Multinet Gas Networks

Attachment 9.7

Distribution Mains and Services Strategy

Final Plan 2023/24 – 2027/28

July 2022

Distribution Mains and Services Strategy

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1. Executive summary

The Distribution Mains and Services Strategy for the Multinet Gas Network (MGN) outlines the program of work we plan to undertake to manage network performance and integrity on a rolling five-year basis. Mains and services replacement is our largest ongoing program – both in terms of scale and cost.

Activity for the next AA period (2023/24 to 2027/28) comprises six key programs:

1. Low pressure cast iron (CI) and unprotected steel (UPS) mains replacement
2. Early generation high density polyethylene (HDPE) mains replacement – [redacted]
3. [redacted] medium pressure (MP) steel replacement
4. Reactive services replacement
5. HDPE assessment
6. Reactive mains replacement

This builds on the program of work being undertaken during the current AA period (January 2018 to June 2023):

- Continued replacement of low pressure mains, with 530 km already delivered over the period 2018 to 2021 and another 128 km scheduled for replacement through to the end of June 2023;
- Targeted replacement of all MP CI mains, with 30 km already replaced over the period 2018 to 2021 and the remaining 5 km scheduled for replacement in 2022[1]; and
- Scheduled replacement in 2022 of 2.3 km of early generation HDPE main.

1.1. Forecast capital expenditure

1.1.1. Low pressure cast iron and unprotected steel mains

The largest program within the portfolio of works is the ongoing program to remove low pressure CI and UPS pipes from our network. The CI and UPS network is old, prone to corrosion and leaks, and well past its useful life. The program to remove these mains commenced in 2003, with more than 650 km of CI and UPS mains having been replaced during the current AA period.

By the end of June 2023, there will be approximately 1,360 km of low pressure mains left in the network. During the next AA period, we plan to remove a further 704 km of low pressure main, with the aim of eliminating all CI and UPS mains by 2033. All CI and UPS mains will be replaced with new polyethylene (PE) pipe, which is capable of operating at much higher pressures. This program equates to replacing around 141 km per year, which is the same run rate as delivered during the first four years of the current AA period (2018 to 2021).

[1] At the beginning of the 2023 period there will be one 60 m segment of medium pressure cast iron remaining.

1.1.2. Early generation HDPE mains

While CI and UPS mains are the priority, we also need to manage the other families of mains in our network. In particular, HDPE) mains installed in the 1970s are reaching the end of their useful life and showing signs of deterioration.

There is a total of 488 km early generation HDPE mains in our network. Rather than commencing an exhaustive and expensive program to remove all these mains rapidly, our plan for the next AA period is to take a conservative approach. We will target sections of our network that contain the oldest of these types of early generation HDPE mains, and replace those first. During the course of these replacement works we will collect data and sample the HDPE mains to understand more fully how they are performing and what the most efficient method and schedule for replacement will be. We can then use this data to inform a replacement program over subsequent AA periods.

We have identified [redacted] as sections of our network that contain some of the oldest HDPE assets. The leak rate in these areas is higher than average, and this section of the network is among the oldest in Victoria, containing a combination of different assets[2] and construction types.

During the next AA period we will target these areas for mains replacement, removing approximately 55 km of early generation HDPE, as well as 27 km of aged MP steel mains that is interspersed with the HDPE. All these mains will be replacing it with new PE. The [redacted] networks will then be uprated from medium to high pressure.

1.1.3. [redacted] MP steel replacement

Protected steel on the MGN network is generally in good condition. However, the [redacted] steel replacement program is necessary to address a poorly constructed area of steel mains where cathodic protection systems are also no longer effective. These are MGN's highest risk steel assets.

The [redacted] network was built in the 1960s and is a haphazard mixture of protected and unprotected steel designed to operate at low or medium pressure. Many of the mechanical fittings and service connections are not adequate to contain high pressure, and cathodic protection in the area has been ineffective, resulting in corrosion.

This network was previously part of the colonial gas network. It is built from an assortment of connections and fittings that are no longer approved for use. Growth in the area means the network should be uprated to high pressure to keep pace with demand, however, the network is unsuitable for pressure above 140 kPa.

The [redacted] network is two discrete networks that are adjacent to one another, unconnected, but isolated from the networks around them. Each have a single supply from independent, ageing field regulators. Past attempts to raise pressure in the Mount Waverley network resulted in significant leakage and gas escape, meaning it cannot be interconnected with the surrounding networks in its current state.

The proposed program for the next AA period will install 24.3 km of new PE mains in [redacted] over two projects. The projects will abandon 20.9 km of steel at the end of its life, as well as 2.4 km early generation HDPE that is interconnected sporadically in the area.

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[2] These networks contain a mixture of vintage HDPE and MP steel, often with sections of these different asset types interconnected.

Once construction is complete the network will be uprated from medium pressure to high pressure and integrated into the surrounding high pressure networks, increasing security of supply and capacity of the network for current and future customers.

1.1.4. Reactive services replacement

We will continue our ongoing reactive services replacement program during the next AA period. Historically, we reactively replace [redacted] services per year that fail and are beyond repair. We have used these historical volumes to estimate the volume of services we can expect to replace upon failure during the next AA period.

We therefore consider it prudent to include an amount in MGN's revenue determination to cover the cost of replacing approximately [redacted] services during the next AA period. Failed services are typically replaced with new PE assets.

1.2. Operating expenditure

1.2.1. HDPE assessment

During the period we will collect samples of HDPE mains. These will be used in our ongoing testing program with Deakin University. By testing these samples we can understand more about the condition and failure mode of these mains, and use that information to inform the priority order and replacement schedule for the remaining ~433 km of early generation polyethylene.

1.2.2. Reactive mains replacement

Historically, we reactively replace around [redacted] of mains per year that fail and are beyond repair. We have used these historical volumes to estimate the volume of mains we can expect to replace upon failure during the next AA period. We therefore consider it prudent to include an amount in MGN's revenue determination to cover the cost of replacing approximately [redacted] of mains during the next AA period. Failed mains are typically replaced with new PE assets.

1.3. Summary of expenditure during the next AA period

Expenditure (capex and opex) on mains and services replacement during the next AA period is forecast at $393 million. We consider this represents a prudent level of activity to manage risk over the next five years.

As discussed, the highest priority program is the low pressure CI and UPS replacement, and this comprises the bulk of expenditure ($333 million). MGN has the most remaining low pressure CI and UPS of three Victorian gas distribution businesses, and is working as efficiently and effectively as possible to position ourselves in alignment with the rest of the industry. The volume of mains replacement across the AGIG resource base in Victoria (AGN Victoria and Albury and MGN combined) is decreasing over the next five years and efficient resource utilisation will ensure unit rates are not adversely affected by a lack of trained and experienced resources able to deliver the works.

The HDPE and MP steel replacement programs are more conservative, at $36.6 million and $12.97 million respectively. Our approach for the next AA period is to take a considered and pragmatic approach to testing and replacing the HDPE mains, with the aim of informing the most efficient practicable ongoing replacement strategy. The MP steel in [redacted] simply has to be addressed before it degrades further and serious network integrity issues arise.

Reactive mains and services replacement volumes are consistent with historical levels. The forecast unit rates are based on the actual rates achieved during the current AA period. We highlight that the actual reactive replacement volumes will inevitably vary from forecast (as it is not possible to forecast how many assets will fail with any certainty), but only costs actually incurred will be recovered via regulated revenue.

TableExecSumm 1 summarises the MGN mains and services program for the next AA period.

TableExecSumm 1: MGN mains and services replacement forecast expenditure $'000 real 2021

Program name	2023/24	2024/25	2025/26	2026/27	2027/28	Total
Low pressure CI & UPS mains	62,759	65,953	66,100	67,484	70,679	332,974
Early generation HDPE replacement	3,010	5,415	7,036	9,429	11,698	36,589
[redacted] MP steel replacement	4,640	8,334	-	-	-	12,974
Reactive service replacement program	1,102	1,102	1,102	1,102	1,102	5,510
Total capex	**71,511**	**80,804**	**74,238**	**78,015**	**83,479**	**388,047**
HDPE testing program	199.6	199.6	199.6	199.6	199.6	998
Reactive mains replacement program	730	730	730	730	730	3,650
Total opex	**930**	**930**	**930**	**930**	**930**	**4,648**
Total expenditure	**72,441**	**81,734**	**75,168**	**78,945**	**84,409**	**392,695**

The mains and services programs are necessary to maintain alignment with the Network Objectives and compliance with regulatory obligations contained in the Gas Safety Case, Gas Distribution System Code and AS 4645. The primary drivers for the above programs are:

- reduction of public and maintenance personnel risk associated with cast iron gas main fractures and leaks from the cast iron and unprotected steel network;
- reduction of public and maintenance personnel risk associated with squeeze–off failures, resulting from brittle cracking of early first generation high density polyethylene mains;
- improve network reliability and capacity;
- maintain and improve operational, safety and regulatory requirements; and
- reduce environment impacts from methane emissions associated with unaccounted for gas (UAFG).

Works will be delivered by MGN's combined contractor resource pool (shared with AGN Victoria and Albury). The mains replacement volumes for MGN is an uplift on previous periods, however, there is a significant drop in the main replacement activities for AGN Victoria and Albury, allowing resources to be moved from one business to the other. Unit costs for are based on the latest market rates where available.

2. Document overview

2.1. Purpose

This document articulates our approach to the management of its gas distribution mains and services. It is one of several asset strategies developed and maintained for the management of MGN's natural gas distribution network. The Distribution Mains and Services Strategy has the following objectives:

- identify the capital works program for 2023/24 to 2027/28;
- present cost estimates for the works program;
- provide justification and evidence that demonstrates the proposed program is prudent and efficient (as per requirements of NGR 79);
- demonstrate that the program cost and volume estimate have been arrived at on a reasonable basis (as per requirements of NGR 74); and
- provide a record of the proposed works program to help inform program delivery and asset management during the period (2023/24 to 2027/28).

The document is intended for use by:

- MGN staff (and its contractors); and
- regulators - technical, safety and economic.

2.2. Scope

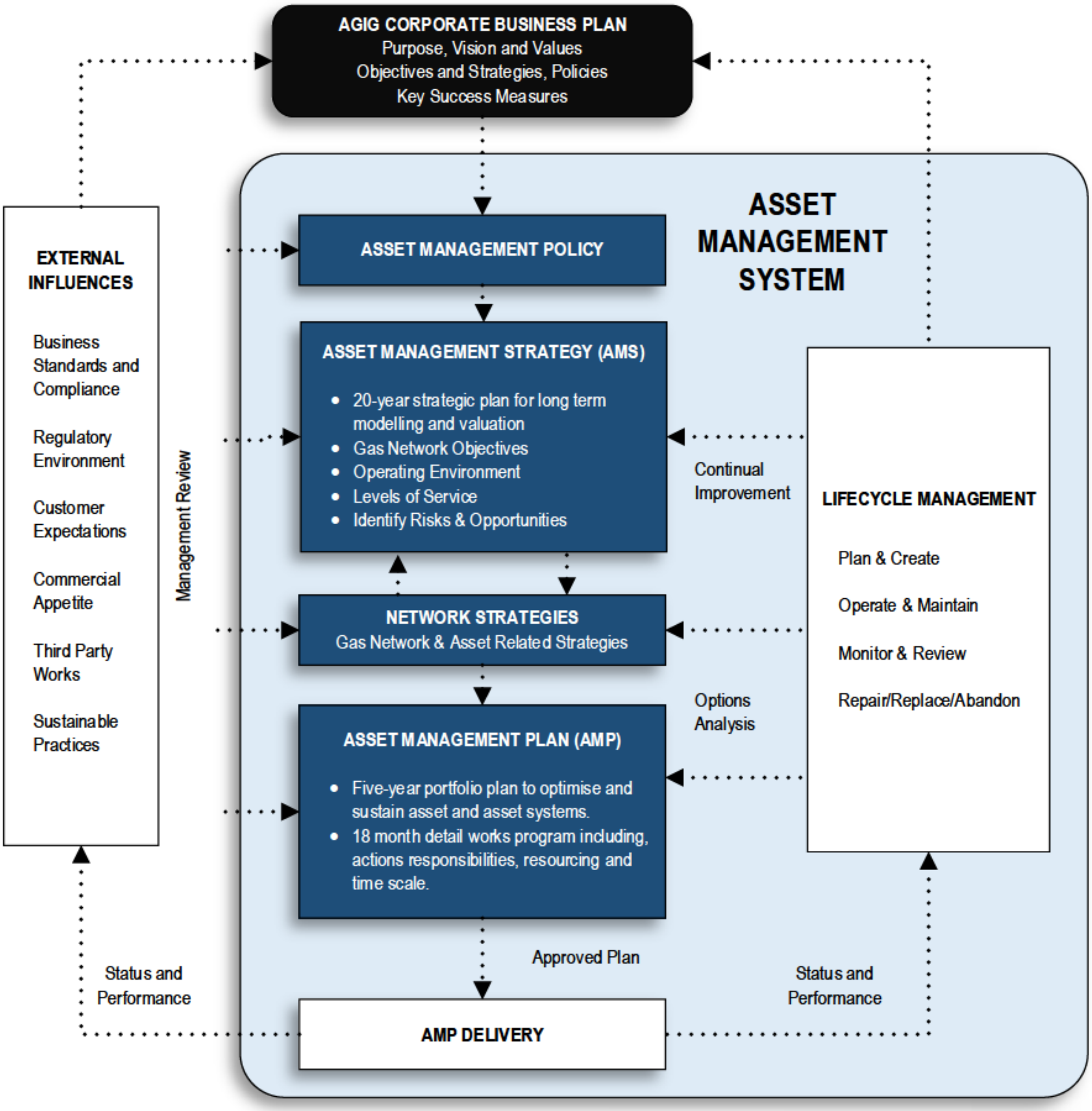
This strategy covers the management MGN's gas distribution assets. The focus of this strategy is on all gas distribution gas mains and services. Assets are located in inner and outer east metropolitan Melbourne, the Yarra Ranges and South Gippsland. Gas distribution mains and services for the purposes of this strategy are those defined as operating from 1.4 kPa to less than 1050 kPa.

This document defines the strategy to maintain public and personnel safety, integrity and security of supply, through compliance with regulation, technical, and safety standards. This strategy relates to MGN's expenditure requirements in relation to distribution mains and services.

