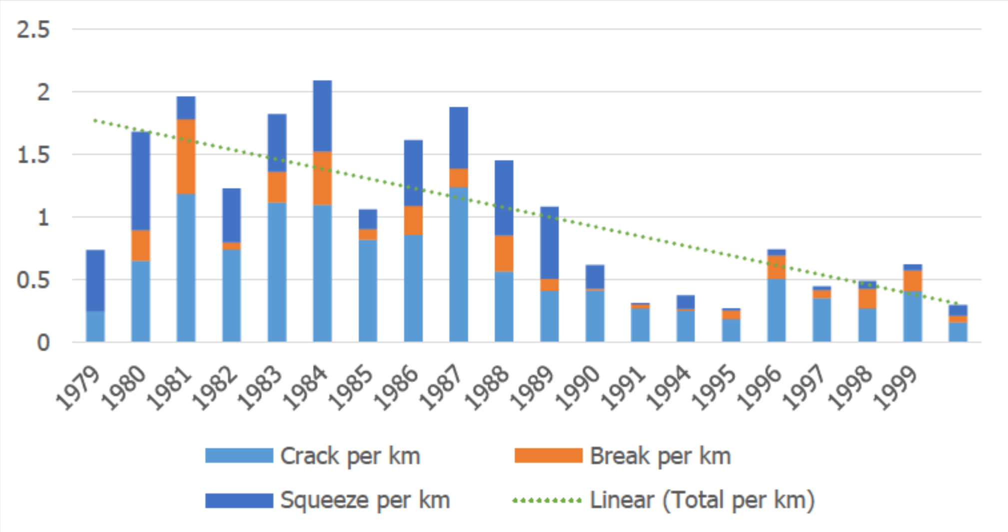
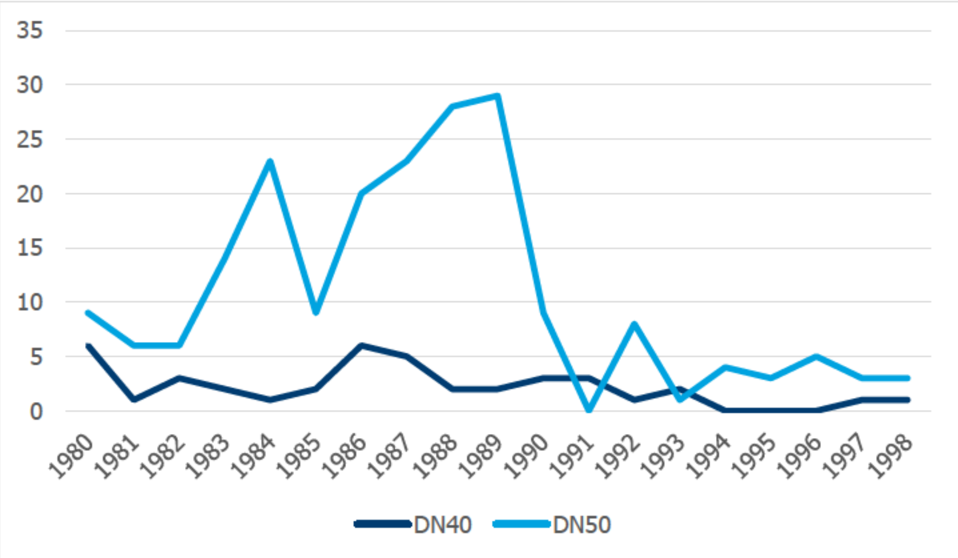


Figure 8 presents the squeeze off failure for HDPE 575 mains by year laid and diameter.

Figure 8: HDPE class 575 mains - squeeze off failure history by year laid and diameter



HDPE DN50 has been prone to a greater level of squeeze off failure than the HDPE 575 DN40 over time. However, the inline inspection program is not available for DN40, so the risk of failure is only able to be mitigated through replacement.

We also observe a significant decrease in squeeze off failures for HDPE 575 DN40 in the 1990s which provides an opportunity to prioritise any replacement based on age. This is considered as an effective risk mitigation option in Section 4.

Table 8 presents the HDPE categories, kilometres of mains at the commencement of the next AA period and the untreated risk assessment that is described in Section 3.

Table 8: HDPE Gas Mains overview[30]

Asset Category	Pressure	Kilometres at July 2021	Untreated risk
HDPE 250	Medium	14	High
HDPE 575 DN40	Medium and High	447	Intermediate
HDPE 575 DN50	High	57	High
HDPE 575 DN50	Medium	259	Intermediate
HDPE 575 DN50 inspected	Medium and High	310	Intermediate (ALARP)

2.1.3. New Polyethylene

New Polyethylene (PE) mains are made up of two main categories – PE 80 and PE 100.

PE 80, also referred to as medium density polyethylene (MDPE), was installed in our Network from the late 1990s until early 2010s, when HDPE 100 was introduced. PE 100 has been laid since 2010 and is expected to continue to maintain its integrity for up to 100 years.

Both new PE mains materials are rated as low risk and are not considered susceptible to cracking. No targeted risk mitigation action is planned in the current or next AA period.

Table 9 presents the New PE categories, kilometres of mains at the commencement of the next AA period and the untreated risk assessment that is described in Section 3.

Table 9: New PE Gas Mains overview

Asset Category	Pressure	Kilometres at July 2021	Risk
MDPE 80	Medium and High	3,300	Low
PE 100	Medium and High	2,200	Low
Total new PE		**5,500**	

2.1.4. Other mains

The other mains in our Network are made up of Protected Steel (SP) and Copper (CU).

Protected steel mains are steel mains with a PE coating that is typically now used only in the high pressure system and is cathodically protected to maintain integrity and longevity. These mains are not susceptible to the type of cracking and integrity issues that affect other pipe materials. The untreated risk of this category is low.

There is 1 kilometre of copper main on our Network. The untreated risk of this category is also low.

[30] As noted in Section 1.2, all LP mains are included within the count for CI/UPS - block as the block replacement program does not discriminate based on material type. All LP will be removed from our Network in the next AA period (with the specific exception of the new 7kPa LP in the CBD)

No targeted risk management action in addition to BAU monitoring activities is required for protected steel or copper mains in the current or next AA period.

Table 10 presents the other main categories, kilometres of mains at the commencement of the next AA period and the untreated risk assessment that is described in Section 3.

Table 10: Protected Steel Gas Mains overview

Asset Category	Pressure	Kilometres at July 2021	Risk
Protected Steel mains	High and Medium	1,704	Low
CU mains	Medium	1	Low
Total PS and Copper		**1,705**	

2.2. Services

A service is a dedicated network asset comprising of a service pipe, fittings and metallic upstand with ball valve which can be used to isolate customer supply in the event of an emergency. There are over 470,000 inlet services connecting mains (typically located in the street) to customer meters located at each network user.

Services are typically of the same vintage (though not always the same material) of the gas main to which they are connected, as they generally were laid together as one project. That is, when cast iron mains were laid, galvanised steel services would have been laid at the same time and when such mains were replaced the associated services were also replaced.

When a main is replaced, the associated services are deemed to have the same age of the main and share a similar risk profile (but with additional risk associated due to the closer proximity of service pipes to a house or building). However, this information is not individually captured within the GIS, so although there may be exceptions, for example where there has been recent infill development (or subdivision) and a new service has been laid, no distinction is made between mains and services when assessing useful life or risk. Exceptions are addressed on a case by case basis as mains replacement is undertaken in the area.

From time to time there are cases where services need to be renewed on a stand-alone piecemeal basis. The need for such service renewals arise when leaks or damage occur on the service and inspection reveals that the service is heavily corroded or in such poor condition that repairs are not viable. Such ad hoc replacement will continue up until the end of the replacement program.

The only effective way to manage the risk associated with leaks in services is to replace the service. During the current AA period we replaced an average of 490 non-AMRP services per year, which is just 0.1% of the total population. We have assumed the same level of replacement for the next AA period as shown in Table 11 below, reflecting a consistent volume over time, despite the expansion of our Network, as the number of premature failures are expected to reduce as a result of the MRP offsetting any increases which might otherwise arise as a result of the growing network.

Table 11: Forecast non-AMRP (piecemeal) service replacements

Category	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Piecemeal service replacement	490	490	490	490	490	2,450

2.2.1.1. Multi user services

Multi user services (MUS) are services running through unit developments and commercial premises that supply gas to multiple users. These assets are located across our Network. Prior to 2012, the renewal of internal services at these MUS sites was not captured within the scope of the MRP.[31] This leaves an inventory of older MUS that were not replaced during MRP in their area between 1993 and 2012.

We will have some 2,110 priority group 1 and 2 MUS as at July 2021 which require specific action and/or monitoring because they have reached the end of their useful life, have been found to be non-compliant, or their location poses a risk to public safety or security of gas supply in the event of a leak. This is an increase from the opening inventory estimate at the beginning of the current AA period of 1,328, which considered only MUS remaining in our Network as a result of the 2004 to 2012 MRP policy of replacing only MUS which failed a pressure test. Their replacement was expected to be done on a suburb by suburb basis.

During the current AA we undertook a desktop review and site survey of all MUS (pre and post 2004) and selected a sample to be replaced to inform the prioritisation of the MUS replacement program.

This process revealed that replacing MUS by suburb would result in the unnecessary replacement of assets that may be new, compliant, or not at the end of their useful life. Nevertheless, replacement of MUS is the only effective way to reduce the risk if an asset is identified to be failing, or likely to fail imminently due to age and condition, non-compliance or being located in a high risk location such as in proximity to an ignition source. Therefore, these assets have been categorised as:

- Priority 1: Replacement required as soon as practical due to failure, non-compliance or a location of specific concern;
- Priority 2: Assets that are generally compliant but aging and typically constructed of CI/UPS or HDPE so will require replacement as they approach the end of their useful life;
- Priority 3: Assets that were assumed to be of the same age as the mains but were installed more recently using newer PE materials, meter locations are compliant, or the dwellings within the MUS site are supplied with individual service connections direct to the main (as opposed to a boundary regulator and trunk service installation).

Additional leak surveys and awareness campaigns have been implemented for Priority 1 and Priority 2 MUS until they are replaced, to ensure that new failures or changes in condition are identified in a timely manner and re-prioritisation of replacement or other risk mitigation can occur if required.

Table 12 presents the MUS categories, sites at the commencement of the next AA period and the untreated risk assessment that is described in Section 3.

Table 12: Multi user site overview

Asset Category	Pressure	Sites at July 2021[32]	Risk

[31] When mains in the area were replaced and upgraded to operate at HP, a boundary regulator was installed to allow the MUS to remain operating at LP

[32] A total of 505 MUS have been surveyed to date and the results of this survey have been extrapolated to forecast volumes for each priority group.

MUS – Priority group 1	Low	457	High
MUS – Priority group 2	Low	1,653	Intermediate
MUS – Priority group 3	Low	361	Low
Total		**2,471**	

2.3. Obligations and responsibilities

In providing distribution services, we aim to

- achieve our vision;
- deliver on our business plan; and
- comply with our obligations.

A key aspect of our vision is to deliver for customers. Two of the ways we do this is by ensuring public safety and reliability which entails maintaining the integrity of distribution mains and services to minimise risks to safety and supply.