2.3. Relationship with other key asset management documents

The Distribution Mains and Services Strategy is one of a number of key asset management documents developed and published by MGN in relation to its gas network. As shown in Figure 2-1, detailed network strategies, including this Distribution Mains and Services Strategy, inform both the Asset Management Strategy (AMS) and Asset Management Plan (AMP) of the programs needed to achieve the long-term objectives of the gas distribution network.

Figure 2-1: Asset Management Framework



2.4. Financial figures used in this document

All financial figures quoted within this document, unless otherwise specifically stated, are:

- real unescalated expenditure / cost (reference year = June 2021);
- direct expenditure only (i.e. excludes overheads and finance costs); and
- in units of $1,000 (i.e. $'000).

2.5. Data sources

The following data sources have been drawn on to develop the Distribution Mains and Services Strategy:

- SAP - the MGN primary asset management database;
- Tableau - uses an extract (duplicate) of the SAP database so reporting can be performed in real time without diminishing the available bandwidth of SAP for business as usual processes; and
- GIS Data - GE Smallworld application used for spatial data representation.

2.6. References

- Gas Safety Case
- Gas Distribution System Code Ver. 15.0
- AS/NZS 4645 – Gas Distribution Network Management
- AS/NZS4645.2 - Installation and maintenance of steel pipe systems for gas
- AS/NZS 2885 Series – Pipelines Gas and liquid Petroleum
- EP-PL-7600 – Multinet Gas Engineering Standard - Pressure Classifications and Operating Pressure Ranges

3. Asset overview

3.1. Introduction

MGN operates a gas distribution network in eastern Melbourne. It consists of 9,575 km of mains operating at high, medium, and low pressures. It also has 78 km of mains operating between 550 to 1050kPa referred to as high pressure 2 (HP2). The distribution network includes all assets between city gates, and the outlet of consumer's meter assemblies.

The majority of our distribution system operates at high pressure (HP). HP has a minimum allowable pressure of 140 kPa, and a maximum of 515 kPa. The distribution network feed comes from: the Declared Transmission System (DTS), Bass Gas (South Gippsland Towns), and MGN's HP2 network. Major facilities known as field regulators or city gates regulate network pressures.

The MP distribution systems operate between 35k Pa to 210 kPa. Field regulators regulate and supply gas typically from the HP networks. The low pressure (LP) distribution systems operate up to 7 kPa. District regulators regulate and supply gas typically from high and medium pressure networks.

The gas distribution main age profile encompasses a broad timespan. Some of the oldest mains date to the late 1880s. Cast iron was prominent from the beginning, up until the late 1960s. Steel (both protected and unprotected) was introduced in the early 1950s. Minor amounts of protected steel still used today. PVC and polyethylene made their debut in the early 1970s. PVC usage phased out in the early 1990s. Polyethylene (PE) is now the prominent material. 98% of mains constructed in the last ten years were PE.

The mains material type has a major bearing on the maximum allowable operating pressure (MAOP) of the network. CI can only operate at medium and low pressures. We manage the capacity and integrity of the network by the replacing obsolete CI mains with PE. At the end of this period there will be about 60 m of MP CI remaining in the MGN network. The single piece will be surveyed annually for leaks until it is replaced.

3.2. Network length

MGN's distribution network length[3], as presented in Figure 3-1, has grown at an average rate of 0.4% p.a. from 2011 to 2017. This is mainly associated with expansion into the regions of Yarra Ranges and South Gippsland along with localised growth and redevelopment within the inner urban areas of the network.

Since 2017, the network length has decreased at an average rate of 0.23% p.a. MGN is still experiencing growth of the network via new connections in the aforementioned regions, however, the rate of CI mains being decommissioned exceeds the new HP PE mains being laid. This is occurring due to optimisation of new network design, and utilising the additional capacity of HP PE.

For example, one HP PE main can be installed down a single street that currently has end of life mains on both sides. The extra capacity of the new PE main can provide sufficient gas to both sides, therefore allows old mains on either side to be decommissioned. The decommissioned length of old mains can therefore be double the length of installed new network.

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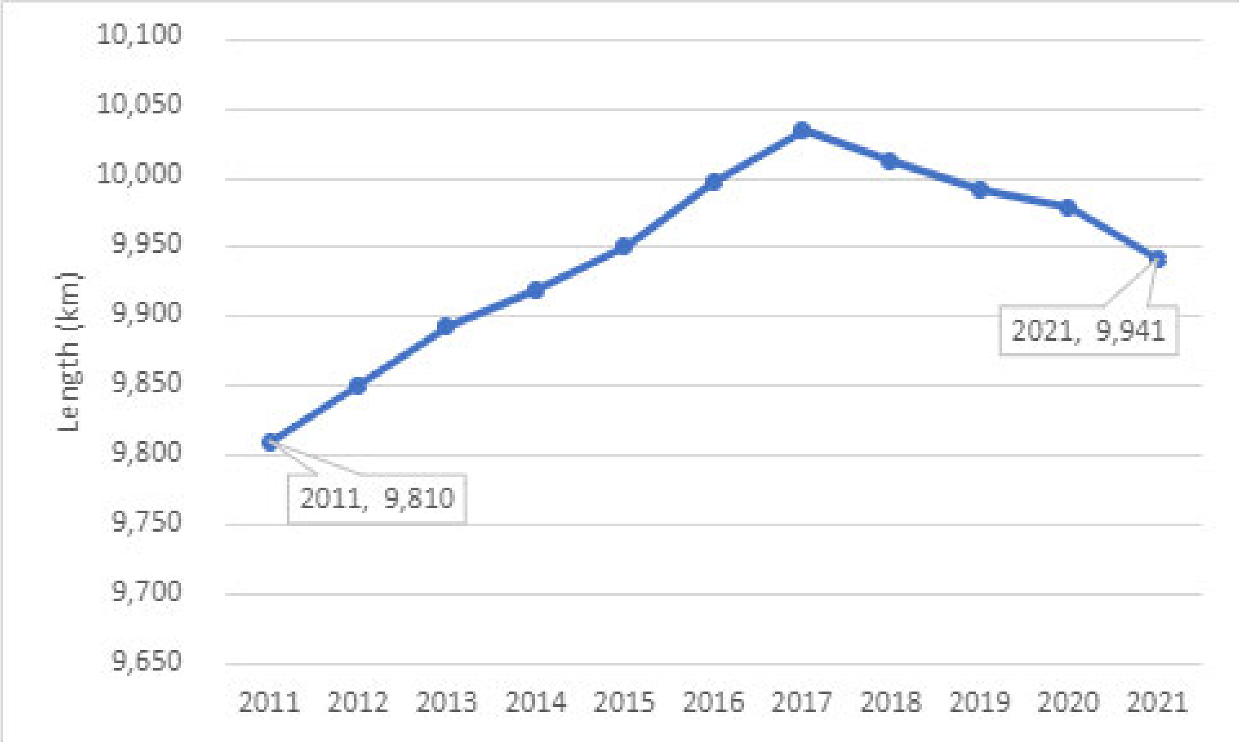
[3] Mains length data based on annual ESV report.

Figure 3-1: Total network length 2011 - 2021



3.3. Asset classification and profiles

3.3.1. Overview

As discussed in section 3.1, our network comprises a range of pipeline materials operating at different pressures. PE is now the prominent material.

PE polymers have continued to develop since the 1970s. We introduced the latest generation polymer (PE100) in late 2014. This generation has greater strength, toughness, improved crack growth resistance and rapid crack propagation resistance.

Table 3-1 details the percentage of mains within the network by operating pressure and material classification.

Table 3-1: Percentage of distribution main by pressure and material classification

Pressure tier	CI	PVC	Unprotected steel[4]	Protected steel	PE	Total
Low Pressure (LP)[5]	8.38%	4.52%	1.29%	0.63%	0.27%	15.15%
Medium Pressure (MP)	0.05%	0.00%	1.07%	4.35%	2.75%	8.23%
High Pressure 2 (HP2)[6]	0.00%	0.00%	0.00%	0.81%	0.00%	0.81%
High Pressure (HP)[7]	0.00%	0.00%	0.91%	26.20%	48.70%	75.81%
Total	**8.43%**	**4.52%**	**3.27%**	**32.00%**	**51.73%**	**100.00%**

3.3.2. Pressure classification

There are three main pressure tiers; low, medium, and high pressure. There is a fourth minority pressure tier known as HP2. This pressure tier accounts for less than <1% of the total distribution network

Table 3-2 details the operating pressure tiers and the proportion of mains length.

Table 3-2: Length of mains by pressure classification (Feb 2022)

Pressure tier	Operating pressure	Length (km)	Percentage (%)
Low pressure (LP)	1.4 to 7 kPa	1,463	15%
Medium pressure (MP)	35 to 210 kPa	794	8%
High pressure (HP)	140 to 515 kPa	7,318	76%
High pressure 2 (HP2)	550 to 1050 kPa	78	1%
Total		**9,653**	**100%**

3.3.3. Material classification

There are four material types; cast iron, poly vinyl chloride, polyethylene and steel. Steel is further classified as either unprotected or protected. This is based on an external protective coating and an active cathodic protection system. Material has a major bearing on the MAOP of the network.

Table 3-3 details the material types and the proportion of mains length.

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[4] For the purposes of classification, unprotected steel is considered mains which are uncoated and for protected steel mains are considered externally coated.
[5] Low pressure normal operating maximum is 3.5 kPa as per Multinet Gas Engineering Standard EP-PL-7600.
[6] High Pressure 2 is provided as a pressure category in the Gas Distribution System Code Schedule 1.
[7] High Pressure 1 has historically been referred to as High Pressure.

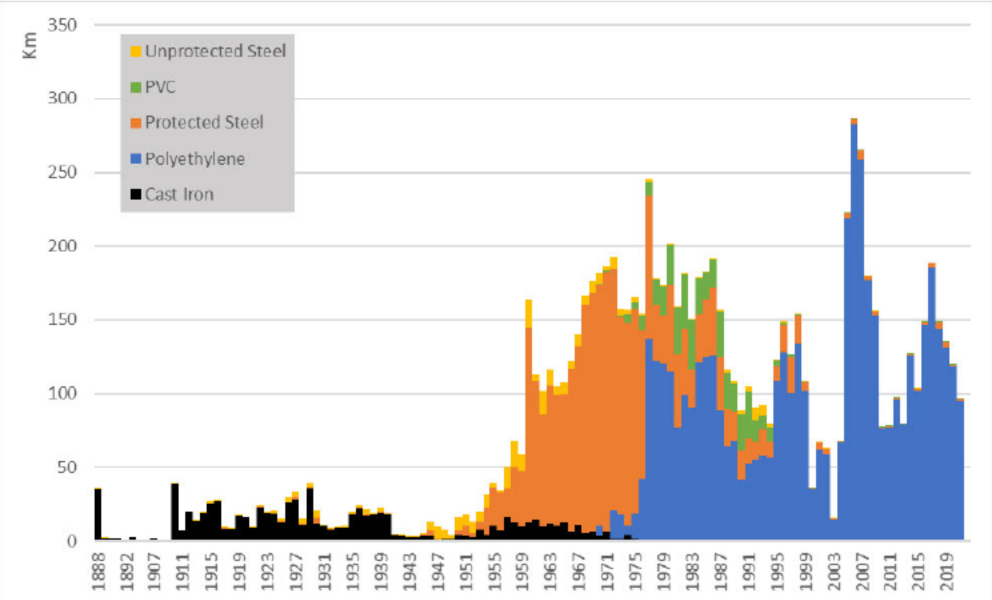
Table 3-3: Length of mains by material classification (Feb 2022)

Material	Length (km)	Percentage (%)
Cast iron (CI)	819	8%
Poly vinyl chloride (PVC)	436	5%
Unprotected steel (UPS)	316	3%
Protected steel	3,089	32%
Polyethylene (PE)	4,993	52%
Total	**9,653**	**100%**

3.3.4. Age profile

Figure 3-2 provides an age profile by mains material type and length. It provides an overview of when material types were introduced, their period of use, and when their usage was phased out. This gas distribution network was constructed across 134 years with cast iron mains dating back to the late 1800s. CI mains span from 1800s to the early 1970s. UPS spans from the early 1920s to early 1970s.

Figure 3-2: Asset age profile by material classification



The average age of the MGN distribution network is 38.2 years. Table 3-4 shows the low pressure network is the oldest at over 65 years.

Table 3-4: Average age profile by pressure (Feb 2022)

Pressure	Low	Medium	High
Average age (years)	65.9	45.9	30.3

Table 3-5 shows the cast iron network averages 88 years old. The unprotected steel network averages 62 years. CI and UPS are heavily targeted in the mains replacement programs.

Table 3-5: Average age profile by material (Feb 2022)

Material	CI	PE	PVC	Protected Steel	Unprotected Steel
Average age (years)	87.9	20.9	36.1	49.2	62.1

3.3.5. Asset life profile

Distribution mains display a wear-out characteristic at the end of their technical life (i.e. useful life). Technical life typically ranges between 50 and 140 years and is based on material and construction. Technical life does not constitute actual life, however, it does provide a snapshot of where assets are in their life cycle.

Table 3-6 shows the sum of the length of mains that will be beyond their technical live as of 2023, and those that will reach end of life (EOL) from 2023 to 2028.

Table 3-6: Asset life summary by pressure and length (km)

Pressure	EOL mains pre 2023	2023	2024	2025	2026	2027	2028	EOL mains to 2028
LP	831.8	2.5	3.0	3.4	2.1	7.0	3.7	853.4
MP	67.1	2.7	2.0	3.9	2.1	3.0	4.5	85.3
HP	0.2	0.0	0.0	0.1	0.0	0.1	0.1	0.6
Total	**899.1**	**5.1**	**4.9**	**7.4**	**4.1**	**10.2**	**8.4**	**939.3**

This analysis shows the network has 939.3 km of assets that have reached end of technical life as of 2028. Figure 3-3 shows this information by length and pressure.

Figure 3-3: Asset life failure profile by pressure classification

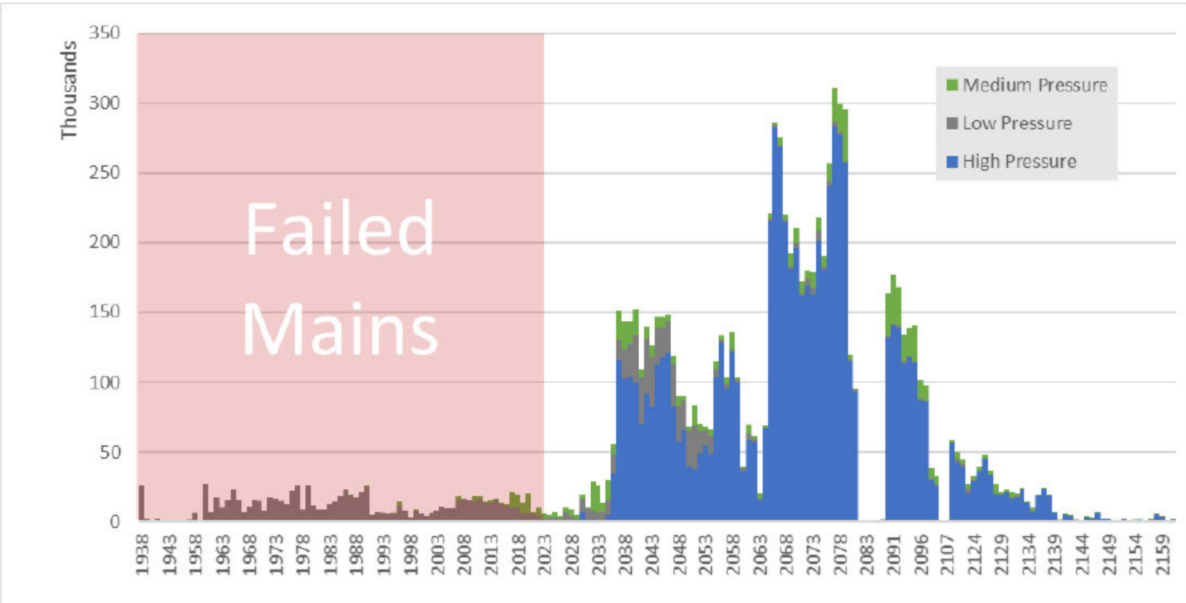


Table 3-7 shows the total length of mains that have passed their technical life based on material type.

Table 3-7: Asset life summary by material and length (km)

Material	Failures pre 2023	2023	2024	2025	2026	2027	2028	Failures to 2028
CI	722.9	1.3	1.1	0.7	1.5	3.8	2.3	733.5
PE	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.2
PVC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Protected steel	2.2	0.0	0.0	1.3	0.0	1.8	0.9	6.2
UPS	174.0	3.8	3.8	5.4	2.7	4.6	5.1	199.4
Total	**899.1**	**5.1**	**4.9**	**7.4**	**4.1**	**10.2**	**8.4**	**939.3**

3.4. Asset performance

3.4.1. Leak incident rates

We define leak incident rate as the number of leaks[8] per km of mains. Leak incident rate is a key indicator of network performance over time. Figure 3-4 shows the total network leak incident rate rapidly increasing since 2018.

Figure 3-4: Distribution mains leak incident rate

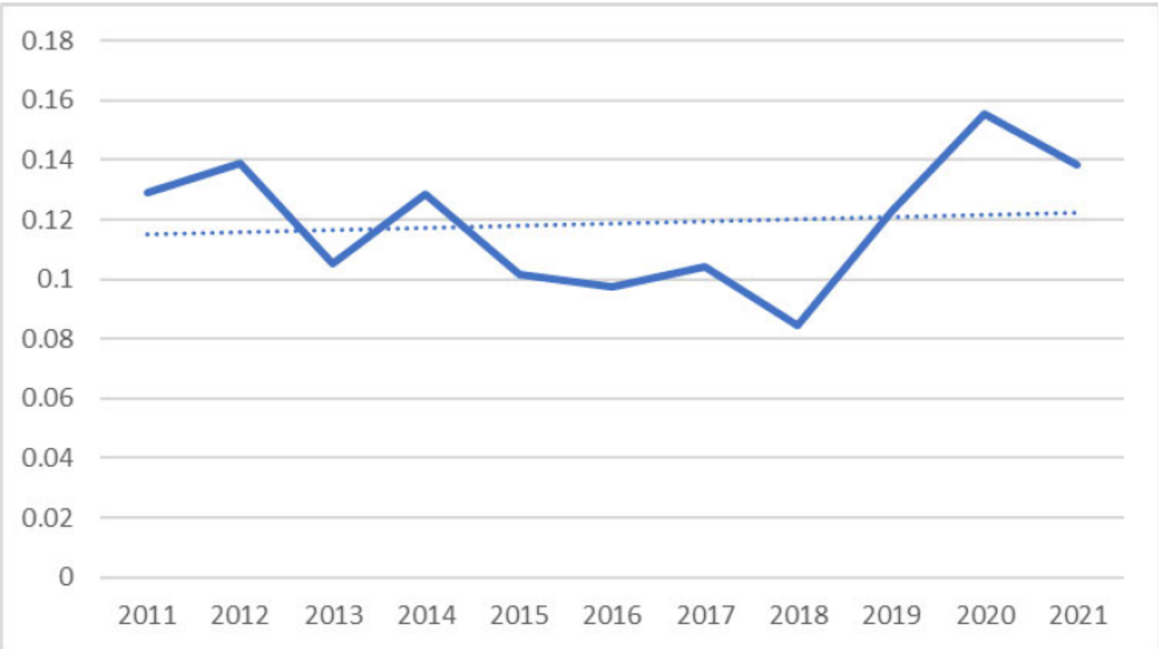
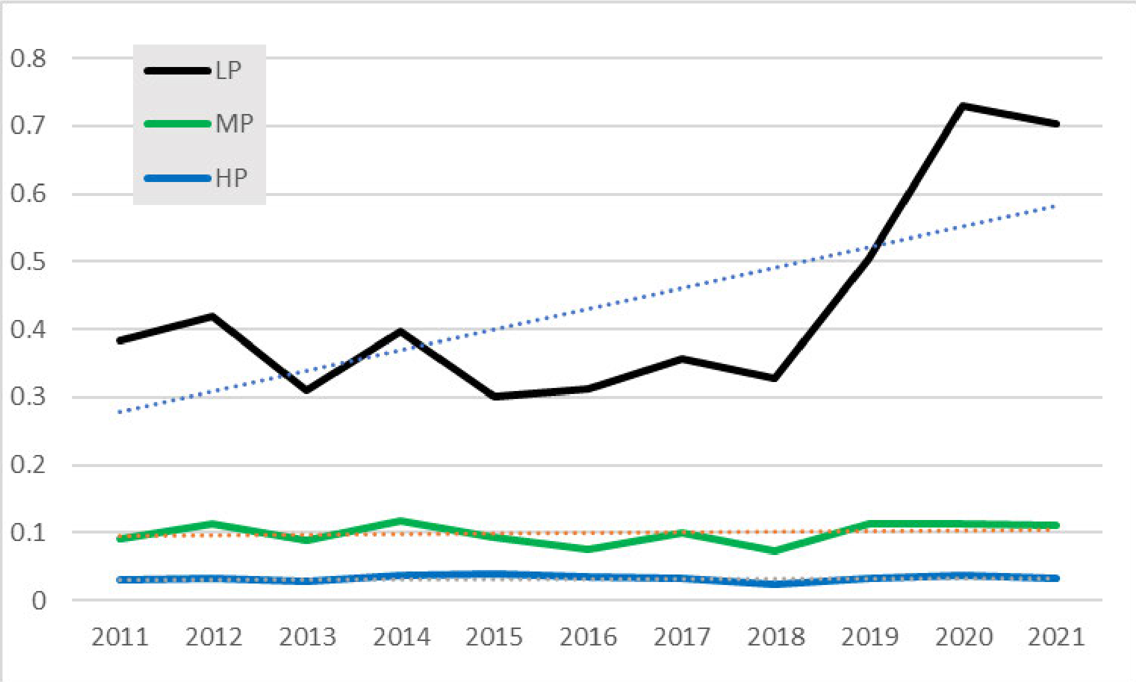


Figure 3-5 shows distribution main leak incident rates by pressure. A rapid increase in leaks has occurred on the LP network, rising from a low of 0.32 in 2018, to a height of 0.73 in 2020. This

[8] Leaks considered for analysis are those reported by the public (Public Reported Escape) or resulting from proactive Leakage Surveying.

123% increase is indicative of the networks failing integrity. Proactive replacement is therefore a high priority to maintain public safety and network performance. MP and HP leak incident rates have remained stable at 0.098 and 0.032.

Figure 3-5: Distribution mains leak incident rate by pressure

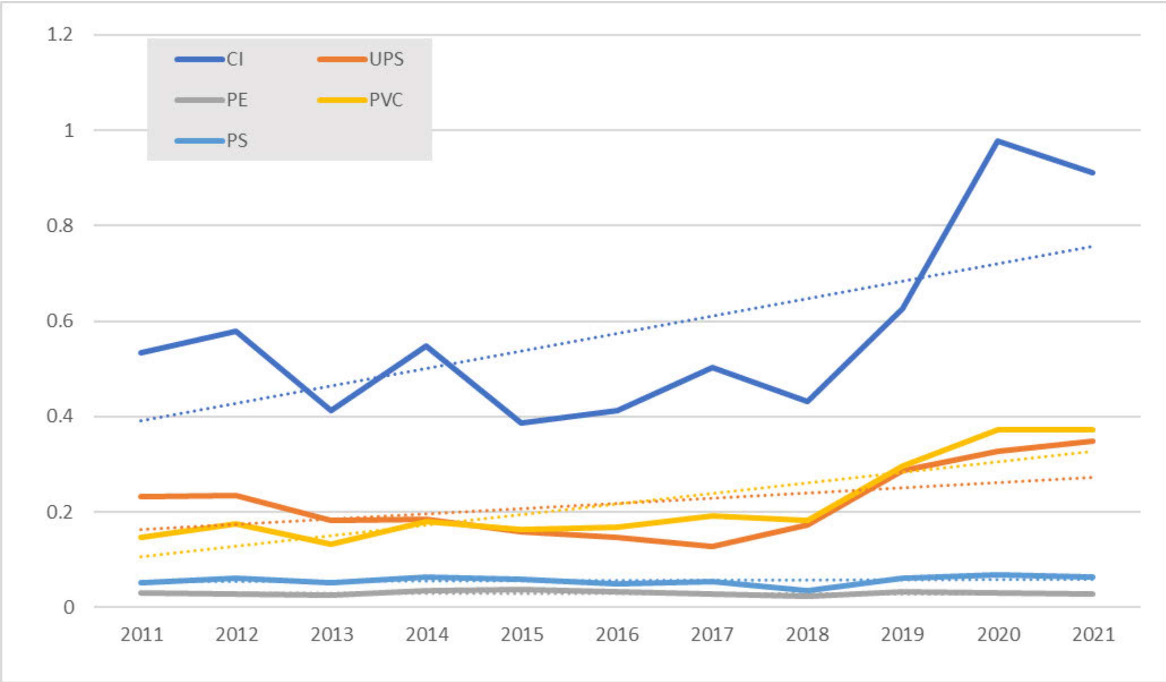


Leak incident rates by material is shown in Figure 3-6. CI, PVC, and UPS have all increased since 2018. This is consistent with the trend in low pressure leak incident rates.

These three material types constitute over 94% of the low pressure network. CI has seen the largest increase in leak incident rate over the period. A 226% increase from 2018 to 2020. UPS has seen a 180% increase over the same period.

The rate for PE (0.031) and protected steel mains (0.056) remains low and stable. PE and protected steel account for 84% of the distribution network.

Figure 3-6: Distribution mains leak incident rate by material



These graphs demonstrate that the network is deteriorating at an increasing rate. This is primarily due to the LP CI and UPS network passing the end of its technical and useful life. Despite there being a decreasing volume of these mains in the ground, failures are accelerating in the remaining sections of these assets.

Material or joint failure cause most leaks on CI and UPS. This is due to:

- corrosion faults, of both mains and fittings;
- mechanical joint failures, of both mains and fittings, and;
- fracturing of CI mains.

We expect leak incidents rates will grow as these asset types deteriorate. Deterioration is unavoidable and it is not technically possible to protect these assets from corrosion and external stress loading. CI and UPS account for the highest gas leak incidents rates. This makes it prudent to focus of the proactive mains replacement program on these asset types.

3.4.2. Cast iron fractures

The primary mode of failure for CI mains is pipe fracture. CI mains fracture either circumferentially or axially depending on the pipe diameter, extent of corrosion and external stresses. These fractures are primary caused by ground movement creating stress on the pipe in excess of its beam[9] strength. The result is that the main breaks completely, typically into two pieces. Although a seemingly small proportion of mains are experiencing fractures, CI main fractures can occur independent of age or condition of pipe, making failures difficult to predict.