The safe distribution of gas is managed within the legislative framework which governs our obligations. The key legislation which governs our obligations are:

- Gas Act 1997 (SA);
- National Gas Laws (NGL);
- National Gas Rules (NGR);
- Work Health and Safety Act 2012; and
- Risk management standards.

Under the Gas Act, we have an obligation to minimise hazards and ensure the safety of our workers and the community. This is supported by the Work Health and Safety Act 2012. The NGL and NGR contain obligations in relation to our pipeline safety duty as well as the requirement for the efficient investment in, use, operation and management of assets. Like many of our peers, we apply the risk assessment and rating contained in Appendix C of the AS/NZS 4645 standard and ISO 31000 which provides guidance on the principles and processes for managing risks and a framework for assessing and mitigating risk.

Our systems, processes and policies are designed to ensure our ongoing compliance with our obligations and responsibilities. The requirements of each of these key pieces of legislation are summarised below.

2.3.1. Gas Act 1997

The South Australian *Gas Act 1997* is the primary regulatory instrument which directs our obligations regarding gas safety.

According to Part 1 Section 3, the objects of the *Gas Act 1997* are:

(a) to promote efficiency and competition in the gas supply industry; and

(b) to promote the establishment and maintenance of a safe and efficient system of gas distribution and supply; and

(c) to establish and enforce proper standards of safety, reliability and quality in the gas supply industry; and

(d) to establish and enforce proper safety and technical standards for gas installations and appliances (including such standards relating to the design of gas installations); and

(e) to protect the interests of consumers of gas

2.3.2. Gas Act – Section 55

Under Section 55 of the *Gas Act 1997*, we have a responsibility to

"… take reasonable steps to ensure that –

(a) the infrastructure complies with, and is operated in accordance with, technical and safety requirements imposed under the regulations; and

(b) the infrastructure is safe and safely operated."

The relevant regulation references in Section 55 is Regulation 37, which provides:

"For the purposes of Section 55 of the Act—

(a) gas infrastructure must be designed, installed, operated and maintained to be safe for the gas service conditions and the physical environment in which it will operate and so as to comply with any applicable requirements of AS/NZS 4645, AS/NZS 1596 and AS 2885 or achieve, to the satisfaction of the Technical Regulator, the same or better safety and technical outcomes; and

(b) a gas installation must be designed, installed, operated and maintained to be safe for the gas service conditions and the physical environment in which it will operate and so as to comply with any applicable requirements of—

  (i) in the case of a liquefied petroleum gas installation—AS/NZS 5601 and AS/NZS 1596;

  (ii) in any other case—AS/NZS 5601."

As required by the *Gas Act 1997* (and consistent with good industry practice, which requires compliance with applicable Australian Standards in the absence of any direction by safety legislation or a safety regulator to the contrary), we apply the AS/NZS 4645 standard to assessing the risk associated with our individual asset categories. We additionally adopt risk mitigation activities such as pressure reduction and increased inspections to reduce risk as required under the standard.

The DMSIP work program identified in this Plan has been designed to achieve the maximum risk reduction possible given delivery capability, without imposing costs that are disproportionate to the risk reduction on customers.

2.3.3. Gas Act – Section 26

Under Section 26, (and re-iterated in the Gas Distribution Code) as part of the condition of having a license to operate a gas distribution system we are required

(i) to prepare, maintain and periodically revise a safety, reliability, maintenance and technical management plan dealing with matters prescribed by regulation; and

(ii) to obtain the approval of the Technical Regulator—

(A) to the plan (prior to the commencement of the operation of the distribution system to which the plan relates); and

(B) to any revision of the plan; and

(iii) to comply with the plan as approved from time to time; and

(iv) to audit from time to time the entity's compliance with the plans and report the results of those audits to the Technical Regulator…"

Guidelines published[33] by the South Australian government for the preparation of the Safety, Reliability, Maintenance and Technical Management Plan (SRMTMP) state:

"An SRMTMP should make particular reference to the technical and safety standards adopted by the entity. These standards should be consistent with the requirements of the Technical Regulator as set out in legislation.

The SRMTMP should include policies for:

- protection of personnel
- protection of property
- protection of the public
- technical standards compliance.

The SRMTMP should also cover the life cycle of all elements of the technical infrastructure, including:

- planning
- design
- acquisition (construction, testing and commissioning)
- operation
- maintenance
- repair and modification
- decommissioning and disposal.

The SRMTMP should include evidence that appropriate systems are established to ensure the SRMTMP is implemented. It should also address:

- the organisational structure and defined responsibilities
- competencies of persons appropriate to their responsibilities
- auditing of activities (key performance indicators)
- records and traceability
- any special notes."

Our SRMTMP is submitted annually to the Technical Regulator, most recently in August 2019. It is part of our overall approach to system management. It follows a continuous improvement cycle of Commit, Plan, Do, Check and Act, with the objectives of:

[33] https://www.sa.gov.au/topics/energy-and-environment/electrical-gas-and-plumbing-safety-and-technical-regulation/compliance-and-enforcement/srmtmps, reviewed online June 2019

- maintaining a strong focus on safety and reliability in relation to the operation and management of our distribution network;
- ensuring suitable safety management systems are in place and operating to effectively manage and keep risks associated with the operation of our network to as low as reasonably practicable; and
- communicating relevant information related to the safe and reliable operation of our distribution network with our regulators.

Our Strategic Asset Management Plan (SAMP) is a key part of our Asset Management Framework and safety management systems. The DMSIP is subordinate to our SAMP and focuses on our approach to managing the integrity of our mains and services and provides the basis for the forecast replacement of mains over the next AA period. It outlines how we continually monitor, evaluate, plan and undertake asset integrity assessments to extend the remaining life, improve, replace, or where necessary, retire assets. This ensures efficient, reliable and safe operations of the Network are maintained.

Though, our driver for compliance with the SRMTMP is to ensure the safety of the community and its employees, we are aware that failure to comply with the *Gas Act 1997* can lead to the imposition of financial penalties and potentially criminal prosecution. Failure to comply with the approved SRMTMP would mean we are in breach of section 27 of the *Gas Act 1997*. Such a breach would expose us to a penalty of up to $1,000,000.

In summary, the *Gas Act 1997* and regulations, codes and guidelines under it create a duty on us to ensure that we manage the safety and supply risks of our gas mains and services, and that we do so in such a way that is consistent with the requirements of the Technical Regulator (which includes technical standards compliance).

2.3.4. National Gas Law

Under the NGL, we are required to ensure that our approach to managing the integrity of mains and services is efficient. The NGL also requires that we provide services in a safe and effective manner. The National Gas Objective (NGO) under the NGL provides:

"The objective of this Law is to promote efficient investment in, and efficient operation and use of, natural gas services for the long term interests of consumers of natural gas with respect to price, quality, safety, reliability and security of supply of natural gas."

The focus of the NGO is on the long term interests of consumers with respect to price, quality, safety, reliability and security of supply. This Plan supports achievement of this outcome by ensuring the system and approach to managing supply and safety risks effectively identifies, assesses, prioritises and mitigates these risks in the most efficient way.

The NGL in section 28 outlines the role of the AER in ensuring proposals and outcomes of gas distribution businesses will or are likely to contribute to the achievement of the NGO. The AER must take into account the revenue and pricing principles under section 28(2) of the NGL when exercising a discretion in approving or making those parts of an AA relating to a reference tariff.

This ensures the ability for a gas distribution business to recover the cost of efficient and effective risk management practices so as to not put at risk the implementation of effective risk management practices.

In the context of this Plan, the most relevant revenue and pricing principle is section 24(2) of the NGL, which provides:

"A service provider should be provided with a reasonable opportunity to recover at least the efficient costs the service provider incurs in—

(a) providing reference services; and

(b) complying with a regulatory obligation or requirement or making a regulatory payment."

Section 6 of the NGL also includes a "pipeline safety duty" which is defined in section 2 of the NGL as:

"pipeline safety duty means a duty or requirement under an Act of a participating jurisdiction, or any instrument made or issued under or for the purposes of that Act, relating to—

(a) the safe haulage of natural gas in that jurisdiction; or

(b) the safe operation of a pipeline in that jurisdiction;"

As outlined, there are several pipeline safety duties arising from the *Gas Act 1997* and the *Work Health and Safety Act 2012* requiring us to implement risk mitigation activities such as mains replacement.

2.3.5. National Gas Rules

The NGR impose requirements on a gas distribution business to ensure its asset management strategies and plans are efficient. In order to recover the efficient cost of providing services, the NGR provides for the AER to assess whether the expenditure required complies with the capital and operating expenditure criteria. Those criteria require that expenditure must be such as would be incurred by a prudent service provider acting efficiently, in accordance with accepted good industry practice, to achieve the lowest sustainable cost of delivering pipeline services.[34]

In addition, capital expenditure must also be justified under NGR 79(2) as follows:

(a) the overall economic value of the expenditure is positive; or

(b) the present value of the expected incremental revenue to be generated as a result of the expenditure exceeds the present value of the capital expenditure; or

(c) the capital expenditure is necessary:

(i) to maintain and improve the safety of services; or

(ii) to maintain the integrity of services; or

(iii) to comply with a regulatory obligation or requirement; or

(iv) to maintain the service provider's capacity to meet levels of demand for services existing at the time the capital expenditure is incurred (as distinct from projected demand that is dependent on an expansion of pipeline capacity); or

(d) the capital expenditure is an aggregate amount divisible into 2 parts, one referable to incremental services and the other referable to a purpose referred to in paragraph (c), and the former is justifiable under paragraph (b) and the latter under paragraph (c)."

Our approach to managing mains and services integrity includes an assessment of options available to manage risk and ensure that the most efficient option is chosen and delivered at least cost. We have adopted the framework of ISO 31000 to guide this process.

[34] NGR 78(1)(a) and NGR 91.

2.3.6. Work Health and Safety Act 2012

In addition to safety obligations under the *Gas Act 1997*, we have obligations under the *Work Health and Safety Act 2012* to ensure the health and safety of our workers and the community.

Division 2 Section 19 of the *Work Health and Safety Act 2012* provides:

(1) A person conducting a business or undertaking must ensure, so far as is reasonably practicable, the health and safety of—

(a) workers engaged, or caused to be engaged by the person; and

(b) workers whose activities in carrying out work are influenced or directed by the person, while the workers are at work in the business or undertaking.

(2) A person conducting a business or undertaking must ensure, so far as is reasonably practicable, that the health and safety of other persons is not put at risk from work carried out as part of the conduct of the business or undertaking.

Division 2 Section 19 imposes a general duty on an employer to ensure that both workers and other persons are not exposed to risks to their health or safety arising from the conduct of the undertaking of the employer, to the extent that is reasonably practicable.

Subdivision 2 Section 18 addresses reasonably practicable:

"In this Act—

reasonably practicable, in relation to a duty to ensure health and safety, means that which is, or was at a particular time, reasonably able to be done in relation to ensuring health and safety, taking into account and weighing up all relevant matters including—

(a) the likelihood of the hazard or the risk concerned occurring; and

(b) the degree of harm that might result from the hazard or the risk; and

(c) what the person concerned knows, or ought reasonably to know, about—

   (i) the hazard or the risk; and

   (ii) ways of eliminating or minimising the risk; and

(d) the availability and suitability of ways to eliminate or minimise the risk; and

(e) after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk."

Our approach to ensuring the safety of our workers (and the community) is incorporated in the procedures and practices adopted in operating and maintaining our Network. These are captured in our Asset Management Plan and supporting plans and reports.

Our approach to identifying and managing safety risk is consistent with ISO 31000, AS 4645 and our SRMTMP as outlined in Section 3.

2.3.7. Risk Management Standards

We manage the integrity of our mains and services and the arising safety and supply risks consistent with the relevant standards for managing risks on gas distribution networks. AS/NZS 4645.1:2018 Gas distribution networks Part 1: Network management (AS/NZS 4645) is the standard that applies to the management of gas distribution networks in Australia. This standard prescribes a risk management approach in accordance with ISO 31000, which outlines the process that should be adopted by a business that includes:

- communication and consultation with external and internal stakeholders during all stages of the risk management process;
- the internal and external environment in which the organisation seeks to achieve its objectives is to be assessed;
- risk assessment is the overall process of risk identification, risk analysis and risk evaluation;
- risk treatment involves selecting one or more options for modifying risks, and implementing those options;
- there should be planned monitoring and review as part of the risk management process; and
- risk management activities should be traceable.

The risk analysis process under ISO 31000 may be undertaken with varying degrees of detail, depending on the risk, the purpose of the analysis and the information, data and resources available. This standard provides a framework for considering, assessing, rating and mitigating risks.

This standard is general in nature and so we have applied the guidance contained in Appendix C of AS/NZS 4645 to consider the consequence and frequency of a risk event to inform a rating system and risk treatment options.

AS/NZS 4645 requires that all actions and activities not unduly expose personnel, the public or the environment to unacceptable risks. Measures to mitigate those risks are to be identified, reviewed and documented. The areas to be considered include:

- safety of the public (including consumers);
- safety of personnel working on the gas distribution network;
- integrity of the network;
- minimisation of environmental impacts; and
- protection of property.

This framework provides for circumstances where the cost of mitigating risk is disproportionate to the impact on the risk when a risk is rated as intermediate. Where this occurs and the costly mitigation activities are not undertaken, a business is able to determine the risk to be as low as reasonably practical (ALARP).

3. Risk assessment – approach and outcomes

There is an inherent risk associated with gas mains. Whenever a gas main leaks, cracks or breaks there is the potential for a negative impact on people, gas supply or the environment. The risk can vary based on location, material type, pressure and age of each gas main, which means the management and mitigation requirements of the underlying asset also vary. We review the performance indicators of mains to assess the potential risk associated with any deterioration in condition.

We manage network integrity by regularly updating our risk assessment to reflect new information on asset condition. A risk assessment and derived risk rating guides the actions and activities required ensuring that safety and compliance is maintained as efficiently and effectively as possible.

Risk management is a constant cycle of identifying, analysis, treatment, monitoring, reporting and then identifying once again, as shown in Figure 9. This cycle is complemented by our commitment to balance outcomes sought with delivery and cost implications.

Figure 9: Risk management principles applied

3.1. Risk Assessment Approach

Our risk assessment approach focuses on understanding the potential severity of failure events associated with each asset and the likelihood that the event will occur.

Based on these two key inputs, the risk assessment and derived risk rating then guide our actions and the activities required to ensure network safety and service is not compromised, while delivery of this outcome is done as efficiently and effectively as possible.

Our risk management framework, as applied to our distribution mains and services, is based on:

- ISO 31000 Risk Management – Principles and Guidelines, and
- AS/NZS 4645 Gas Distribution Network Management.

ISO 31000 Risk Management provides principles, framework and a process for managing risk, embedding the 'Plan, Do, Check, Act' cycle.

The Gas Act 1997 and Gas Regulations 2012 through their incorporation of AS/NZS 4645 and the Work Health and Safety Act 2012 place a regulatory obligation and requirement on us to reduce high and extreme[35] Network risk as soon as possible (if high) or immediately (if extreme) to low or negligible and if this is not possible to as low as reasonably practicable (ALARP).

We apply Appendix C of AS/NZS 4645 to identify the consequence and likelihood of an event occurring for each asset category. Costs are then considered against the relative impact of different replacement or other risk mitigation program or volumes in order to determine the most prudent and efficient course of action to minimise the risk exposure.

Where assets are rated as intermediate, we assess whether the risk can be reduced to low or negligible and how that might be achieved. If the risk cannot be reduced to low or negligible, or the cost of doing so is disproportionate to the relative risk reduction, action to reduce the risk to the extent practicable which demonstrates ALARP is then considered.

For some assets, the only way to reduce identified risk is to replace them. For others, the risk can be appropriately managed through increased inspection and monitoring programs.

Table 17 outlines our obligations under AS/NZS 4645 and Section 2 shows how we meet them.

3.2. Categorisation of Assets – Grouping by Characteristic

Assets are categorised in accordance with the variables which we identify as key drivers of risk. These have been introduced earlier in Section 2.

In our submission for the current AA period, the categorisation primarily focused on pressure, material and location. The categories for the current AA and actual inventory at the beginning of the period are shown in Table 13.

Table 13 Categories of 'at risk' mains and services at the beginning of the current AA period

Material	Location	Description	Pressure	Kilometres at July 2016	Untreated Risk
Mains					
CI/UPS	CBD	CBD mains and trunk	Low	53	Extreme
CI/UPS	General	CI/UPS and other	Low/Medium	849	High
CI/UPS	General	MP trunk	Medium	59	Extreme
HDPE	General	HDPE 250	Medium	305	High
HDPE	General	HDPE 575	Medium/High	1,431	High
Total at risk mains				**2,697**[36]	

[35] Currently no mains in the network are rated as 'extreme'

[36] Note that actual 'at risk' mains inventory at July 2016 differs to the forecast included in our response to the Draft Decision, which estimated 2,619 km of 'at risk' mains in our Network on this date

Material	Location	Description	Pressure	Kilometres at July 2016	Untreated Risk
Services					
CI/UPS	General	MUS (2004 to 2012)	Low	1,328 sites[37]	High
Total at risk services				**1,328**	

Consistent with our process to continually review and update our assessment of 'at risk' mains we have incorporated new information, performance and condition data to further delineate asset groups.

This has resulted in further disaggregation of asset categories, which is influenced by the characteristics that drive risk and the risk mitigation options available.

The framework for assessing risk across these asset categories is unchanged and is discussed further in the following sections.

Table 14 summarises the categories of mains and the assessed untreated risk for the next AA period.

Table 14: Inventory of mains and services at the beginning of the next AA period (July 2021)

Asset	Asset type	Pressure	Kilometres at 2021	Untreated Risk
At risk mains				
1	CI/UPS - block[38]	Low and Medium	558	High
2	HDPE 250 - remaining	Medium	14	High
3	HDPE 575 DN50 - HP	High	57	High
4	HDPE 575 DN50 - MP	Medium	259	Intermediate
5	HDPE 575 DN40	Medium and High	447	Intermediate
6	HDPE 575 DN50 inspected	Medium and High	310	Intermediate (ALARP)
At risk services				
7	MUS – Priority group 1	Low	457 sites	High
8	MUS – Priority group 2	Low	1,653 sites	Intermediate (ALARP)
9	MUS – Priority group 3	Low	361 sites	Low
Other mains				
10	New PE (PE80 and PE100)	Medium and High	5,500	Low

[37] MUS are measured in units (sites) not kilometres. 1,328 was the inventory estimate at the beginning of the current AA for all MUS relating to mains replacement program from 2004 to 2012. This number has since been revised to reflect pre 2004 MUS and re-categorised based on underlying risk.

[38] As noted in Section 1.2, other LP materials such as HDPE 250, HDPE 575 and New PE are also included in this program

Asset	Asset type	Pressure	Kilometres at 2021	Untreated Risk
11	Protected steel and copper	Medium and High	1,705	Low
12	CBD LP	Low (7kPa)	27	Intermediate (ALARP)

3.3. Severity or Consequence of Event

For each category of asset, the risk is assessed based on the severity (or consequence) of a failure event. The consequence of the potential event is then mapped against the AS/NZS 4645 severity classes.

The AS/NZS 4645 framework considers the consequences of a mains failure event on people, gas supply and the environment. The framework ranks the severity of the failure event from catastrophic to trivial.

The most significant threat posed by the network is that escaped gas gathers in a building (or another confined space) to a volume where it becomes explosive and causes an explosion. We have therefore used the AS/NZ 4645 consequence analysis to assess the following:

> *"The consequence of a crack (or other failure) in a gas main that leads to the escape of sufficient gas that results in a 'gas in building' explosion".*

We consider it prudent to develop our integrity management plan based on the most severe consequences (as per the Standard) of a mains failure event, therefore the severity ratings in the People category of AS/NZS 4645 take precedence for the purpose of assessing the risk associated with each category of mains or MUS. This is aligned with the findings of a Jacob's report for our Network from December 2015, which noted that the use of people events as a focus is a direct acknowledgement that the risk of a gas escape leading to an explosion causing significant loss of life and/or property damage is, and should be, the principal concern.[39]

The key driver of consequence severity on people for mains and MUS is the location of the asset, the pressure it operates and the type of failure it experiences. This is prompted by proximity to population centres and buildings where escaped gas has the potential to collect and result in an explosion, the potential for an abrupt release (crack or break) and the pressure of the gas in the pipe – relating to the amount of gas escaping from a failure.

The inherent risk associated with pressurised natural gas means any substantial release of gas (regardless of the asset that fails) gives rise to the potential for explosion and fatalities or several people with life-threatening injuries.[40] Therefore, we consider the lowest plausible severity ranking for any gas main or MUS is major.

With regards to the impact on gas supply and environment, the consequences of a mains failure is far less severe. The meshed design of a gas network, where mains are fed from multiple locations, means that only a failure to a significant supply main which occurred at a period of high demand would have the potential for a significant restriction of supply to end users, with the most likely outcome being an outage to a limited number of end users. The environmental impact of mains failure is minor and very isolated, not only because of the short duration of any escape but because natural gas will dissipate into the atmosphere and leave negligible residual localised effect Table 15

[39] Jacobs 2015, Mains Replacement Program Review, December 2015, pg. 29
[40] AS/NZS 4645 Risk Severity Matrix, Major rating

illustrates our assessment of the severity of consequences of mains failure on people, supply and environment as set out in AS/NZS 4645 across the categories of mains identified in Table 16 above.

The CI/UPS MP trunk and CBD mains assessed as catastrophic consequence in the current AA period will have been replaced by the end of the current AA period. However, new low pressure mains will remain in the CBD. The location of the mains in the CBD means the consequence of an incident could be catastrophic.

The following table presents the consequence assessment for all 12 categories of assets.