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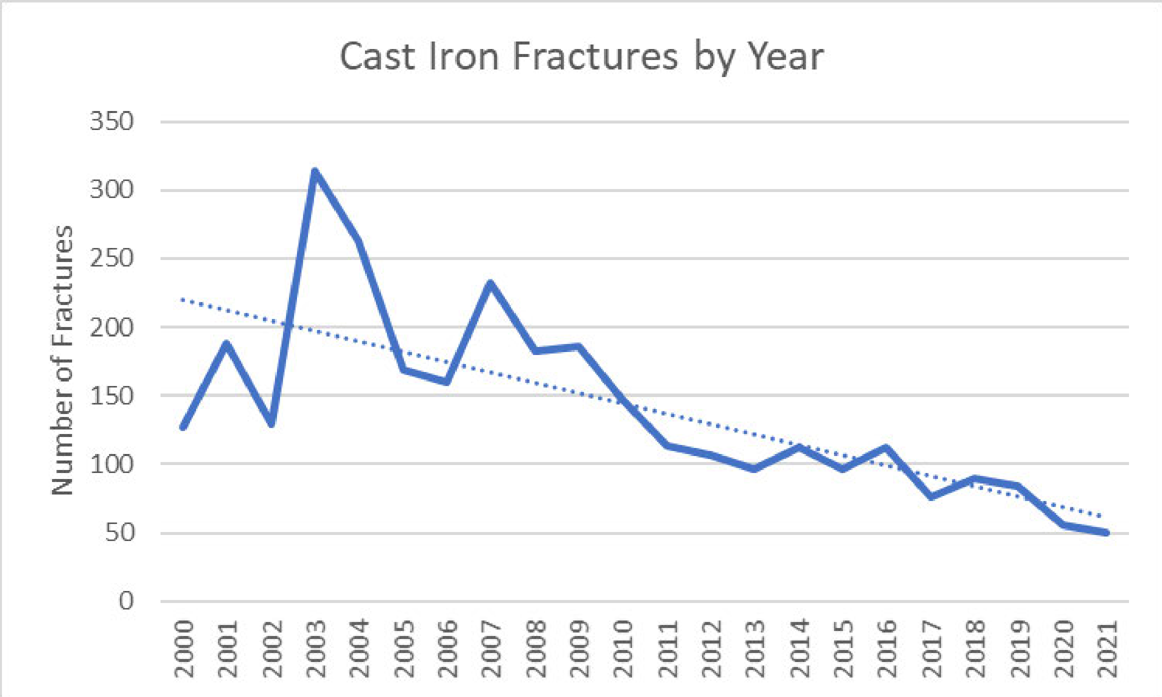
[9] Beam strength of a pipe element is a measure of its ability to withstand load primarily by resisting against bending. The bending force induced into the material as a result of the external loads, own weight, span and external reactions to these loads is called a bending moment.

As shown in Figure 3-7, CI mains fracture volumes (on average) have been declining since 2001. The 65% reduction in fracture volumes is a direct result of our targeted cast iron mains replacement program.

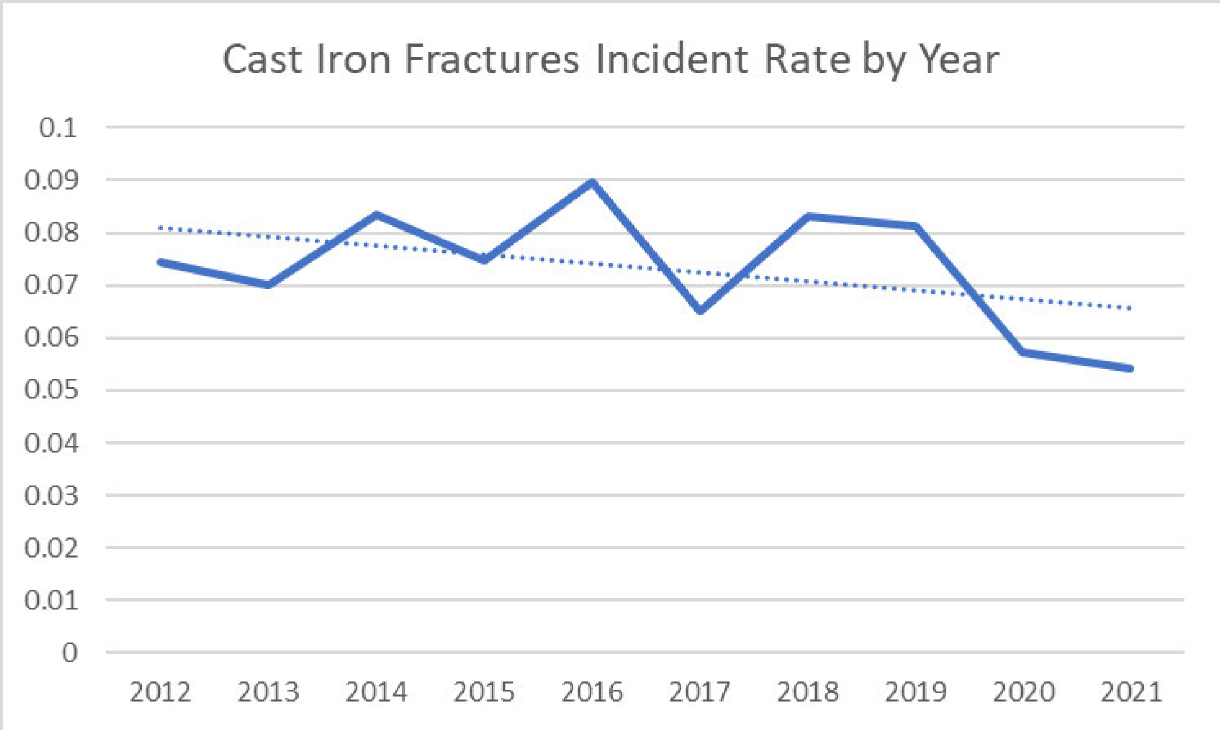
Figure 3-7: Distribution mains CI fracture volumes



A fracture on CI compromises the integrity of the pipe and increases the risk of further cracks and breaks. This risk is increased by higher operating pressures, with a catastrophic fracture on a MP main resulting in an uncontrolled release of a larger volume of gas compared to that from a LP fracture. Regardless of operating pressure, the risk of a CI mains fracture represents a hazard that impacts public and field personnel safety, with potential for serious harm in the event of a gas explosion.

Fractures are monitored across the network by measuring the number of fractures per km of CI mains. This is known as Fracture Incidence Rate (FIR). Over the 2001 to 2015 period FIR was increasing. In 2015 MGN switched to prioritised replacement and abandonment of areas with a high FIR. Over the 2012 to 2021 period there has been a decreasing FIR, shown in Figure 3-8.

Figure 3-8: CI fracture incident rate over time



In addition to fractures, CI is susceptible from other forms of failures such as joint failure and corrosion. Early jointing of CI was performed by using bell and spigot connections packed with hemp and sealed with lead. This joint was eventually phased out in preference of a mechanical type joint using bolts and a gasket to form a seal. Both ground movement and the introduction of natural gas (drying out the hemp) has resulted in these joints leaking. Where possible joints are repaired by injecting a sealant (anaerobic) or externally sealed by encapsulation but in some cases the joint is irreparable and requires removal. Corrosion, otherwise known as graphitisation, occurs when cast iron is exposed to ground water which dissolves the iron leaving a residual graphite. While CI mains below ground will (in general) be exposed to ground water and therefore have some degree of corrosion, the overall rate is influenced by soil types.

The major concern with CI is failure by fracture, however graphitisation represents a concern that cannot be dismissed and supports the case that CI is not a suitable material for a gas network. Graphitisation results in loss of wall strength and can pose a risk to maintenance personnel from sudden mains blow out while in the process of effecting a repair.

While the resulting volume of gas from a CI fracture (operating at low or medium pressure) is far less than a similar sized failure in mains operating at higher pressures, the gas can remain undetected for a period of time and can, under the right conditions, cause an explosion. This has resulted in a number of fatalities in both the US and UK.

3.4.3. Unprotected steel mains corrosion

For UPS mains, the primary concern is corrosion and the development of leaks over time. UPS mains deteriorate due to contact with moisture present in the soil. The rate of corrosion varies depending on soil characteristics, specifically moisture and acidity. Uncontrolled corrosion will ultimately result in numerous, relatively small gas leaks. Steel mains in the low pressure network are not actively cathodically protected and as such when the coating on a steel main is breached, rapid metal loss will be experienced at the location where the coating defects occur, eventually allowing gas to escape.

Initially, a leak from an UPS pipe starts as a pinhole leak. Over-time metal loss will increase in size and location, allowing more gas to escape, eventually resulting in numerous relatively small gas leaks. Eventually, these small leaks multiply and can grow to the point where they threaten the integrity of the pipe. In general, the deterioration of bare and unprotected steel accelerates as it ages. Clay soils can make detection of the leaks difficult and can act as a conduit through which the gas migrates.

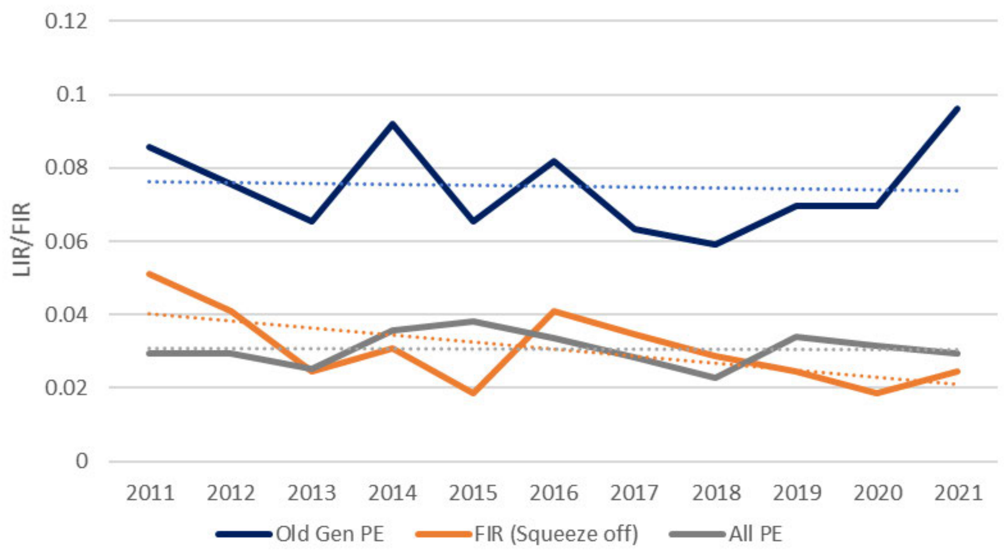
While MGN's CI and UPS mains replacement program is smaller in comparison with UK and US based accelerated mains replacement programs, it addresses proportionally the same risks given the asset composition, age and failure conditions.

3.4.4. Early generation HDPE leaks and fractures (breaks)

MGN's PE mains network has the lowest leak incident rate per kilometre in comparison to all other material types used on the gas distribution network. Over 2011 to 2021 the PE network exhibited average of 0.03 leaks/km despite the incremental volume of polyethylene installed on the network.

However, much of this good performance is due to the installation of new PE100 during the past decade. As shown in Figure 3-9, older, early-generation HDPE exhibits a higher leak rate (0.07 leaks/km).

Figure 3-9: Distribution mains PE leak and fracture incident rate comparison



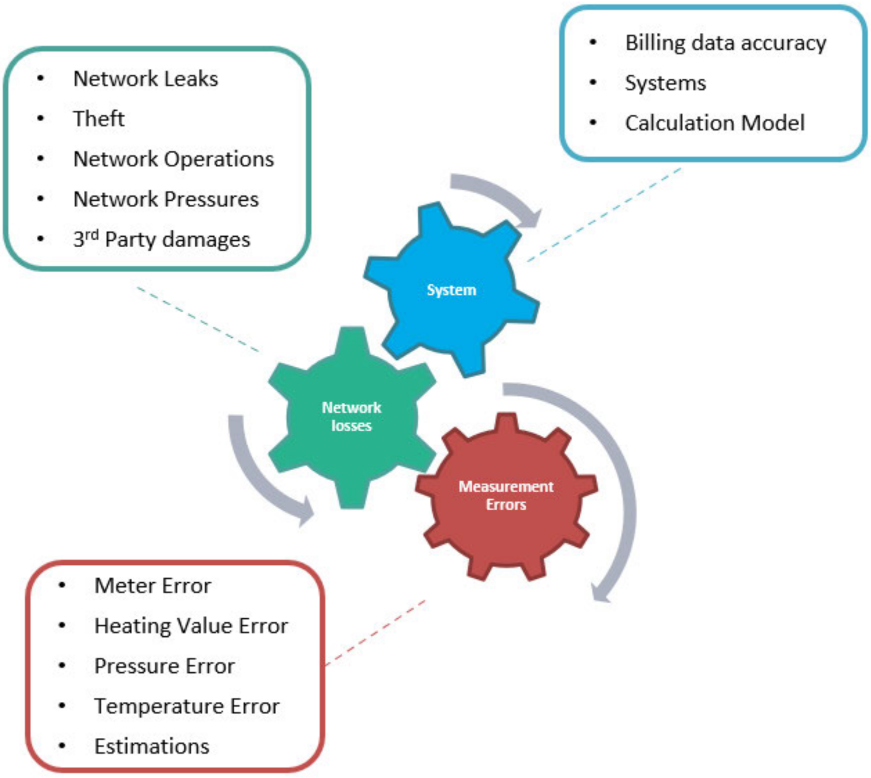
The leak incident rate is decreasing for the overall PE network, however there is an emerging issue with older HDPE mains. Introduced in the early 1970s, these early generation HDPE mains are experiencing brittle failures because of slow crack growth through the pipe wall. These brittle failures, referred to as fractures or breaks (typically associated with previous squeeze-off operations) are a subset of the leaks occurring on early generation HDPE mains, and as can be seen in the graph above, represent a significant proportion of the leaks/km

A conservative replacement project is required for early generation HDPE to better understand asset performance and condition, so that future replacement programs can be better informed as this asset continues to decline.

3.4.5. Unaccounted for gas

UAFG is the difference between the total measurements of gas injected into a pipeline system and the total measurements of gas withdrawn from the same pipeline system with a correction for any changes in the quantity of gas stored in the pipeline over the measurement period. It is composed of a number of contributors which can be roughly categorized as measurement errors, network losses/fugitive emissions, or system errors.

Figure 3-10: UAFG components



Measurement errors are related to metering errors, heating value compensation, gas pressure and temperature correction, etc. While fugitive emissions are those relating to general network leakage (mains, valves, fittings, meters, regulators etc.), leakage due to third party damage, gas consumed during mains commissioning and gas lost from asset abandonment and theft. System errors correspond to billing data accuracy, or calculation model errors.

Specific to mains network leakage, gas losses from the cast iron and un-protected steel are the highest, and as a result are considered a material contributor to UAFG.