Table 15: AS/NZ 4645 Consequence Assessment

Item	Catastrophic	Major	Severe	Minor	Trivial
People	Multiple fatalities result 12	Few fatalities or several people with life-threatening injuries 1 to 11	Injuries or illness requiring hospital treatment	Injuries requiring first aid treatment	Minimal impact on health and safety
Supply	Long Term interruptions of supply	Prolonged interruption or long-term restriction of supply	Short term interruption or restriction of supply	Short term interruption or restriction of supply but shortfall met from other sources 1 to 12	No impact, no gas restriction of gas distribution network supply
Environment	Effects wide spread viability of ecosystems or species affected, permanent major damage	Major off-site impact or long-term severe effects or rectification difficult	Localised (<1ha) and short-term (<2 years) effects easily rectified	Effect very localised (<0.1ha) and very short-term (weeks), minimal rectification	No, effect, or minor on-site effects rectified rapidly with negligible residual effect 1 to 12

1	CI/UPS - block	7	MUS – Priority group 1
2	HDPE 250 - remaining	8	MUS – Priority group 2
3	HDPE 575 DN50 - HP	9	MUS – Priority group 3
4	HDPE 575 DN50 - MP	10	New PE
5	HDPE 575 DN40	11	Protected Steel
6	HDPE 575 DN50 inspected	12	New CBD LP

3.4. Likelihood of Event

The next stage of the risk assessment considers the likelihood (frequency) that the failure event will occur and result in the predefined consequence.

AS/NZS 4645 has five frequency classes, ranging from Frequent (expected to occur once per year or more) down to Hypothetical (theoretically possible but has never occurred on a similar gas distribution network).

Though the AS/NSZ 4645 risk matrix considers impact on people, supply and the environment, standard risk management practice is to assess the likelihood of the highest consequence risk occurring when rating the risk event.

Therefore, we have used the AS/NZS 4645 frequency analysis to assess the frequency that a crack or other failure in a gas main or service results in gas collecting in a building and causes an explosion that results in fatalities or several people with life-threatening injuries.

The key drivers of risk frequency are the pipe material and condition (propensity to fail and the failure type) and the mains pressure (the volume of gas that escape from a failure).

When assessing frequency, it is also important to consider proximity of the mains to the general population and/or buildings, and the historical occurrence of incidents that either resulted in or had the potential to result in a catastrophic or major event.

The table below shows our assessment of likelihood of an event associated with gas mains.

Table 16: AS/NZ 4645 Likelihood Assessment

Frequency Class	Frequency Description	AGN Asset Classification
Frequent	Expected to occur once per year or more	
Occasional	May occur occasionally in the life of the gas distribution network	
Unlikely	Unlikely to occur within the life of the gas distribution network, but possible	1, 2, 3, 7
Remote	Not anticipated for this gas distribution network at this location	4, 5, 6, 8, 9
Hypothetical	Theoretically possible but has never occurred on a similar gas distribution network	10, 11, 12

1	CI/UPS - block	7	MUS – Priority group 1
2	HDPE 250 - remaining	8	MUS – Priority group 2
3	HDPE 575 DN50 - HP	9	MUS – Priority group 3
4	HDPE 575 DN50 - MP	10	New PE
5	HDPE 575 DN40	11	Protected Steel
6	HDPE 575 DN50 inspected	12	New CBD LP

The following sections outline the basis for the asset category frequency rating assessment.

3.4.1. Unlikely – unlikely to occur within the life of the network, but possible

The likelihood of an event on remaining CI/UPS, HDPE 250 and HDPE 575 DN50 HP (Categories 1, 2 and 3) mains and MUS – Priority group 1 (Category 7) is rated as unlikely, consistent with the assessment in the current period. Though these assets are in poor condition and some are at the end of their useful lives (hence the focus of existing replacement programs), their failure history suggests the likelihood of serious harm resulting from failure of an individual main remains unlikely but possible.

3.4.2. Remote – not anticipated for this network at this location

The likelihood of an event on other HDPE 575 mains (Categories 4, 5 and 6) is considered remote, due to the lower history of leaks and squeeze off failures, as shown in Table 16 in Section 3.4. For HDPE 575 DN50 Inspected (Category 6), the remote likelihood is linked to the fact that inline camera inspection and reinforcement is considered a temporary but effective risk mitigation activity which reduces the likelihood of a significant event occurring. The likelihood of an event for MUS – Priority groups 2 (Category 8) is also considered remote, with increased leak surveys undertaken for Priority group 2 to manage to remote until such time as replacement is required.

3.4.3. Hypothetical – may occur occasionally in the life of the network

The likelihood of an event occurring with MUS – Priority group 3, new PE, protected steel, new CBD LP mains (Categories 9, 10, 11 and 12) is considered 'Hypothetical' as these assets are relatively new, in good condition and with negligible leakage rates.

3.5. Overall Risk Rating

The AS/NZS 4645 risk framework then provides for the consequence and frequency analysis to determine an overall risk rating. The ratings range from high to negligible and correspond to a recommended risk treatment action. Based on the above severity and frequency analysis, Figure 10 shows the overall risk rating for the different categories of mains in the network.

Figure 10: Overall risk rating

	Catastrophic	Major	Severe	Minor	Trivial
Frequent					
Occasional					
Unlikely		1, 2, 3, 7			
Remote		4, 5, 6, 8			
Hypothetical	12	9, 10, 11			

1	CI/UPS - block	7	MUS – Priority group 1
2	HDPE 250 - remaining	8	MUS – Priority group 2
3	HDPE 575 DN50 - HP	9	MUS – Priority group 3
4	HDPE 575 DN50 - MP	10	New PE
5	HDPE 575 DN40	11	Protected Steel
6	HDPE 575 DN50 inspected	12	New CBD LP

The risk assessment has resulted in a rating of high for four categories of mains, intermediate for five categories and low for three categories.

Categories 1 to 5, 7 and 8 have been assessed as high or intermediate risk in accordance with AS/NZS 4645.

Categories 9 to 11 have been assessed as low risk as these MUS require no specific intervention at this stage and these mains are newer additions to our Network and do not have the propensity to crack or break and are more stable. These low risk categories of assets will continue to be subject to usual inspection cycles. These assets will be replaced in a piecemeal fashion in the unlikely event of a failure, or when an inspection identifies a compromised asset (such as insufficient groundcover) which requires early replacement.

The following categories have been assessed as intermediate risk but are considered ALARP:

- Category 6 is HDPE 575 DN50 mains which have been inspected using the inline camera program and reinforced where squeeze off locations are identified have also been assessed as intermediate risk. The likelihood of abrupt release of gas from squeeze off failure is expected to be reduced as a result of this treatment for a period of an estimated 10 years.[41] The reduction in risk is considered to be reasonable compared to the cost of replacing these mains to reduce the risk. These mains are therefore assessed as ALARP.

- Category 12 assets have also been assessed as intermediate risk because of their location in CBD. This risk is unable to be reduced further without removing the mains altogether. Therefore, the risk is considered to be ALARP.
- Category 8 are priority 2 MUS and have been rated as ALARP because they remain compliant and additional leak surveys and an awareness campaign for residents will improve the timeliness of identifying a failure or non-compliance. Further, we use the same type of crew for MUS and mains replacement (though we do need more fitters to install meters for MUS replacements) which could present delivery challenges and higher costs. Therefore, the cost of replacing these assets compared to the reduction in risk is disproportionate.

All high risk mains are not being removed from our Network '…within a timescale of not more than a few weeks' as it is not achievable. Instead, we focused on replacing as many as possible within delivery capability during the current AA period, with all remaining high risk mains addressed as soon as reasonably practicable.

3.6. Required Action

AS/NZS 4645 provides direction on how the risks in a gas distribution network should be treated and places an obligation on network operators to act.

Table 17 shows the relevant risk treatments required under AS/NZS 4645 and the categories of main that require each treatment.

[41] No squeeze off failure has been recorded on any inspected HDPE 575 DN50 since the inline camera inspection has begun

Table 17: AS/NZ 4645 Risk Treatment Actions

Risk Rating	Required Action	Asset category
Extreme	Modify the threat, the frequency or the consequences to ensure that the risk rank is reduced to Intermediate or lower. For a gas distribution network in operation the risk must be reduced immediately.	
High	Modify the threat, the frequency or the consequences to ensure that the risk rank is reduced to Intermediate or lower. For a gas distribution network in operation the risk must be reduced as soon as possible, typically within a timescale of not more than a few weeks.	1, 2, 3, 7
Intermediate	Repeat threat identification and risk evaluation process to verify and, where possible, quantify the risk estimation; determine the accuracy and uncertainty of the estimation. Where the risk rank is confirmed to be Intermediate, if possible modify the threat, the frequency or the consequence to reduce the risk rank to Low or Negligible. Where the risk rank cannot be reduced to Low or Negligible action shall be taken to: (a) remove threats, reduce frequencies and/or reduce severity of consequences to the extent practicable; and (b) demonstrate ALARP. For a gas distribution network that is in operation the reduction to low or negligible or demonstration of ALARP must be completed as soon as possible, typically within a timescale of not more than a few months.	4, 5, 6, 8, 12
Low	Determine the management plan for the threat to prevent occurrence and to monitor changes which could affect the classification.	9, 10, 11
Negligible	Review at the next interval	

1	CI/UPS - block	7	MUS – Priority group 1
2	HDPE 250 - remaining	8	MUS – Priority group 2
3	HDPE 575 DN50 - HP	9	MUS – Priority group 3
4	HDPE 575 DN50 - MP	10	New PE
5	HDPE 575 DN40	11	Protected Steel
6	HDPE 575 DN50 inspected	12	New CBD LP

The next step in our assessment is to consider the risk mitigation options available to address the risk consistent to reduce the risk rating appropriately.

3.7. Risk mitigation options

There are three primary risk mitigation options available to us to address identified risks:

- Replacement with newer, low risk mains or services;
- Inline camera inspection and reinforcement of squeeze off locations; and
- Monitor condition and undertake action as needed.

The impact of these risk mitigation options differ, as shown in Table 18.

Table 18: Impact of primary risk mitigation options

Option	Description	Impact on risk
Replacement	Replace with new low risk main	Removes risk
Inline camera inspection and reinforcement when required	Inspection of high risk main with squeeze off locations reinforced via steel clip clamping	Temporary reduction of risk by addressing key vulnerability through reinforcement
Monitor	Monitoring of integrity and performance of mains through inspections and reporting The scope of monitoring activities is dependent on the residual risk of the asset, meaning, we do a higher number of leak surveys on assets in high risk areas then assets that transverse a paddock. For assets that are being replaced, they are subjected to increase monitoring activities to reduce risk to ALARP prior to replacement.	No change but allows for prompt intervention

These are supported and supplemented by the following risk mitigation activities:

Table 19: Description of other risk mitigation options

Description	Impact on risk
Setting and monitoring relevant network KPIs	The monitoring of network performance allows us to identify trends in network performance and safety issues across asset classes to optimise safety outcomes. It also allows us to effectively manage our operations to ensure leaks are responded to and repaired within required timeframes.
Responding to leak reports and undertaking repairs	Prompt response and rectification of leaks reduce the potential for negative outcomes. Leak response is a top priority for our operational teams.
Leak surveys of mains	Proactive surveying of mains helps us identify, monitor and repair leaks before they become an issue or are detected by the public. Our Leak Management Plan outlines our leakage management frequencies.
Pressure reduction in areas with history of crack failure	The amount of gas released from a leak is related to the pressure within the gas mains. Where possible, we reduce network pressures to limit the volume of gas that might escape from a mains if a leak was to occur. This is the reason the Adelaide CBD network is limited to low pressure (7kPa).

Description	Impact on risk
Gas odourisation to improve leak detection	Natural gas, in its natural form, is odourless. We odourise the gas so leaks can be detected by us and the public. Gas odourisation standards ensure gas is odourised to a level where it is discernable at 20% of the lower explosive limit (LEL).
Corrosion protection of steel mains	Corrosion protection increases the life of steel mains and reduces the likelihood of leaks.
Review of network condition and performance through Distribution System Performance Review (DSPR)	The monitoring of network performance allows us to identify trends in network performance and safety issues across asset classes to optimise safety outcomes.
Sampling program to improve information on condition and deterioration rates	Sampling mains helps us to proactively assess the condition of mains (through material testing) to better understand their condition.
Installation of ground vents over HDPE mains where ground conditions could seal gas leaks	It is common for leaks to occur on a gas distribution network. A leak, by itself, is not dangerous if the gas in venting to a safe location and never reaches a concentration where it becomes explosive. The installation of ground vents directs leaks (if they were to occur) to a safe location and not into enclosed spaces (e.g. within a building) where gas can build and become a hazard.

A combination of primary and other risk mitigation activities is proposed for the ongoing management of risk in our Network. These are discussed in Section 4.

4. Option assessment

This section presents a number of scenarios which were developed and evaluated to identify the most appropriate program of mains replacement and related activities to achieve the desired outcomes for the next AA period.

We considered a number of scenarios available to achieve different cost and risk outcomes to arrive at an optimal balance of risk reduction for the costs incurred. The recommended scenario addresses risk consistent with the actions of a prudent and efficient service provider, acting in accordance with accepted good industry practice to maintain and improve the safety of gas distribution services whilst minimising costs to customers.

4.1. Scenario development

We identified 12 distinct categories of mains and services within our Network, each with a different underlying driver for risk and requirement for risk reduction or elimination.

Each of these categories was assessed to understand the inherent risk associated with each category and the effectiveness of options to mitigate the risk. The table below presents the risk categories, the inventory of asset in our Network, the assessed untreated risk, and the available treatments to reduce risk.

Table 20: Inventory of mains and services at the beginning of the next AA period (July 2021)

Asset	Asset type	Pressure	Kilometres at 2021	Untreated Risk	Available treatment to reduce risk
At risk mains					
1	CI/UPS - block[42]	Low and Medium	558	High	Replace
2	HDPE 250 - remaining	Medium	14	High	Replace
3	HDPE 575 DN50 - HP	High	57	High	Replace or inspect and reinforce
4	HDPE 575 DN50 - MP	Medium	259	Intermediate	Replace or inspect and reinforce
5	HDPE 575 DN40	Medium and High	447	Intermediate	Replace
6	HDPE 575 DN50 inspected	Medium and High	310	Intermediate (ALARP)	Replace or Monitor
Total at risk mains			**1,645**		

[42] As noted in Section 1.2, other LP materials such as HDPE 250, HDPE 575 and New PE are also included in this program

Asset	Asset type	Pressure	Kilometres at 2021	Untreated Risk	Available treatment to reduce risk
Services					
7	MUS – Priority group 1	Low	457 sites	High	Replace
8	MUS – Priority group 2	Low	1,653 sites	Intermediate (ALARP)	Replace or monitor
9	MUS – Priority group 3	Low	361 sites	Low	Not required
Total at risk services			**2,471 sites**		
Other mains					
10	New PE (PE80 and PE100)	Medium and High	5,500	Low	Not required
11	Protected steel and copper	Medium and High	1,705	Low	Not required
12	CBD LP	Low (7kPa)	27	Intermediate (ALARP)	Monitor
Total other mains			**7,232**		

Of the 12 asset categories identified, three were identified as low risk which will continue to be monitored but do not require further mitigation activities in the next AA period unless there is a failure or an incident, wherein we will respond and rectify.

Three categories were identified as ALARP without replacement.

Where risk is assessed as high or intermediate, we must reduce the risk to low or negligible and if not possible then to ALARP. This is in accordance with Appendix C AS/NZS 4645 which provides direction on how the risks in a gas distribution network should be treated and places an obligation on network operators to take action, as noted in Table 17.

A number of scenarios were developed to assess the cost of achieving different risk outcomes while also considering the cost to consumers.

The scenarios considered various blends of the key mitigation options available, namely:

Table 21: Mitigation options for next AA period

Mitigation option	Impact of mitigation
Proactive asset replacement	Remove risk from the Network
Reactive asset replacement	Remove risk from the Network
Asset inspection and reinforcement	Reduce risk for impacted asset
Asset monitoring	Proactively identifies change in risk

The scenarios assessed are as follows:

- Scenario A: Complete established programs only – this program replaces only the remaining CI/UPS block and HDPE 250 mains;
- Scenario B: Achieve low risk – this program removes all high and intermediate risk assets from our Network;
- Scenario C: Remove all high risk – this program removes all high-risk mains and priority 1 MUS;
- Scenario D: Maintain ALARP for all mains and MUS – this program removes all high and intermediate risk mains unless they can, or have been, inspected through the in-line inspection program and removes all priority 1 MUS;
- Scenario E: Efficient ALARP for all mains and MUS – this program is the same as Scenario D except that it takes a prioritised approach to replacing HDPE 575 DN40 mains, deferring the replacement of some of these mains until the subsequent AA period as the incremental cost of replacing all these mains is not proportionate to the incremental reduction in risk. This is the recommended scenario.

A summary of the scenarios and their outcomes is shown in Table 22.

Table 22: Scenarios considered for next AA period (summary view)

Asset Category	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E (Recommended)
Total replacement (km)	632	1,655	669	1,029	870
Total inspection (km)	-	-	-	316	316
Total MUS replacement	125	2,110	457	457	457
Risk at June 2026	High	Low	Intermediate	Intermediate (ALARP)	Intermediate (ALARP)
Total capex ($ million)[43]	**$197.1**	**$467.4**	**$203.7**	**$300.6**	**$259.1**
Cost to customer ($ million)[44]	**$14.3**	**$33.1**	**$14.8**	**$21.0**	**$18.3**

[43] Note that there is no inclusion of non AMRP in these capex totals. Their cost and impact are unchanged across all scenarios.
[44] This reflects the cost to customer over the 5 years of the next AA period only and does not consider the impact over future periods.

4.1.1. Scenario A – Complete established programs only

We have established that the only effective way of reducing risk associated with CI, UPS and ageing HDPE 250 mains is to replace them.

With this scenario, we would replace all remaining mains in these categories. All remaining CI/UPS mains are considered highest risk due to their propensity to crack and their age. All remaining HDPE 250 have also been identified as highest risk, as they have become brittle and susceptible to cracking, have sustained squeeze off damage and are considered likely to exhibit slow crack growth failures in the future.

This scenario would result in the replacement of 632 kilometres of mains, including 60 kilometres of piecemeal (unplanned) replacement, and the reactive replacement of 125 MUS, at a total cost of $197.1 million.

High risk HDPE 575 DN50 mains and high risk MUS would remain in our Network to be replaced in subsequent AA periods. The cost to customers of this scenario is $14.3 million over the next AA period, which equates to $5.94 per customer per year for the 5 years.

This scenario is not a viable option because it would leave an unacceptable high risk main in our Network without us doing anything to reduce the risk, which would contravene requirements of AS/NZS 4645.

Table 23: Scenario A – Complete established programs only

Asset Category		Inventory at July 2021	Risk at July 2021	Inventory at July 2026	Risk at July 2026
1	CI/UPS - block[45]	558	High	0	Low
2	HDPE 250	14	High	0	Low
3	HDPE 575 DN50 - HP	57	High	57	High
4	HDPE 575 DN50 - MP	259	Intermediate	259	Intermediate
5	HDPE 575 DN40	447	Intermediate	512	Intermediate
6	HDPE 575 DN50 inspected	310	Intermediate (ALARP)	310	Intermediate (ALARP)
7	MUS – Priority group 1	457	High	332	High
8	MUS – Priority group 2	1,653	Intermediate (ALARP)	1,653	Intermediate (ALARP)
Residual risk in 2026					**High**
Total capex ($ million)					**$197.1**
Total cost to customer ($ million)					**$14.3**
Cost per customer p.a.					**$5.94**

4.1.2. Scenario B - Achieve a low risk rating

Under this scenario all high and intermediate risk mains and MUS would be replaced. This would include the replacement of HDPE 575 DN50 mains that have been previously inspected and reinforced. The total mains to be replaced in this scenario is 1,655 kilometres (including 10 kilometres of piecemeal replacement) and 2,110 MUS would be renewed. The cost of this scenario is $467.4 million and only low risk rated assets would remain in the Network.

The cost to customers of this scenario is $33.1 million over the next AA period, which equates to $13.72 per customer per year for the 5 years.

[45] As noted in Section 1.2, other LP materials such as HDPE 250, HDPE 575 and New PE are also included in this program

Table 24: Scenario B – Achieve low risk rating

Asset Category	Inventory at July 2021	Risk at July 2021	Inventory at July 2026	Risk at July 2026
1 CI/UPS - block[46]	558	High	0	Low
2 HDPE 250	14	High	0	Low
3 HDPE 575 DN50 - HP	57	High	0	Low
4 HDPE 575 DN50 - MP	259	Intermediate	0	Low
5 HDPE 575 DN40	447	Intermediate	0	Low
6 HDPE 575 DN50 inspected	310	Intermediate (ALARP)	0	Low
7 MUS – Priority group 1	457	High	0	Low
8 MUS – Priority group 2	1,653	Intermediate (ALARP)	0	Low
Residual risk in 2026				**Low**
Total capex ($ million)				**$467.4**
Total cost to customer ($ million)				**$33.1**
Cost per customer p.a.				**$13.72**

4.1.3. Scenario C - Remove all high-risk assets

In this scenario, all high-risk mains and MUS would be removed in the next AA period. This includes all remaining CI/UPS, HDPE 250, all HDPE 575 that have not yet been reinforced and all high risk MUS.

This scenario would include replacing 669 kilometres of mains (including 40 kilometres of piecemeal (unplanned) replacement) and the renewal of 457 MUS, at a total cost of $203.7 million. Nevertheless, intermediate risk assets would remain in our Network for the subsequent AA period.

The cost to customers of this scenario is $14.8 million over the next AA period, which equates to $6.13 per customer per year for the 5 years.