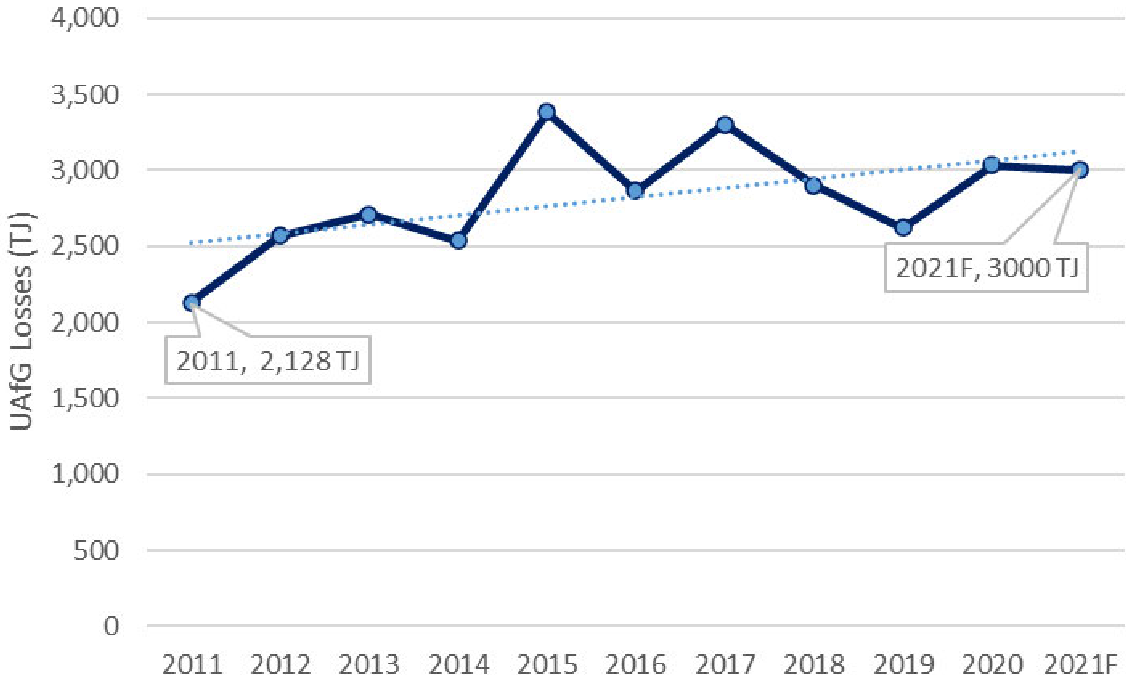
Figure 3-11 provides the reconciled annual UAFG actual losses from the MGN metropolitan gas network over the period 2011 to 2021 and shows an increasing trend in losses, with the volume doubling over the period from 2,128 terajoules (TJ) in 2011 to 3,393 TJ in 2015. This trend aligns to the increasing leakage due to ongoing deterioration of the remaining CI and UPS mains, which are exhibiting increasing failure rates. Replacing failed cast iron and unprotected steel mains will help change this trend.

A number of strategies[10] in addition to asset replacement are in place to reduce UAFG. It is the fugitive losses and the release of methane emissions into the atmosphere that result in an

[10] Refer to MG-SP-0017 Un-Accounted for Gas Strategy

environmental impact given methane has an atmospheric warming potential 34[11] times that of carbon dioxide.

Figure 3-11: UAFG actual losses Metropolitan Melbourne



3.4.6. Supply reliability

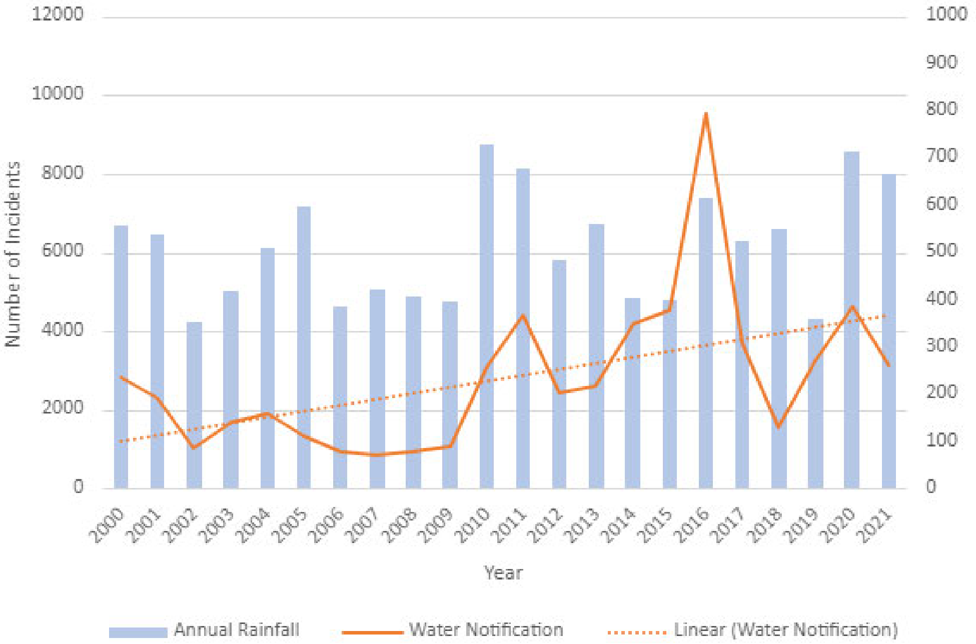
Water in mains and services is the primary supply reliability issue on the MGN low pressure network. The ingress of groundwater occurs due to mains breaks, corrosion, and porosity, and is an indicator that the pipe has reached the end of its useful life. Network interconnection enables water to travel and as a result water can be found in perfectly good pipes with the source of the ingress originating from another section of the low pressure network. This movement of water makes it difficult to pinpoint the source of the ingress, although it is generally accepted that the aging CI and UPS mains are key sources.

Figure 3-12 details the number of water incidents on both mains and services over the period 2000 to 2021. It shows an overall increase of service incidents over the period. The chart also provides annual rainfall from a single Melbourne based weather observation station[12], which is geographically located in close proximity to part of the MGN low pressure network.

[11] Global warming potential (GWP) source from Wikipedia and based on a 100 year GWP time horizon. https://en.wikipedia.org/wiki/Global_warming_potential

[12] Annual rainfall data sourced from the Australian Bureau of Meteorology website. Observation station 'Melbourne Airport (Station 086282)' which is located within close geographic proximity to the MGN Network. Annual rainfall data for this station was the most complete and quality checked for the period 2000 to 2021 when compared to other observation stations within the Multinet Gas low pressure distribution area.

Figure 3-12: Water ingress incidents on LP distribution mains and services – annual rainfall data for a single observatory (Melbourne Airport)



With the amount of rainfall being a contributing factor to water ingress, it is worthwhile relating the annual rainfall trend to that of the incidents of water in mains and services. For service incidents a correlation is evident with the changes in annual rainfall - particularly for 2010 and 2011 - which recorded comparatively high rainfall in the period and a sharp increase in notifications. In contrast, over the period 2018 to 2019, rainfall declined, however notifications doubled over the same period. Overall, the variance in water in main incidents shows no clear correlation to that of annual rainfall. This could be attributed to planned mains syphon pumping, which reduces the volume of reactive water in mains incidents.

Figure 3-13 provides spatial density[13] map of cumulative water in mains incidents associated with the low-pressure network over the period 2010 - 2022.

Figure 3-14 summarises the mean spatial distribution and orientation of water in mains incidents for each time-period as per the hotspot maps.

These are useful for tracking the change in incident distribution over time and the impact of mains renewal programs.

[13] Method: Point density spatial map of water in mains was developed using the ArcGIS kernel density spatial tool and input dataset, water incidents attributed to mains equipment over the period 2000 to 2022. Kernel based on cell size of 50 and search radius of 500m and then classified manually, using the mean spatial density value. Additional classes were derived from multiplications of the mean – as this is a concept that is generally, easily understood. Before generating a hotspot map of water ingress incidents, Average Nearest Neighbour Index summary was performed to test for clustering to ensure the data truly has hotspots of water ingress incidents. The NNI result for all three period intervals (2010-2015, 2015-2020, 2020-2022) were less than 1, indicating highly clustered water incidents that are unlikely the result of random chance.

Figure 3-13: Kernel Point Density Surface classified into multiples of the mean density value for each data set

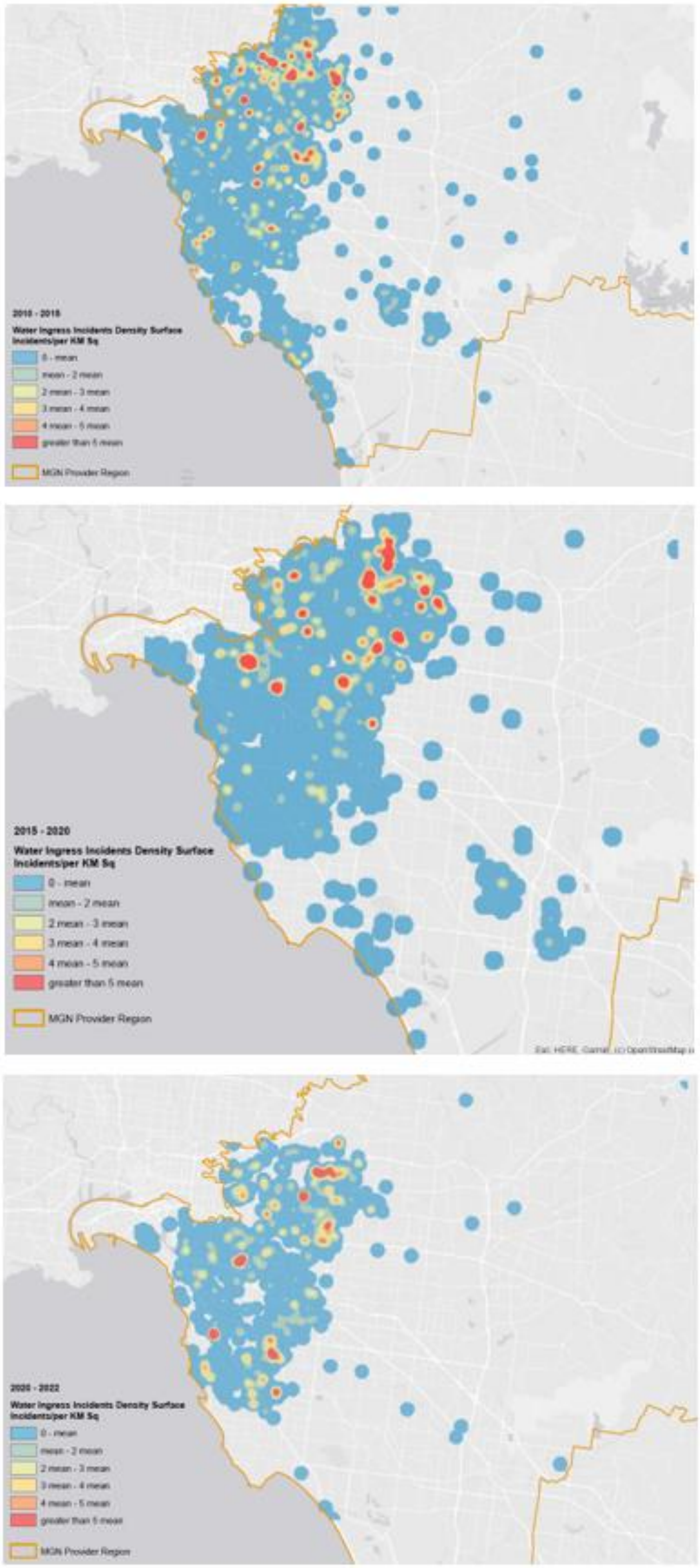
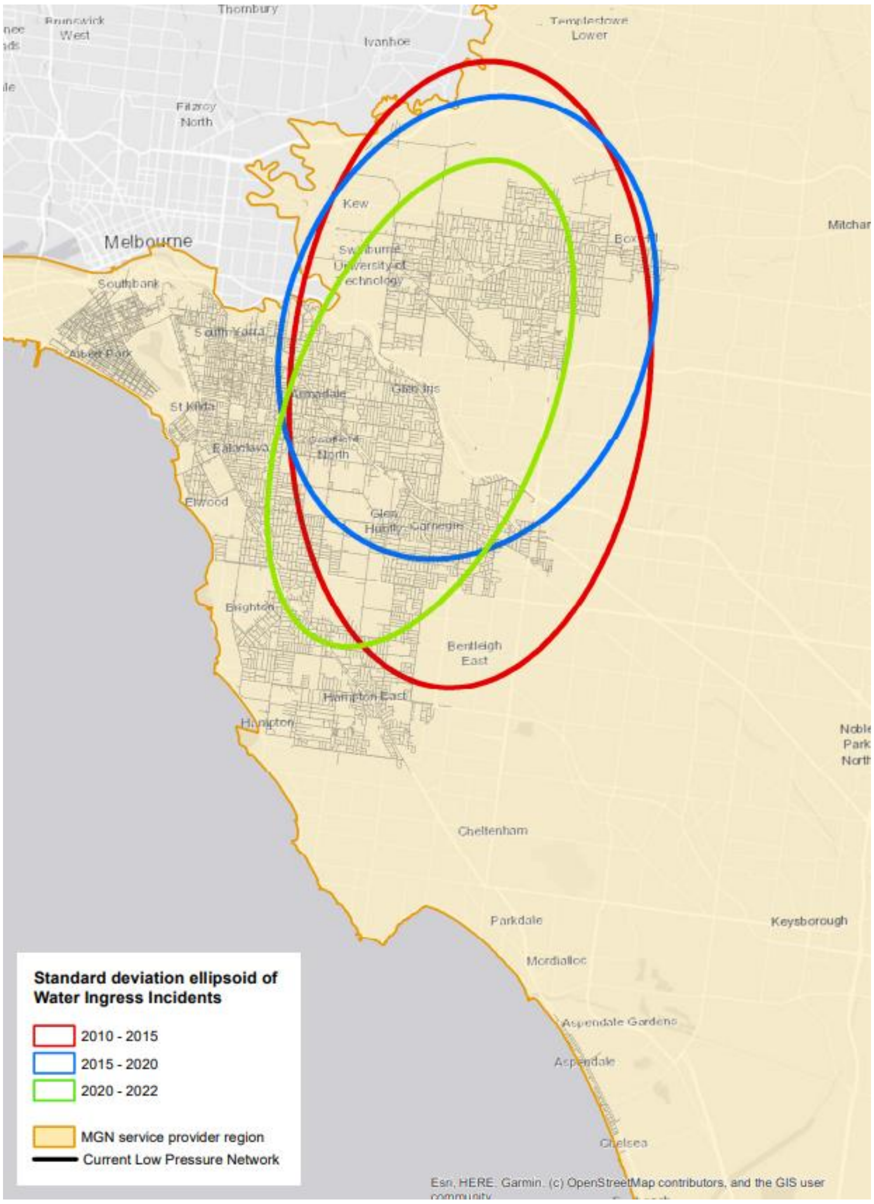


Figure 3-14: Standard deviational ellipses



Standard deviational ellipses have been used here to visualize the distributional trend of water ingress incidents across the MGN network. By comparing the size, shape and overlap of the ellipses we can track the changing spread of incidents over time and location, to deduce the impact of mains renewal projects.[14]

[14] Standard deviational ellipses were calculated using ArcMap's directional distribution tool. The output ellipses are centred on the mean centre for all water ingress incidents for the specified time period and used one standard deviation, to cover 63% of incidents.