[46] As noted in Section 1.2, other LP materials such as HDPE 250, HDPE 575 and New PE are also included in this program

Table 25: Scenario C – Remove all high risk mains and services

Asset Category		Inventory at July 2021	Risk at July 2021	Inventory at July 2026	Risk at July 2026
1	CI/UPS - block[47]	558	High	0	Low
2	HDPE 250	14	High	0	Low
3	HDPE 575 DN50 - HP	57	High	0	Low
4	HDPE 575 DN50 - MP	259	Intermediate	259	Intermediate
5	HDPE 575 DN40	447	Intermediate	447	Intermediate
6	HDPE 575 DN50 inspected	310	Intermediate (ALARP)	310	Intermediate (ALARP)
7	MUS – Priority group 1	457	High	0	Low
8	MUS – Priority group 2	1,653	Intermediate (ALARP)	1,653	Intermediate (ALARP)
Residual risk in 2026					**Intermediate**
Total capex ($ million)					**$203.7**
Total cost to customer ($ million)					**$14.8**
Cost per customer p.a.					**$6.13**

4.1.4. Scenario D – ALARP

Under this scenario all high and intermediate risk mains would be replaced except where an effective risk mitigation alternative is available to achieve ALARP.

In the current AA period, we have tested the effectiveness of the inline camera inspection program for use in the larger diameter HDPE 575 DN50 mains. While this does not completely remove the risk associated with these mains, it reduces risk for a much lower relative cost when compared with replacement. This approach is an effective and efficient way of addressing risk in HDPE 575 DN50 mains to achieve ALARP. Therefore, this scenario adopts this approach rather replacement for these mains.

This scenario includes the replacement of 1,029 kilometres of mains (including 10 kilometres of piecemeal), with a further 316 kilometres of HDPE 575 DN50 mains inspected and reinforced when required. Only the MUS – Priority group 1 are replaced (457 sites) because we consider the MUS – Priority group 2 ALARP as a result of the increased leak survey frequency and education (awareness) campaign for households. The total cost of this scenario is $300.6 million.

The cost to customers of this scenario is $21.0 million over the next AA period, which equates to $8.72 per customer per year for the 5 years.

[47] As noted in Section 1.2, other LP materials such as HDPE 250, HDPE 575 and New PE are also included in this program

Table 26: Scenario D – ALARP

Asset Category	Inventory at July 2021	Risk at July 2021	Inventory at July 2026	Risk at July 2026
1 CI/UPS - block[48]	558	High	0	Low
2 HDPE 250	14	High	0	Low
3 HDPE 575 DN50 - HP	57	High	0	Intermediate (ALARP)
4 HDPE 575 DN50 - MP	259	Intermediate	0	Intermediate (ALARP)
5 HDPE 575 DN40	447	Intermediate	0	Low
6 HDPE 575 DN50 inspected	310	Intermediate (ALARP)	626	Intermediate (ALARP)
7 MUS – Priority group 1	457	High	0	Low
8 MUS – Priority group 2	1,653	Intermediate (ALARP)	1,653	Intermediate (ALARP)
Residual risk in 2026				Intermediate (ALARP)
Total capex ($ million)				**$300.6**
Total cost to customer ($ million)				**$21.0**
Cost per customer p.a.				**$8.72**

4.1.5. Scenario E – Efficient ALARP

In this scenario, all remaining high risk mains would be replaced or inspected and reinforced when required. All high risk MUS would also be renewed.

Intermediate risk HDPE 575 DN50 mains would be inspected and reinforced when required and the majority of intermediate risk HDPE 575 DN40 mains would be replaced. The volume of HDPE 575 DN40 mains to be replaced (288 kilometres) reflects a prioritised replacement of older, higher risk mains (consistent with the prioritised program being undertaken in the current AA) and defers the replacement or inspection and reinforcement of the relatively lower risk DN40s (159 kilometres) to the subsequent AA period. This achieves a more efficient delivery program.

We are continuing to investigate the use of inline inspection for these smaller diameter mains which, if it became possible in the future, would reduce the cost of mitigating the risk in future periods.

This scenario includes replacement of 870 kilometres of mains, inspection and reinforcement of 316 kilometres of mains and renewal of 457 MUS. The total cost of this scenario is $259.1 million.

The cost to customers of this scenario is $18.3 million over the next AA period, which equates to $7.57 per customer per year for the 5 years.

[48] As noted in Section 1.2, other LP materials such as HDPE 250, HDPE 575 and New PE are also included in this program

Table 27: Scenario E – Efficient ALARP

	Asset Category	Inventory at July 2021	Risk at July 2021	Inventory at July 2026	Risk at July 2026
1	CI/UPS - block[49]	558	High	0	Low
2	HDPE 250	14	High	0	Low
3	HDPE 575 DN50 - HP	57	High	0	Intermediate (ALARP)
4	HDPE 575 DN50 - MP	259	Intermediate	0	Intermediate (ALARP)
5	HDPE 575 DN40	447	Intermediate	159	Intermediate (ALARP)
6	HDPE 575 DN50 inspected	310	Intermediate (ALARP)	626	Intermediate (ALARP)
7	MUS – Priority group 1	457	High	0	Low
8	MUS – Priority group 2	1,653	Intermediate (ALARP)	1,653	Intermediate (ALARP)
Residual risk in 2026					Intermediate (ALARP)
Total capex ($ million)					**$259.1**
Total cost to customer ($ million)					**$18.3**
Cost per customer p.a.					**$7.57**

4.2. Assessment of Scenarios

The following table presents the cost and risk outcomes for each of the scenarios considered.

[49] As noted in Section 1.2, other LP materials such as HDPE 250, HDPE 575 and New PE are also included in this program

Table 28: Risk impact of scenarios considered ($ million 2019/2020)

Scenario	Summary	Residual risk at July 2026	Capex	Net Present Cost to customer	Cost per customer p.a. ($)
A	Established programs only	High	$197.1	$14.3	$5.94
B	Achieve low risk	Low	$467.4	$33.1	$13.72
C	Remove all high risk	Intermediate	$203.7	$14.8	$6.13
D	ALARP	Intermediate (ALARP)	$300.6	$21.0	$8.72
E	Efficient ALARP	Intermediate (ALARP)	$259.1	$18.3	$7.57

Scenario E is recommended because it is the most prudent and efficient approach to achieving ALARP. The other scenarios are not recommended because:

- Scenario A is neither compliant with our obligations nor prudent. This scenario would retain a large amount of high risk assets within our Network longer than necessary;
- Scenario B is not prudent or efficient. This scenario would include replacing HDPE 575 DN50 which have recently been repaired and have an estimated remaining useful life of 10 years, and replace 259 kilometres of HDPE 575 DN50 which could be managed effectively with the continuation of the lower cost inline camera inspection (and reinforcement) program. The additional $208 million in cost to achieve low risk rather than ALARP is not considered to be proportionate or efficient;
- Scenario C is not compliant with our obligations nor prudent. This scenario includes the replacement of HDPE 575 DN50 mains that can be inspected with an inline camera and reinforced where required. This is a more cost-effective risk mitigation than replacing these assets;
- Scenario D is not recommended because ALARP can be achieved more efficiently. This scenario achieves a low or ALARP risk assessment by the end of the next AA period, but delivery challenges would increase the cost of achieving ALARP.

Scenario E addresses the highest risk mains in our Network through replacement or inspection, and leaves only the lower priority HDPE 575 DN40s and inspected DN50s for replacement in the subsequent (July 2026 to June 2031) AA period. With Scenario E, all other high and intermediate risks are either removed or reduced to low or ALARP is demonstrated. This scenario reflects an efficient deliverable volume of activity and avoids the significantly higher cost of achieving a low risk rating. This scenario replaces all the highest risk mains which cannot be managed through other risk mitigation options.

Inline camera inspections are a key component of managing risk so that it is ALARP, consistent with our obligations for those mains that are not replaced. ALARP is achieved for these mains, because the incremental cost of removing all HDPE 575 DN50 mains (including those which have already been inspected and repaired) is not proportionate to the risk reduction achieved compared to inline inspection and reinforcement when required.

Our process for estimating costs is outlined in Section 5 and in more detail in Attachment 8.9 - Unit Rates report. Where there are known variances to actual historical rates, these are discussed in Section 5.

5. Program costs and impact on customers

This section outlines the cost of the DMSIP work program to be undertaken in the next AA period, the methodology adopted to estimate the cost and a comparison with the cost estimated and incurred in the current AA period. These costs are also presented on a cost to customer basis as this was considered in assessing the impact on customers of achieving a lower risk outcome. Customer numbers used to calculate the cost to customer impact are based on the straight average across Tariff V, C and D customers over the forecast period (July 2021 to June 2026).

5.1. Cost estimation method

The cost of the program for the next AA period has been estimated by multiplying the volume of mains to be replaced or inspected by the unit rate cost of replacing or inspecting the mains. The unit rate differs for main type and inspection/replacement approach. Unit rates reflect the most relevant actual cost incurred or the price resulting from a tender process.

5.1.1. Mains replacement

The unit rate for mains replacement differs depending on whether the mains are replaced in a planned ('block') or 'piecemeal' fashion and also whether the replacement occurs through direct bury or insertion. Directly burying mains is more costly.

Further, the unit rates for CI and UPS differ when being replaced in North Adelaide because this location requires working in a congested area with similar conditions to the Adelaide CBD such as more congested traffic and pedestrians, increased levels of reinstatement (fully paved footpaths, heritage footpaths), increased working restrictions and increased commercial/business considerations (interruptions, coordination/liaison). It is also part of the Adelaide City Council area and similar requirements by the Adelaide City Council will be imposed in terms of performing a proportion of these works at night and on the weekends to minimise disruption to businesses, traffic and pedestrians.

Where the volume of work completed recently is high and of similar scope, the unit rates reflect the weighted average of the most recent actuals incurred. In this case the most recent actual cost information for the period July 2019 to March 2020 has been adopted. This approach has also allowed us to factor in the cost of changes to external regulatory requirements in July 2019 and new third party asset owner requirements from December 2019.

Further information on how the unit rates have been derived is provided in Attachment 8.9 - Unit Rates Report.

5.1.2. Inline inspection

Inline camera inspection will occur on the HDPE 575 DN50 mains due to the relatively lower cost and the success evidenced to date in the reduction of risk associated with squeeze off failure. As noted in Section 3, by performing the inline camera inspection and reinforcing squeeze off locations where identified, the underlying risk of these mains essentially moves from high to intermediate. We consider these mains ALARP once inspected, as we do not believe the incremental cost that would be incurred to reduce this risk to low is proportionate with the incremental risk reduction achieved through replacement. This is an effective risk mitigation activity which supports the deferral of replacement for an estimated 10-year period.

The cost of inspection is estimated based on the most recent cost incurred.

5.1.3. Multi-user service replacement

We will replace the MUS that have been rated as Priority group 1. However, we have introduced additional leak survey activities for those MUS that have been rated as Priority group 2 to ensure any deterioration is identified in a timely manner to reduce the underlying risk of these assets. Therefore, these assets are considered ALARP.

The cost of replacement of MUS is estimated based on the weighted average actual cost over the past three years, as described in Attachment 8.9 – Unit Rates Report. This approach is taken as the scope of work at individual MUS is variable depending on the number of individual services, location and other site specific factors.

5.2. Forecast cost for the next AA

There are six categories of assets that will be replaced or inspected in the next AA period. However, included in the cost of the program is a small allowance for piecemeal replacement across asset types to allow for unplanned events. The forecast piecemeal replacement reflects the lower level of piecemeal replacement achieved in the current AA period.