4. Asset management drivers

4.1. Network vision

The MGN vision informs the way we manage and invest in our assets.

Figure 4-1: Network vision and objectives

When developing our work program and asset management strategies for the MGN network, we consider how the work we conduct and investments we make will help achieve the three key vision objectives outlined in the figure above.

These vision objectives and how they relate to the mains and services replacement program is summarised in the following sections.

4.1.1. Delivering for customers

Our aim is to continue to deliver customers the service they want and value. This includes keeping people safe from harm, maintaining a reliable gas supply, and providing quality customer service.

The MGN gas distribution network is located in densely populated areas. This means we have a duty of care to make certain our assets are functioning properly, and that we remove/repair any assets that are likely to cause safety risks before they occur.

4.1.2. A good employer

We strive to be a leader in health and safety by ensuring employees and contractors are mindful of the factors affecting their physical and mental health. This is done through strict health and safety procedures, incentive programs and regular workshops and health screenings.

Wherever practicable and prudent to do so, we aim to apply technologies such as telemetry and remote monitoring, which helps limit our employees' and contractors' exposure to manual and sometimes hazardous network management activities. We also focus on maintaining asset integrity, reducing the risk of leaks and/or failure which carry the potential for harm.

We aim to ensure high employee engagement by keeping employees up to date with relevant town halls and workshops of the entire business. Skills development is also a focus, ensuring both contractors and employees have the relevant skills and requirements for performing their roles.

This strategy aims to achieve a high level of reliability and personnel / public safety through proactive (and reactive) replacement of aged and failing mains and services.

4.1.3. Sustainably cost efficient

We aim to be sustainably cost efficient, working within benchmarks while still providing benefits to the customer and to shareholders. We intend to ensure natural gas remains a competitive, value-for-money fuel option in line with customer interests and expectations.

The maintenance and replacement strategies outlined in this document are aimed at improving the efficiency of the MGN network – providing the lowest cost of service to network users. We aim to deliver these programs for the lowest practicably sustainable cost, and consider a range of options before committing to a course of action.

We are also mindful of our environmental and social responsibilities, and will test our asset management strategies and work practices against relevant environmental, sustainability and societal obligations.

4.2. Network objectives

We manage the network in line with six asset objectives, which are linked to the AGIG vision and underpin our asset management practices. Achieving these network objectives enables us to provide good customer service, remain a good employer and be sustainably cost efficient.

Table 4-1: Summary of MGN network objectives

Operate and invest in assets to keep the public and MGN's employees safe	MGN will achieve this by: • Investing in and operating the network in line with the Gas Safety Case, zero harm principle and all laws and relevant industry standards; • Managing known risks to as low as reasonably practicable (ALARP); and • Meeting emergency response Key Performance Indicators (KPIs) (call centre, high priority leaks).
Maintain continuity of supply to MGN's customers	MGN will achieve this by: • Meeting network availability KPIs; • Maintaining operating pressures through monitoring and augmenting MGN's network; and • Addressing leaks in line with MGN's leak management plan.
Improve MGN's customers' service experience in line with their expectations	MGN will do this by: • Maintaining accuracy of metering assets within relevant industry standards; • Delivering valued services to customers at the lowest sustainable price; and

- Meeting customer KPIs (reliability/outages, safety, complaints, and overall customer satisfaction).

Balance network performance and costs to deliver affordable services

MGN will do this by:

- Optimising overall asset lifecycle management costs;
- Maintaining operating efficiency without compromising safety and reliability;
- Developing investment plans that consider stakeholder expectations; and
- Leveraging people, data and technology to deliver continuous improvement.

Promote gas usage to ensure the networks remain sustainable

MGN will achieve this by:

- Connecting new greenfield expansion projects in a timely manner;
- Enabling new urban infill connections;
- Engaging with key stakeholders to develop adequate network solutions for future supply options;
- Increasing long term competitiveness of networks through higher asset utilisation; and
- Promoting use of gas.

Embrace innovation and work towards net-zero emissions

MGN will achieve this by:

- Considering alternative innovative, sustainable and/or lower long-term cost solutions;
- Pursuing research and development opportunities where they facilitate us to meet MGN's vision and objectives; and
- Supporting the decarbonisation of MGN's gas supplies and the move to smarter gas networks.

4.3. 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.

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

- Gas Safety Act 2001 (Vic)
- Occupational Health and Safety Act 2004 (Vic)
- National Gas Laws (NGL)
- National Gas Rules (NGR)
- Work Health and Safety Act 2012

- Risk management standards

Under the Gas Safety Act, we have an obligation to minimise hazards and ensure the safety of our workers and the community. This is supported by the Occupation Health and Safety Act. 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, our risk management framework is based on the risk assessment and rating contained in Appendix C of AS/NZS 4645 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 in the following sections.

4.3.1. Gas Safety Act 1997 (Vic)

The Gas Safety Act 1997 is the primary regulatory instrument in respect of MGN's obligations regarding gas safety.

According to Section 1 of the Act, the purpose of the Gas Safety Act 1997:

> *"…is to make provision for the safe conveyance, sale, supply, measurement, control and use of gas and to generally regulate gas safety."*

Under section 32, AGN has a general duty to:

> *"… manage and operate each of its facilities to minimise as far as practicable –*

a) the hazards and risks to the safety of the public and customers arising from gas; and

b) the hazards and risks of damage to property of the public and customers arising from gas; and

c) the hazards and risks to the safety of the public and customers arising from –

i. interruptions to the conveyance or supply of gas; and

ii. the reinstatement of an interrupted gas supply.

> *Penalty: In the case of a natural person, 300 penalty units. In the case of a body corporate, 1500 penalty units"*

What is 'practicable' is defined in section 3 as:

"practicable in sections 32, 33, 61, 62 and 63 means practicable having regard to–

a) in sections 32, 61, 62 and 63 the severity of the hazard or risk in question; and

c) the state of knowledge about the hazard or risk and any ways of removing or mitigating the hazard or risk; and

d) the availability and suitability of ways to remove or mitigate the hazard or risk; and

e) the cost of removing or mitigating the hazard or risk."

Under section 37, MGN is required to provide a 'safety case' with respect to its facilities. The Safety. Case must be submitted to ESV for approval. The Safety Case outlines how MGN proposes to comply and demonstrate compliance with its obligations.

Section 37(2) requires that the safety case for a facility must –

a) be in writing; and

b) in accordance with the regulations, specify the safety management system being followed or to be followed by the gas company –

i. to comply with the gas company's duties under division 1; and

ii. in relation to any other matters relating to the safe conveyance, supply, sale, measurement or control of gas that are prescribed."

If MGN fails to comply with its approved Safety Case, MGN will be in breach of section 44(2) of the Gas Safety Act 1997. Such a breach exposes AGN to a penalty of 1500 penalty units ($227,505). However, MGN's driver for compliance with the Safety Case is to ensure the safety of the community and its employees.

The prescribed content of a gas safety case is set out in the Gas Safety (Safety Case) Regulations 2008. Regulations 25 and 26 require a gas safety case to include a formal safety assessment and a safety management plan:

25 Formal safety assessment

1. *A safety case must contain a formal safety assessment.*
2. *The formal safety assessment for a facility must be consistent with the facility description for the facility and must provide—*
    a. *a description of the methodology used and investigations undertaken for the formal safety assessment; and*
    b. *an identification of hazards having the potential to cause a gas incident; and*
    c. *a systematic assessment of risk, including the likelihood and consequences of a gas incident; and*
    d. *a description of technical and other measures undertaken, or to be undertaken, to reduce that risk as far as practicable.*

26 Safety management system

1. *A safety case must specify the safety management system followed or to be followed in relation to the facility. 12 Each unit is $151.67, so 1500 units represents $227,505.*
2. *The safety management system must contain the information specified in Division 5.*

Under regulation 30 of the Gas Safety (Safety Case) Regulations 2008, the safety management system must specify the procedures and the asset management plan that are used or to be used by the gas company to ensure that the design, construction, commissioning and installation, operation, maintenance and decommissioning of the facility and any modification of the facility:

a. *is adequate for the safety and safe operation of the facility; and*
b. *is adequate for the safe and reliable conveyance and supply of gas; and*
c. *is adequate for ensuring the quality of gas conveyed or supplied;*
d. *takes into account the results of the formal safety assessment for the facility.*

In summary, the Gas Safety Act 1997 and regulations under it create two principal duties relevant to managing the safety and supply risks of mains and services:

- First, to assess and manage the risks and the likelihood that a gas incident may result from the condition and utilisation of a main; and

- Second, to do what is practicable to minimise hazards and risks to the public, customers and their property. This duty includes having a system in place to identify the most efficient and effective risk mitigation option including replacing any mains that cause a risk or hazard.

Failure to comply with the Gas Safety Act 1997 can lead to the imposition of financial penalties. In addition, MGN's Gas Distribution Licence issued under the Gas Industry Act 2001 requires MGN to comply with all applicable laws (which include the Gas Safety Act 1997). Ultimately failure to comply with MGN's licence, if not remedied, could lead to revocation of that licence (see clause 3 of the Distribution Licence and section 53 of the Essential Services Commission Act 2001).

MGN's current safety case was submitted to Energy Safe Victoria in 2010. A revised Safety Case was approved January 2022.

4.3.2. Occupational Health and Safety Act 2004

In addition to its safety obligations under the Gas Safety Act 1997, MGN has obligations under the Occupational Health and Safety Act 2004 to ensure the safety of its workers and the community. Section 21(1) of the Occupational Health and Safety Act 2004 provides:

1. *An employer must, so far as is reasonably practicable, provide and maintain for employees of the employer a working environment that is safe and without risks to health. Penalty: 1800 penalty units for a natural person; 9000 penalty units for a body corporate.*

AGN's approach to ensuring the safety of its workers (and the community) is outlined in the safety case and incorporated in the procedures and practices adopted in operating and maintaining the network. While section 21(1) is limited in its scope to workers, section 23(1) imposes a general duty on an employer to ensure that persons other than an employer's employees are not exposed to risks to their health or safety arising from the conduct of the undertaking of the employer.

Section 23(1) provides:

1. *An employer must ensure, so far as is reasonably practicable, that persons other than employees of the employer are not exposed to risks to their health or safety arising from the conduct of the undertaking of the employer. Penalty: 1800 penalty units for a natural person; 9000 penalty units for a body corporate.*

Section 20 defines 'ensuring' health and safety and provides:

1. *To avoid doubt, a duty imposed on a person by this Part or the regulations to ensure, so far as is reasonably practicable, health and safety requires the person—*
    a. *to eliminate risks to health and safety so far as is reasonably practicable; and*
    b. *if it is not reasonably practicable to eliminate risks to health and safety, to reduce those risks so far as is reasonably practicable.*
2. *(2) To avoid doubt, for the purposes of this Part and the regulations, regard must be had to the following matters in determining what is (or was at a particular time) reasonably practicable in relation to ensuring health and safety—*
    a. *the likelihood of the hazard or risk concerned eventuating;*
    b. *the degree of harm that would result if the hazard or risk eventuated;*
    c. *what the person concerned knows, or ought reasonably to know, about the hazard or risk and any ways of eliminating or reducing the hazard or risk;*
    d. *the availability and suitability of ways to eliminate or reduce the hazard or risk;*
    e. *the cost of eliminating or reducing the hazard or risk.*

MGN's approach to identifying and managing safety risk is consistent with AS/NZ ISO 31000.

4.3.3. National Gas Law

Under the NGL, MGN is required to ensure its approach to managing the integrity of mains and services is efficient. The NGL also requires that MGN provides 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 Mains and Services Strategy 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.

Section 28 of the NGL 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 access arrangement relating to a reference tariff.

This provides 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—

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

(d) *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.

4.3.4. Consistency with the National Gas Objective and the National Gas Rules

In developing these forecasts, we have had regard to the National Gas Objective (NGO) and Rule 79/91 and Rule 74 of the National Gas Rules (NGR). With regard to all projects, and as a prudent asset manager/network business, we give careful consideration to whether capex is conforming from a number of perspectives before committing to capital investment.

National Gas Objective

This strategy furthers the NGO by promoting 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.

National Gas Rules

NGR		Description
74		Applying to both capital and operating expenditure, the proposed solutions in this strategy are forecast based on the latest market rate testing and project options consider: • all concurrent MGN strategies and plans • customer requirements and engagements • any third party engagements Estimates ate therefore arrived on a reasonable basis and represent the best estimate possible in the circumstances.
79(1)		Applying to capital expenditure, the proposed solutions in this strategy are • Prudent; • Efficient; • Consistent with accepted and good industry practice; • Achieves the lowest sustainable cost of delivering pipeline services.
79(2)		Applying to capital expenditure, the proposed solutions in this strategy
	(a)	• Provide an overall economic benefit; or
	(b)	• Have an expected revenue that exceeds expected costs; or
	(c)(i)	• Are necessary to improve or maintain the safety of services; or
	(c)(ii)	• Are necessary to maintain the integrity of services; or
	(c)(iii)	• Comply with a regulatory obligation or requirement; or
	(c)(iv)	• Continue to meet existing levels of demand
91		Applying to operating expenditure, the proposed solutions in this strategy are • Prudent; • Efficient; • Consistent with accepted and good industry practice; • Achieves the lowest sustainable cost of delivering pipeline services.

4.3.5. Work Health and Safety Act 2012

In addition to safety obligations under the *Gas Act 1997*, AGN has 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—

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

(a) 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."

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

MGN's approach to identifying and managing safety risk is consistent with ISO 31000 and AS/NZS 4645.

4.3.6. Risk management standards

MGN manages the integrity of 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.

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.

AS/NZS 4645 is general in nature, therefore we have used the standard to underpin our risk management framework, expanding the risk considerations to include compliance, customer impact and financial impacts. This makes for a more rigorous and holistic assessment of risk, ensuring that customer and regulatory/economic impacts are built into our asset management process. However, it is important to note that the fundamental principles of AS/NZ4645 with regard to safety, integrity, and environmental impact are typically the primary risk considerations.

The AS/NZS 4645 risk framework requires that all risks rated 'extreme' or high must be addressed immediately. Any risks rated 'intermediate/moderate' must be addressed as soon as reasonably practicable. However, where the cost of mitigating an 'intermediate/moderate' risk is disproportionate to the level or risk reduction achievable or is simply not economically viable, AS/NZS 4645 allows the business to determine the risk is as low as reasonably practicable (ALARP).

Again, taking guidance from AS/NZS 4645, our risk framework enables us to determine as risk is being managed to ALARP where the costs of risk reduction are prohibitive. Any risks rated ALARP are continually monitored and regularly reviewed to determine whether the risk remains tolerable and whether there is an economical way to reduce the risk to low.

4.4. Risk management

Risk management is a constant cycle of identification, analysis, treatment, monitoring, reporting and then back to identification (as illustrated in the Figure 4-2). When considering risk and determining the appropriate mitigation activities, we seek to balance the risk outcome with our delivery capabilities and cost implications. Consistent with stakeholder expectations, safety and reliability of supply are our highest priorities.

Figure 4-2: Risk Management Principles

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 guides the actions required to reduce or manage the risk to an acceptable level.

MGN's risk management framework is based on:

- AS/NZS ISO 31000 Risk Management – Principles and Guidelines;
- AS 2885 Pipelines-Gas and Liquid Petroleum; and
- AS/NZS 4645 Gas Distribution Network Management.

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 MGN to reduce risks rated high or extreme to low or negligible as soon as possible (immediately if extreme). If it is not possible to reduce the risk to low or negligible, then we must reduce the risk to as low as reasonably practicable (ALARP).

When assessing risk for the purpose of investment decisions, rather than analysing all conceivable risks associated with an asset, we look at credible, primary risk events to test the level of investment required. Where a credible risk event has an overall risk rating of intermediate or higher, we will undertake investment to reduce the risk.

Six consequence categories are considered for each type of risk:

1 **People** – injuries or illness of a temporary or permanent nature, or death, to employees and contractors or members of the public.

2 **Environment** (including heritage) – impact on the surroundings in which the asset operates, including natural, built and Aboriginal cultural heritage, soil, water, vegetation, fauna, air and their interrelationships

3 **Supply –** disruption in the daily operations and/or the provision of services/supply, impacting customers

4 **Compliance** – the impact from non-compliance with operating licences, legal, regulatory, contractual obligations, debt financing covenants or reporting / disclosure requirements

5 **Reputation** – impact on stakeholders' opinion of MGN, including personnel, customers, investors, security holders, regulators and the community

6 **Financial** – financial impact on MGN, measured on a cumulative basis

Note that risk is not the sole determinant of what investment is required. Many other factors such as growth, cost, efficiency, sustainability and the future of the network are also considered when we develop engineering solutions. The risk management framework provides a valuable tool to manage our assets, and prioritise our works program, however it is not designed to provide a binary (yes/no) trigger for investment. As prudent asset managers, we apply our experience and discretion to manage and invest in our distribution networks in the best interests of existing and potential customers.

Our, risk management framework, which is founded on AS/NZ 4645, ranks the severity of the consequences of a risk event. The most severe threats posed by mains and services generally relate to safety and/or supply.

Safety consequences

If a mains or service fails, depending on the location of the asset, the pressure it operates at and the type of failure it experiences (e.g. slow leaks vs sudden cracking), it can cause a major safety incident. The most significant safety risk is that the escaped gas gathers in a building (or another confined space) to a volume where it can cause an explosion if it meets a source of ignition. While these incidents are rare, they have been known to occur and are a credible safety risk.

If a main or service is not located near to a building or in a location where escaped gas is likely to collect in significant volumes, then the safety risk may not be as severe. However, due to the flammable nature of natural gas and the harm or damage that can be caused by striking our assets, there is always some degree of health and safety risk associated with gas escape or people (for example a third party groundworker) coming into contact with our network.

Supply consequences

Failure of a gas main or service can result in disruption to customers' supply. This operations risk has greater consequences for large diameter or higher pressure mains, which may supply a large number of people.

Our HDPE and steel mains pose a greater supply risk than the LP mains, as these assets typically operate at HP or MP and can supply thousands of people. Steel mains also take longer to flow-stop when compared to PE, which means there can be significant loss or disruption to downstream supply if they fail.

These two categories of risk consequence (safety and operations) are the primary considerations when managing our mains and services. However, we also consider the other consequence categories. For example, compliance, customer impact and reputational consequences can be severe if service interruptions are widespread, frequent, or long-lasting. Financial risk is also a consideration when testing whether risk treatments are economically efficient.

4.5. Lifecycle management

Lifecycle management has four components:

1. Plan and create
2. Operate and maintain
3. Monitor and review
4. Repair, replace, abandon

These are discussed in the following sections.

4.5.1. Plan and create

Planning and creation considers current and future customer growth and load demands, asset performance and service needs, and secures the necessary approvals for expenditure. It includes the creation of new assets to:

- extend the network;
- provide new network, metering and SCADA facilities; and
- augment/upgrade/replace existing assets.

For mains and services, the focus is on identifying the most prudent time to replace aged mains and services, as well as gathering asset data to help inform ongoing asset management of different type, material and pressure assets.

4.5.2. Operate and maintain

4.5.2.1. Inspection maintenance

Inspection maintenance typically occurs on in-service assets where a test or a series of tests are performed on a schedule frequency in order to assess the condition of the asset. The outcome of the assessment may result in follow up capital or operation works in order to maintain or extend the life of the asset. In general, inspection of mains is limited to above ground piping, corrosion monitoring, leakage survey and condition assessment dig-ups.

4.5.2.2. Above ground piping (bridge) inspection

MGN has some 55 sites where gas mains are exposed on bridge crossings. The bridges range from multi-lane roads high above the Yarra River to short low level culverts for seasonal creeks. Bridge inspections are conducted annually, and involve the physical inspection of all bridges or exposed mains not associated with supply or consumer regulating installations. The condition of the pipe, coating, supports, transition pieces, abutment, corrosion protection insulation, markers and brackets are all inspected systematically and recorded.

Any corrosion or material defect is then entered into SAP and rectification is scheduled as preventative maintenance. The life cycle of the exposed pipe coating and supports varies between 5 and 20 years depending on the site environment. An average of four bridge crossings require major recoating and/or support refurbishment every year.

4.5.2.3. Corrosion monitoring

Corrosion protection or 'potential' surveys are performed on steel structures – mostly buried steel mains – in order to assess whether a structure is actively corroding or not, the corrosion rate and the nature of the corrosion. Potential surveys record the voltage difference between the soil and the structure being tested over a 24-hour period at corrosion test points that are installed on or along the pipeline structure.

Survey results are recorded and enables reporting of the overall corrosion protection performance system against the level of protection of the steel structure. The survey results are also used in the development of works to maintain or improve corrosion protection levels.

4.5.2.4. Leakage surveys

Leakage surveys involve the surveying of distribution mains and other assets (valves, kiosks etc.) on a systematic basis, which is dependent on risk to public and property. Leakage surveys are carried out in areas considered to be of high consequence in the event of an incident (annual survey) and on an ad-hoc or trigger basis for other areas of the network. Public reported leaks are also recorded, with leakage history giving some indication of mains condition.

There are four different categories of surveying, as detailed in Table 4-2, three of which are location dependent.

Table 4-2: Leakage survey categories

Category No	Description	Survey interval
1	Annualised leakage survey	1 year
2	Systematic leakage survey	5 year
3	Special leakage survey (including trigger based survey)	Ad hoc (as a once off survey)
4	Inspection leakage survey (bridges, valves, pits etc.)	Variable (according to leakage strategy)

Surveying is carried out by mobile or portable detection units. Surveys are generally performed by postcode areas. Upon completion of the surveyed area, any leak detections are assigned what is known as a 'leak ticket' and raised as a notification. The leak tickets are passed onto the pinpointing crew, which attempt to locate the leak. Once located a repair crew is sent to repair the escape such that upon rectification of the leak no gas is present within 200 m of the leak repair.

This type of programmed maintenance based on leak detection gives an indication as to the condition of the main or joints, and forms a basis for estimating ongoing maintenance costs on the network.

4.5.2.5. Condition assessment dig-ups

Physical inspection of a sample of large diameter CI mains is carried out based on feedback from field personnel and maintenance history. This inspection comprises a magnetic flux examination of sample sites to determine the degree of material degradation and the probability of through wall corrosion occurring somewhere within the mains unit under assessment. These assessments assist in the development and prioritisation of future mains replacement programs. Additionally, this type of inspection is used to assess in-service protected steel mains which are identified for potential future pressure upgrade.

4.5.2.6. Cathodic protection

The majority of preventive maintenance is to the coated steel network, which since the mid 1970s has incorporated an active cathodic protection system. This system is designed to eliminate stay currents from the steel network, which are induced by ground conditions, electricity utilities and traction[15] systems. The cathodic protection system is detailed in the MG-SP-0013 Cathodic Protection Strategy document.

4.5.2.7. Syphon pumping

This maintenance is as a result of water ingress into the mains, which accumulates in the syphon. Regular pumping is required in the winter months (planned) and at times of heavy rainfall (unplanned). Therefore this activity falls under both preventative and reactive maintenance. Syphon pumping is in the majority of cases restricted to the low pressure network.

[15] Traction current corrosion is considered to be corrosion caused by track leakage current from DC powered rail return railway and tramway systems using the running rail as the return conductor.

4.5.2.8. Valve and syphon maintenance

This maintenance is purely associated with the upkeep of valve and syphons. It includes but is not limited to, painting, clearing obstructions such as roadway and earth; locating, marking etc.

4.5.2.9. Mains investigation and proving

Mains investigating and proving is either at the request of the public or other utilities to locate our gas assets or as an internal proving function for planning construction works. This activity can fluctuate depending on external construction works and public demand.

4.5.2.10. Maintain mains marker posts

Marker posts are used as an additional form of asset protect, to alert the public to the presence of a critical gas main, which in turn, reduces the occurrences of third party damages to mains assets. Marker post signs become faded, are damaged or vandalised (graffiti) and from time to time require replacing. Approximately 60 marker posts on the distribution network need to be replaced each year.

4.5.2.11. Other maintenance

Other maintenance may be attributed to Repair Corrosion – No Escape, Repair Coating Fault, Repair Customers Property and Maintenance Cathodic Protection. These make up only a small component of maintenance on the network.

4.5.3. Monitor and review

Monitoring

Monitoring of assets includes the following:

- capacity to meet customer demands for gas, delivered at required flow rates and pressures.
- to highlight existing and emerging issues related to normal aging over time, accelerated aging or new risk issues;
- Continuous collection of operational data, trend monitoring for emerging issues and amendment to Operational Procedures or Capital program recommendations post risk analysis.
- Auditing to ensure activities and processes comply with required industry standards. The results of both internal and external auditing are reported to management.

Performance measures

- Network performance measures:
  - SAIFI (System Average Interruption Frequency Index) - measured as a cumulative target of 16.2 interruptions per thousand end users
  - USAIDI (System Average Interruption Duration Index) - has a regulatory target of 5 minutes per consumer per annum
  - Customers with >3 unplanned interruptions per annum - measured as a cumulative target of 300 customer per annum
- Asset replacement performance measures:

  - Monthly tracking and reporting of main replacement rates against annual and 5 year regulatory targets. Current 2018 -2022 AER target is 527 km of mains laid in relation to the existing low pressure main replacement program otherwise known as 'Pipeworks'.
- Future reporting measures:
  - Monthly reporting of in-service mains leak incident volumes and rates per kilometre against a five-year rolling network average by mains pressure.
  - Monthly reporting of low pressure and medium pressure decommissioned mains length against annual set replacement targets as per capital replacement programs and against five-year regulatory period targets.

Audits

Key internal audits include:

- supervisor monitoring audits;
- verification audits – the purpose of these audits is to verify that audits of task related activities provide credible and consistent results; and
- technical facility audits Findings from these audits are reported to management through detailed report.
- MGN audits – "as required" to provide confidence that contractors are operating with due diligence and in compliance with requirements. The results of these audits are communicated to the AGIG management team

Key external audits include:

- regulatory audits – conducted by regulators as a means of ensuring that activities performed conform to legislative requirements. Audit results form an important input to management improvement processes; and
- Safety Management Plan audits – external auditors may be engaged to conduct audits on particular aspects of safety or operating plans.

Reviews

Review includes:

- real time data;
- field reports and assessments;
- asset performance, condition and integrity kep performance indicators (KPIs). These are reviewed on a monthly basis in the monthly operating and management report and annually through, amongst others, the Distribution System Performance Review (DSPR); and
- quarterly and annual regulatory reports.

4.5.4. Repair, Replace, Abandon

Mains repairs are generated predominantly from leakage survey and public reports. Future activity levels are forecast based on current levels and taking into account the forecast rate of mains replacement. Reports from the public pertaining to gas leaks that are not picked up or are generated in between leakage inspections, can only be reduced by renewing or replacing the asset and/or reducing the network pressure.

Mains can be damaged buy third party activities. Typical causes are lack of knowledge and caution when working near gas mains, assets location not recorded accurately, and substandard cover. Current controls are above ground marker plates specific to high risk mains, public awareness and the national referral service known as 'Dial Before You Dig', which provides a single point of contact for locational information in relation to underground assets. It is reasonable to assume third party damage will increase with the growth pattern of the asset and with the reduction in underground space due to increasing congestion in inner urban areas.

Replacement of gas distribution mains are triggered by either:

- failure - which is typically associated with the inability to repair a section of main and will result in a reactive replacement; or
- as a result of proactive replacement in the case where the main is deemed no longer fit for purpose due to safety, and associate risk concerns to the public and field personnel.