The following table presents the categories of assets that will be replaced and inspected in the next AA period, the volume to be replaced, unit rates and the cost by asset category. Due to the higher cost of replacing CI and UPS mains in North Adelaide, these mains are presented separately.

Similarly, for HDPE 575 DN40, some of these mains (medium pressure) will be replaced using direct burial and some (high pressure) can be replaced by insertion, so these have also been presented separately. The additional cost of direct burial has been estimated based on the average Schedule of Rates contract prices across the five current active mains replacement contractors in South Australia ([redacted]/metre). Further information on this premium is provided in Attachment 8.9 - Unit Rates Report.

Table 29: Estimated program cost ($ million 2019/2020)

#	Asset category	Unit rate	Volume	Total Capex	Basis of unit rate
1	CI/UPS - block	[redacted]	520km[50]	[redacted]	Current actual cost
1a	CI/UPS North Adelaide	[redacted]	38km	[redacted]	Current actual cost
2	HDPE 250 remaining	[redacted]	14km	[redacted]	Current actual cost
3 & 4	HDPE 575 DN50 - inspection	[redacted]	316km	[redacted]	Current actual cost
5	HDPE 575 DN40 – insertion	[redacted]	198km	[redacted]	Current actual cost
5a	HDPE 575 DN40 – direct burial	[redacted]	90km	[redacted]	Current actual cost + premium
7	MUS - Priority group 1	[redacted]	457 sites	[redacted]	Weighted historical average rate
-	Piecemeal replacement	[redacted]	10km	[redacted]	Weighted historical average rate
-	Non-AMRP service replacement^	[redacted]	2,450 sites	[redacted]	Weighted historical average rate

^Non-AMRP service replacement is an ongoing reactive program of work to address service replacements for non-compliant (insufficient depth) or corroded/deteriorated services which are identified outside of mains replacement.

For more detail on the unit rate identification and derivation process, please refer to Attachment 8.9 - Unit Rates Report.

5.3. Comparison to the current AA period

We have significantly reduced the risk that remains in the network and delivered on our commitments in the current AA period:

- All extreme risk mains removed from our Network;
- The overall volume of mains replaced in the period is in line with forecast;
- We successfully trialed inline camera inspections as an effective alternative to replacement from both a cost and risk management perspective; and
- We prudently deferred the replacement of a significant number of MUS by utilising better information and replacing only the highest risk MUS.

The reduction in volume of at risk mains in our Network is shown in Table 30

[50] As noted in Section 1.2, other LP materials such as HDPE 250, HDPE 575 and New PE are also included in this program

Table 30: At risk mains inventory over time (km)

Asset category	Risk	2016 inventory	2021 inventory	2026 inventory	Comment
CI/UPS CBD	Extreme	53	0	0	All Extreme risk mains removed in full by 2021
Trunk mains	Extreme	58	0	0	
CI/UPS Block[51]	High	851	558	0	All remaining CI/UPS block mains removed in full by 2026
HDPE 250	High	305	14	0	All remaining HDPE 250 removed in full by 2023
HDPE 575	High and Intermediate	1,430	763	159	Lowest priority DN40s remain in Network in 2026
HDPE 575 - inspected	Intermediate (ALARP)	0	310	626	626 km of DN50s will be inspected and reinforced
At risk mains		**2,697[52]**	**1,645**	**785**	

We committed to replace 1,052 kilometres of our highest risk mains in the current AA period. This included an expectation that 480 kilometres of HDPE 575 DN50 mains and 180 kilometres of HDPE 250 mains would be replaced in future periods. However, during the period, a more granular review of mains was done, which considered individual jobs rather than suburb based prioritisation, and the prioritisation has led to a shift across these two mains, with more HDPE 250s replaced than initially forecast. An additional 20 kilometres of mains was allowed in the current AA period for reactive (piecemeal) replacement. We have undertaken 7 kilometres of reactive replacement.

We also allowed for the replacement of 1,328 MUS which related to the 2004 to 2012 mains replacement program, but a more detailed review of the condition and compliance of a sample of MUS identified the need for a more detailed consideration and assessment of the MUS. This was to ensure the highest priority MUS were replaced first, rather than the initially proposed suburb specific manner. We have focused in the current AA period on planning for the optimal management of a broader number of MUS (pre and post 2004) and are confident that with a more targeted replacement program, we will achieve the best risk mitigation outcome in the most prudent and efficient way. We have introduced additional leak surveys to ensure the risk of MUS - Priority groups 1 and 2 is maintained at ALARP throughout this process.

Table 31 presents the actual volumes, unit rates and total capex compared to the allowance.

[51] As noted in Section 1.2, other LP materials such as HDPE 250, HDPE 575 and New PE are also included in this program

[52] Note that actual 'at risk' mains inventory at July 2016 differs to the forecast included in our response to the Draft Decision, which forecast 2,619 km of 'at risk' mains in our Network on this date

Table 31: Actual versus allowed unit rates and volumes in the current AA period ($ million 2019/2020)

Asset Category	Actual			Allowed			Variance	
	Volume	Unit rate	Capex	Volume	Unit rate	Capex	Volume	Capex
CBD block	46			38	[redacted]	[redacted]	8	
CBD trunk	0.2	[redacted]	[redacted]	4	[redacted]	[redacted]	(3.8)	(6.6)
CBD abandon	7			2	[redacted]	[redacted]	5	
Trunk replacement	48	[redacted]	[redacted]	42	[redacted]	[redacted]	6	(21.7)
Trunk abandonment	11			20	[redacted]	[redacted]	(9)	
CI/UPS - block	293	[redacted]	[redacted]	292.1	[redacted]	[redacted]	0.9	2.8
HDPE 250 MP - block	291	[redacted]	[redacted]	180.1	[redacted]	[redacted]	110.9	13.9
HDPE 575 – block	357	[redacted]	[redacted]	473.8	[redacted]	[redacted]	(116.8)	(33.0)
CI/UPS - piecemeal	6.8	[redacted]	[redacted]	15	[redacted]	[redacted]	(13.2)	(3.2)
HDPE 575 – piecemeal				5	[redacted]	[redacted]		
Total replacement	**1,059**		**255.2**	**1,072**		**302.9**	**(12)**	**(47.8)**
HDPE 575 inspection	310	[redacted]	[redacted]	440	[redacted]	[redacted]	(130)	(2.5)
MUS replacement	233	[redacted]	[redacted]	1,328	[redacted]	[redacted]	(1,095)	(13.6)
Non-AMRP service replacement	2,856	[redacted]	[redacted]	-	[redacted]	[redacted]	2,856	5.3
Total program			**16.5**			**27.4**		**(10.9)**

The total volume of mains replaced in the period is closely aligned with forecast, at 1,052 kilometres of planned replacement with 7 kilometres of piecemeal replacement (allowance was for 20 kilometres) occurring. The following sections outline reasons for variances by asset type.

5.3.1. Extreme risk mains

The opening inventory for our highest risk mains (CBD and Trunk Mains) at period commencement differed to the forecast included at the time of the determination. We commenced the period with 53 kilometres of CBD mains compared to the forecast of 44 kilometres and 59 kilometres of Trunk

Mains rather than the forecast 62 kilometres. Nevertheless, all 112 kilometres of extreme risk mains will have been removed from our Network by June 2021. The following table presents the actual cost incurred and volume replaced compared to the allowance. It shows we have been able to remove extreme risks mains from our network for $28 million (35%) less than forecast, primarily driven by lower unit costs of replacing medium pressure trunk mains.

Table 32: Extreme risk mains – current AA period (km and $ million 2019/2020)

Mains category	Actual km	Allowed km	Actual capex	Allowed capex	Variance $	2016 Risk	2021 Risk
CBD	53	44	25.3	31.9	(6.6)	Extreme	Low
MP Trunk	59	62	25.9	47.6	(21.7)	Extreme	Low
Total	**112**	**106**	**51.2**	**79.5**	**(28.2)**		

5.3.2. Prioritising replacement of high risk mains

The forecast replacement of high risk mains were prioritised using the prioritisation model which assessed mains using the following criteria:

- Likelihood factors (at a construction job level), such as age, operating pressure, diameter and past leaks; and
- Consequence factors, such as soil type [sand versus clay], building construction factor [ranked from 5 to 1, with 5 as most dangerous, with proximity to cottages and 1 being larger properties with concrete slabs] and pressure

Where mains were over 30 years old, an age based deterioration factor was additionally applied.

The prioritisation process is a continuous process within our business, which led to some variation in the program compared to forecast over the period. There was no material change in the volumes of CI/UPS and HDPE mains volumes. However, there was an increase in the number of HDPE 250 mains replaced due to the age of the material and a greater history of cracking compared to some of the HDPE 575 mains. The HDPE 575 mains with a history of squeeze off failure were replaced. Where there was no history of squeeze off failure in the HDPE 575 DN50 mains they were prioritised for the inline camera inspection program.

As shown in Table 33, the overall volume of high risk mains replacement is marginally below forecast primarily due to a lower level of piecemeal replacement than forecast (7 kilometres compared to the allowed 20 kilometres), and the total cost was $20 million (9%) lower than forecast.

The inline camera inspection program was a new activity in the current AA period. We delivered 70% of the forecast program, at a total cost of $8 million (76% of forecast), as the unit rate for inline camera inspection and reinforcement was marginally higher than forecast ([redacted] per metre compared to our forecast of [redacted] per metre).

Table 33: High risk mains – current AA period ($ million 2019/2020)

Mains category	Actual km	Allowed km	Actual capex	Allowed capex	Variance $	July 2016 Risk	July 2021 Risk
CI/UPS - block	293	292	[redacted]	[redacted]	2.8	High	High
HDPE 250	291	180	[redacted]	[redacted]	13.9	High	High
HDPE 575	357	474	[redacted]	[redacted]	(33.0)	High	High
Piecemeal	7	20	[redacted]	[redacted]	(3.2)	-	-
Total replacement	**948**	**966**	[redacted]	[redacted]	**(19.5)**		
Inline inspection	310	440	[redacted]	[redacted]	(2.5)	High	High
Total inspection	**310**	**440**	[redacted]	[redacted]	**(2.5)**		
Total capex			**212.3**	**236.1**	**(22.1)**		

The cost of the high risk program was $22.1 million or 9% less than forecast in the current AA period.

The variation in cost was driven by changes in the unit rates incurred (as displayed in Table 31) and volumes completed when compared to forecast:

- The unit rate for replacing CI/UPS block mains increased to [redacted]/metre (and averaged [redacted]/metre) compared to the forecast [redacted]/metre due to a new requirement that related meter sets needed to be replaced or protected with bollards where it is in a car park or in a driveway (private and single occupancy domestic home) and a vehicle would be within 1 metre. This requirement commenced in July 2019 under the 400-PR-QM-0011_0.0 National Meter Assembly Location Procedure. Similarly, where a gas meter is located on a wall and is installed less than 1 metre from a driveway, there is now a requirement to relocate it or install adequate protection. Previously, these meters were left in place;
- The unit rate incurred for HDPE 250 was lower than allowed ([redacted]/metre versus [redacted]/metre) in the period. This is due to significantly lower rates achieved in 2016/17 and 2017/18 compared to forecast which have in 2018/19 and 2019/20 trended back up toward the forecast rates. This lower unit rate in the earlier years can additionally be attributed to the mix of work being slightly biased to less expensive locations in that period. We also changed our prioritisation during the period which meant we replaced more HDPE 250 and less HDPE 575 than forecast, achieving a slightly lower unit rate for HDPE 250 compared to HDPE 575 replacement. This higher volume of HDPE 250 replacement was a result of the more granular prioritisation process undertaken in the current AA, with more than 60% above forecast volume of HDPE 250 replaced;
- The unit rate for HDPE 575 replacement was also lower than allowed ([redacted]/metre versus [redacted]/metre), as a result of our effective procurement processes. This lower rate combined with a reduced volume of activity in the period (25% below forecast) resulted in a material underspend for this category of mains.

The variation in cost in this period, particularly for activities such as direct lay versus insertion has informed our unit rates for the next AA period.

5.3.3. MUS replacement

The MUS program was reviewed early in the period with the benefit of additional information that became available because of inspections and sample replacement volumes undertaken. The additional information identified significant variability in the condition of individual MUS and enabled a more refined approach to replacing MUS. This led to a significantly lower level of replacement compared to the forecast, as shown in Table 34.

The cost of replacing the MUS is broadly in line with that allowed ([redacted]/unit on average versus [redacted]/unit). However, the current year cost has been higher ([redacted]/unit) because the program in later years has focused on replacing the highest risk MUS which usually included those in poor location or requiring significant rectification activity. The unit rate of an MUS renewal varies greatly, depending on the size, with the cost ranging from [redacted] for small 2 to 4 unit locations up to [redacted] for larger, 20 plus unit locations. A weighted average has been considered for comparative purposes.

Table 34: MUS – current AA period ($ million 2019/2020)

MUS category	Actual units	Allowed units	Actual capex	Allowed capex	Variance ($)	2016 Risk	2021 Risk
MUS	233	1,328	[redacted]	[redacted]	(13.6)	High	High

5.4. Delivery capability

We have assessed our capability to deliver the program outlined for the next AA period.

In the current period, we will have replaced 1,059 kilometres of mains, with 53 kilometres of particularly challenging mains within the Adelaide CBD. We will have also inspected 310 kilometres of HDPE 575 DN50s and replaced 233 MUS.

In the next AA period, we are forecasting the replacement of 870 kilometres of mains – including 38 kilometres of challenging North Adelaide mains, inspection of 316 kilometres of HDPE 575 DN50s and replacement of 457 MUS.

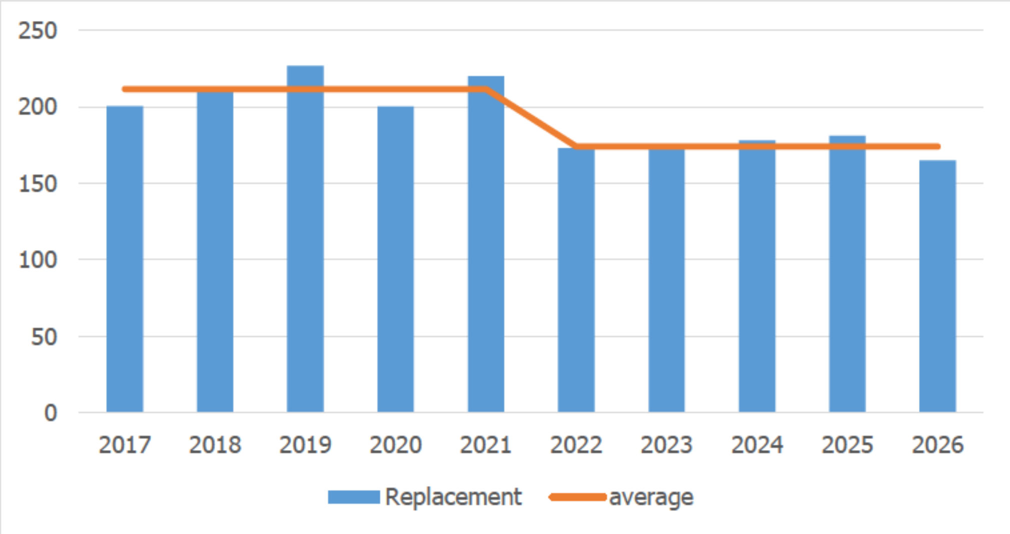
Also in the next AA, 90 kilometres of the HDPE 575 DN40 replacements require replacement through direct lay rather than insertion, which increases time required per unit by an estimated 50% (as reflected in the unit rates of contractors delivering the work).

Despite this anomaly, we do not believe that we will have deliverability constraints in the next AA period.

The following figures present the volume of activity proposed in the next AA period compared to that undertaken in the current AA period.

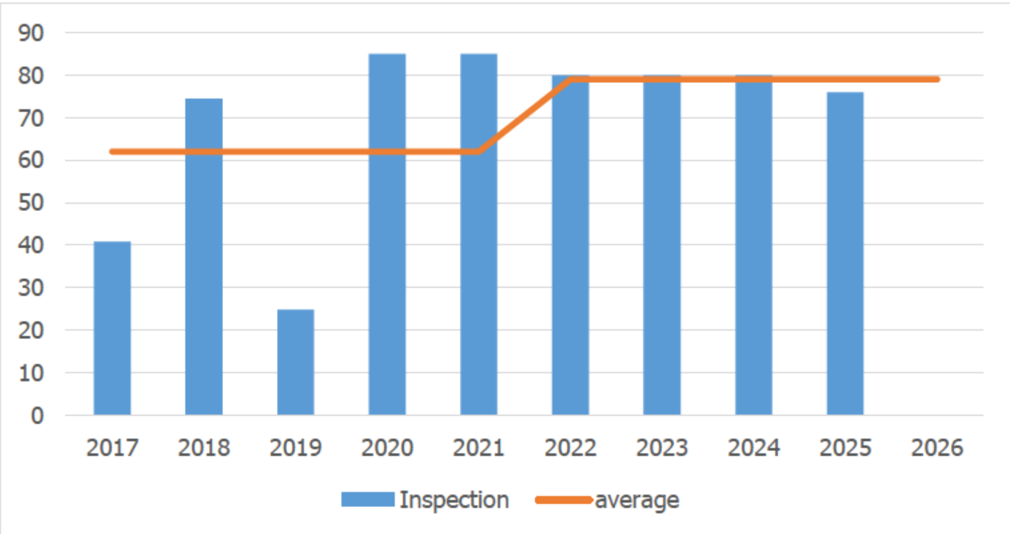
As indicated, the volume of mains forecast for replacement in the next AA period is less than that achieved in the current AA period, with an annual average of 212 kilometres replaced in the current AA period and a forecast average of 174 kilometres forecast for the next AA period.

Figure 11: Delivery capability - mains replacement



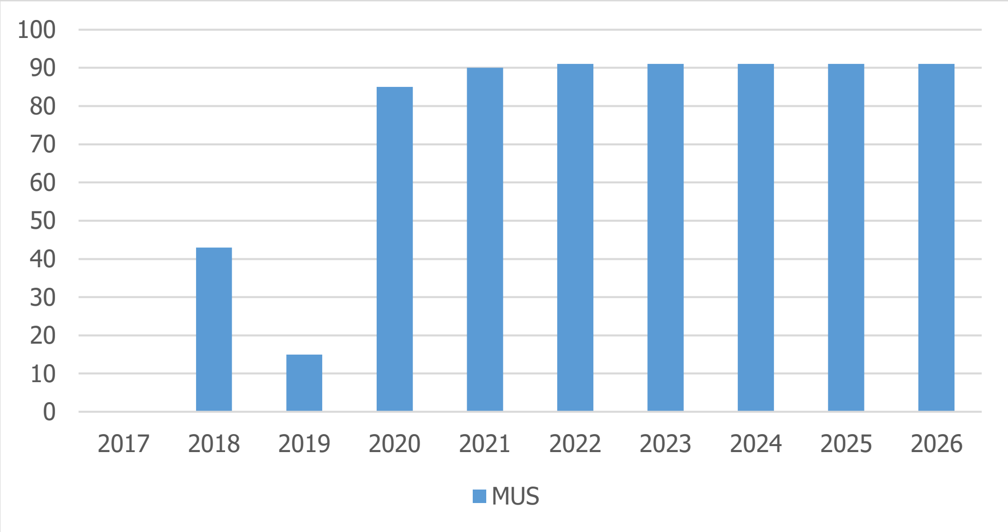
The average volume of mains inspections and reinforcement in the next AA period is marginally more than that achieved in the current AA period, with an annual average of 62 kilometres inspected in the current AA and a forecast average of 80 kilometres forecast for the next AA. The highest annual delivery volume in the current AA period was 85 kilometres however, and the maximum volume forecast for the next AA period is 80 kilometres.

Figure 12: Delivery capability - mains inspection



The average volume of MUS replaced in the next AA period is largely in line with the annual volume achieved in 2019/20 and 2020/21 in the current AA period, with an annual average of over 87 MUS replaced each year. This is considered a sustainable and efficient volume of activity for MUS replacements, with a forecast of 90 per year.

Figure 13: Delivery capability - MUS replacements



We consider that the program can be delivered over the next AA period adopting a similar delivery strategy to the current AA period. We acknowledge that there is potentially capacity to deliver a higher volume of activity in the next AA period, such as that presented in Scenarios B and D, but do not believe that the incremental cost our customers would incur are proportionate to the reduction in risk this additional expenditure would likely result in.

Like the current AA period, most of the work in the next AA period will be conducted by external contractors engaged to deliver in accordance with commercially negotiated unit rates agreed to as a result of a competitive tender. An internal labour crew will be maintained to ensure hands-on experience with the complexity, health, safety, and environmental requirements of our DMSIP work program.

Efficient delivery of the program is consistently achieved by ensuring tenders are released to market as much as 18 months in advance of the scheduled work execution. This ensures planning, budgeting, negotiation and execution cycles align to ensure a cost-effective program, with resource planning optimised and transfer of information and knowledge between us, APA and any delivery contracting parties done in a measured and controlled manner. It also ensures our contractors can be issued stages of work in a way that minimises interference between adjacent replacement areas.

We are committed to continuing with these best practice procurement, asset management and risk management processes to minimise both the risk and costs of procuring services and materials and delivering our operational and associated risk outcomes. These processes underpin our efficient and cost effective capital expenditure.

We report regularly to the OTR on progress of our mains replacement program, and a number of other measures/indicators are also available for review, including:

- Contractor competency audit results – competency audits are completed before a contractor commences a project, as part of the pre-start process; and
- Contractor monthly KPI reports – these KPIs cover work quality, among other items, with KPIs benchmarked and compared across contractors monthly. Contractors also undergo Fatal Risk Activity Reviews which involves a field audit tool that allows for specific checks on a range of items that impact site risk, from Safe Work Method Statements to special procedure requirements (hot tap, deep excavations, etc).

We are committed to transparency of reporting on the effectiveness of our risk reduction program. We are confident we have the processes and measures in place (both internally and with our third party delivery partners) to ensure continued deliverability to appropriate standards.