4.6. Network adaptation – renewable gas

In line with MGN's objective to support energy sector decarbonisation, our asset management practices consider the introduction of hydrogen into MGN's network. Where practicable, when replacing gas distribution network equipment and components, we purchase parts that are compatible with hydrogen and renewable gas, taking a prudent and incremental approach to making the network 'hydrogen ready'.

This incremental approach allows us to facilitate the energy policy direction to decarbonise Australia's energy sector, and to do so in an efficient manner. Gas transmission and distribution pipelines are among Australia's most important energy transportation systems. It is vital these high value assets keep pace with the energy transition happening right across the country, and we ensure the gas networks are ready to transport renewable gas.

5. Works program – 2023/24 to 2027/28

5.1. Program overview

The mains and services replacement program is central in controlling the risks presented by aging and deteriorating mains and services. We have identified the following six programs for the next AA period that are necessary to ensure we remain compliant with regulatory obligations under the Gas Safety Case, Gas Distribution System Code and AS/NZS 4645:

5. Low pressure cast iron (CI) and unprotected steel (UPS) mains replacement
6. Early generation high density polyethylene (HDPE) mains replacement – [redacted]
7. [redacted] medium pressure (MP) steel replacement
8. Reactive services replacement
9. HDPE assessment
10. Reactive mains replacement

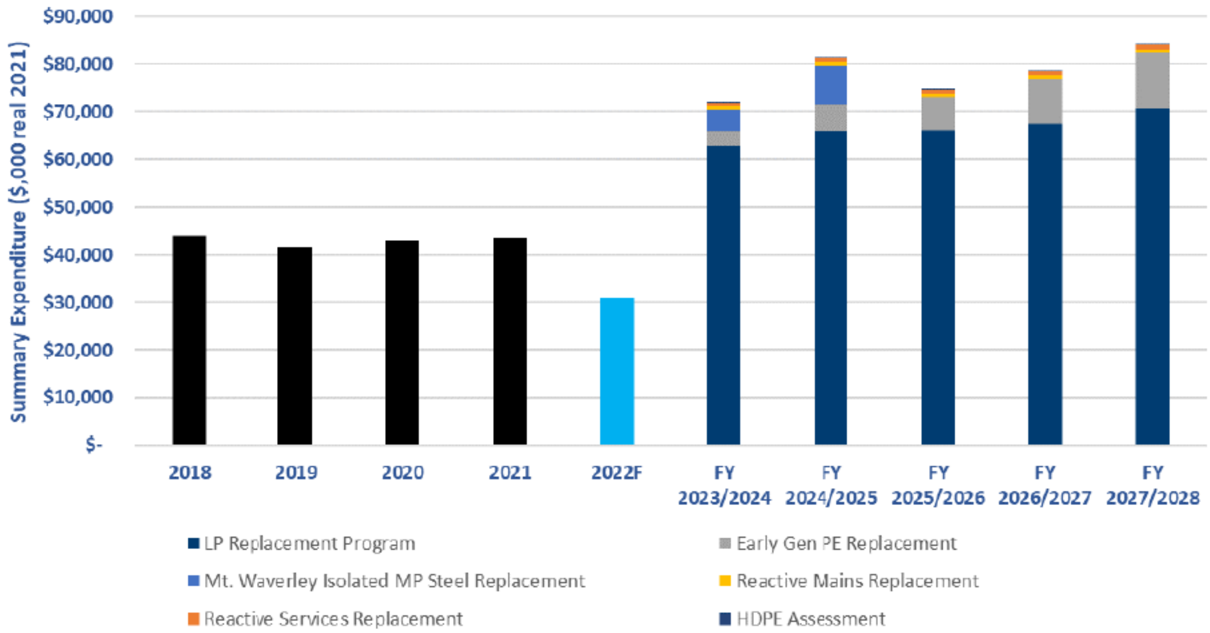
Table 5-1 summaries expenditure from 2023/2024 to 2027/2028 by program.

Table 5-1: MGN mains and services replacement forecast expenditure $'000 real 2021

Program name	2023/24	2024/25	2025/26	2026/27	2027/28	Total
Low pressure CI & UPS mains	62,759	65,953	66,100	67,484	70,679	332,974
Early generation HDPE replacement	3,010	5,415	7,036	9,429	11,698	36,589
[redacted] MP steel replacement	4,640	8,334	-	-	-	12,974
Reactive service replacement program	1,102	1,102	1,102	1,102	1,102	5,510
Total capex	**71,511**	**80,804**	**74,238**	**78,015**	**83,479**	**388,047**
HDPE testing program	199.6	199.6	199.6	199.6	199.6	998
Reactive Mains replacement program	730	730	730	730	730	3,650
Total opex	**930**	**930**	**930**	**930**	**930**	**4,648**
Total expenditure	**72,441**	**81,734**	**75,168**	**78,945**	**84,409**	**392,695**

Forecast expenditure represents a step increase from the current AA period as represented in Figure 5-1

Figure 5-1: Historical and forecast mains and services expenditure, $'000 real 2021



The increase in expenditure over the next AA period is a due to a combination of greater volumes of overall mains replacement, coupled with an increase in unit costs, driven by a shift towards higher density and more complex projects, compounded by the higher cost of materials and labour experienced in the wake of the COVID-19 pandemic. Further information on the mains and services unit rates is provided in the breakdown of each project within this strategy and in the Unit Rates Report provided at Attachment 9.6 to the MGN Final Plan.

The bulk of expenditure is on the low pressure CI and UPS program, which remains a priority for the next AA period. We propose replacement volumes remain consistent with those delivered during the first four years of the current AA period, at ~141 km per year (see section 5.3 below). Maintaining this rate will allow us to remove all remaining low pressure CI and UPS from our network by 2033.

The targeted HDPE and MP steel replacements of poor performing parts of our network ([redacted]) are new programs. The HDPE program is a conservative approach to understanding and addressing the risks associated with these aged assets, while the MP replacement program in [redacted] is driven by declining performance in this antiquated section of our network.

Reactive mains and service replacements are based on historical work volumes, with unit costs reflecting the latest market rates.

Information on the low pressure CI and UPS replacement program, as well as the other mains and services programs, are provided in Sections 5.5 to 5.10.

5.2. Customer and stakeholder engagement

MGN is committed to operating the network in a manner that is consistent with the long-term interests of our customers. To facilitate this, we conduct regular stakeholder engagement to understand and respond to the priorities of our customers and stakeholders. Feedback from stakeholders is built into our asset management considerations and is an important input when developing and reviewing our expenditure programs.

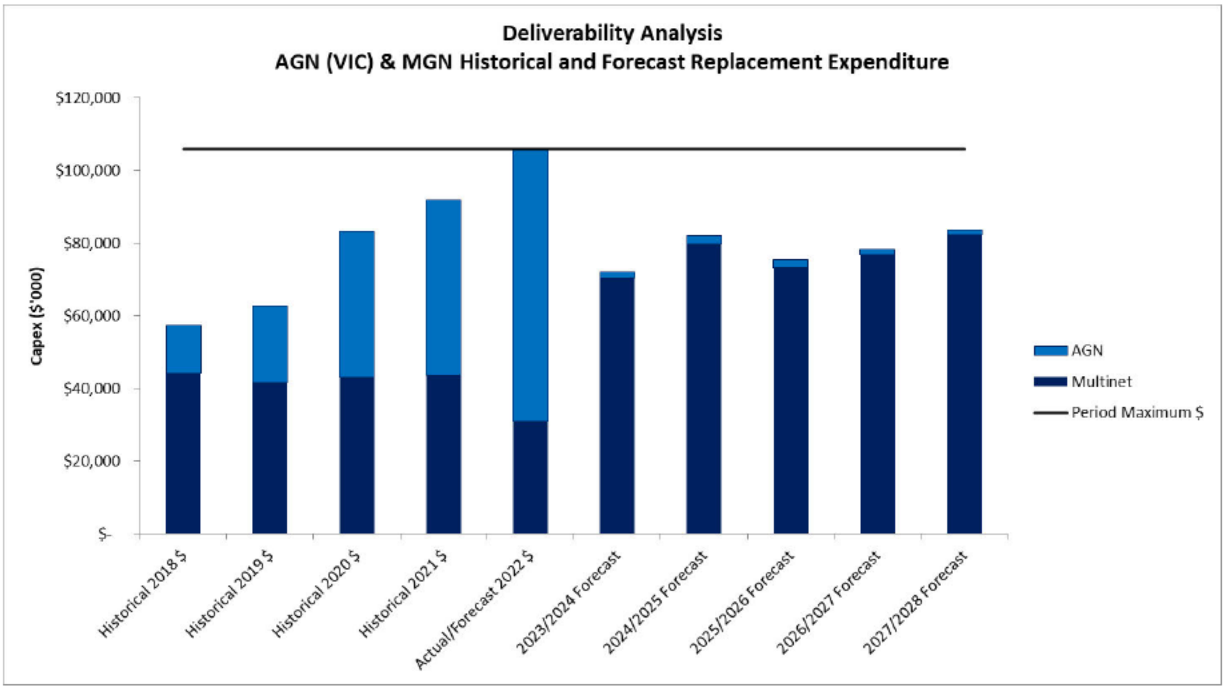
Our customers have told us their top three priorities are price/affordability, reliability of supply, and maintaining public safety. During recent stakeholder workshops we have tested the proposed mains replacement rates with customers and the safety regulator (Energy Safe Victoria). In Phase 2 of our stakeholder engagement program, we found that customers trust MGN's safety and reliability record and support its approach to mains replacement.

Detailed discussion of the findings from our stakeholder engagement is provided in Attachment 5 of the MGN Final Plan.

5.3. Delivery capacity

The forecast program of mains replacement can be delivered cost effectively and efficiently utilising the existing AGIG resource base within Victoria. As shown in Figure 5-2 below, the low pressure mains program for AGN Victoria and Albury falls away after 2022, which means these resources can be redeployed to deliver the MGN low pressure mains replacement program.

Figure 5-2: AGN and MGN combined expenditure for mains replacement programs 2018 to 2028



The decrease in MGN mains replacement in 2022 was an exception[16], as AGIG resources were redeployed to prioritise removal of the final sections of the AGN Victoria & Albury low pressure mains. All CI and UPS mains will have been removed from the AGN Victoria & Albury networks by the end of 2022, which means resources can be moved back to focusing on MGN.

Note that the completion of the AGN low pressure program means the overall volumes of mains replacement across both business are lower in the next AA period than in previous years. This means there will be sufficient resources to deliver the modest MGN HDPE and [redacted] MP steel replacement programs. Deliverability is not expected to be a constraint.

[16] MGN is expected to significantly exceed the AA allowance form mains replacement.

5.4. Estimating efficient costs

Our approach to forecasting mains and services replacement is consistent with the forecasting approach applied and approved by the AER for the current AA period. Mains replacement projects are delivered through our contested capital panel, where individual job packages (scopes) are developed and issued to market for competitive tender by pre-qualified contractors. The establishment of the contestable panel has led to cost efficiencies in the current period.

The current costs incurred for mains replacement reflect these competitively tendered contractor costs. These rates are efficient as they have been determined through competitive market processes in line with our procurement processes.

Unit rate estimates for the next AA period (by postcode for the low-pressure program and project for the MP steel and HDPE programs) have been established with reference to tender prices (where available), historical unit rates, street walks and postcode density correlations to establish unit rates in similar postcodes based on actual historical rates.

Reactive mains and services replacement is based on actual costs incurred in the current AA period.

Our approach to forecasting mains replacement is consistent with the forecasting approach applied and approved for the current AA period

5.5. Low pressure replacement program – cast iron and unprotected steel

5.5.1. Program overview

The 2023/24 to 2027/28 program of works for the low pressure network comprises 704 km of replacement, covering 32 post codes with 51 individual projects. The average replacement over the five-year period is 140.8 km. Due to variances in the length of individual projects, annual volume totals vary slightly, with a high 144 km of replacement forecast in 2027/28, and a low of 139 km for 2024/25 (see Table 5-2).

Table 5-2: Low pressure mains replacement forecast volumes and expenditure, $'000 real 2021

Low pressure mains replacement	2023/24	2024/25	2025/26	2026/27	2027/28	Total
Volumes (km)	140	139	141	141	144	704
Expenditure ($'000)	**62,759**	**65,953**	**66,100**	**67,484**	**70,679**	**332,974**

Program expenditure during the next AA period is forecast at $333 million, a 65%[17] increase compared with that expected to be incurred over the current AA period.

The higher cost is due to the small increase in the total volume of mains to be delivered compared with the current period (704 km vs 662 km), coupled with revised unit rates that reflect the expected cost of replacement in each area postcode (see Section 5.5.2 below).

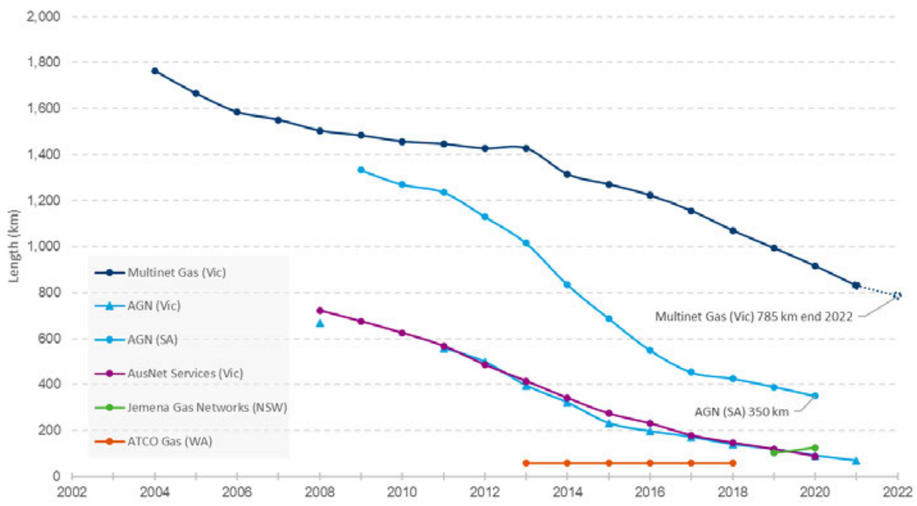
We highlight that the forecast replacement rate of 141 km per year is consistent with that delivered during 2018 to 2021, with the lower level of MGN replacements during 2022 being an outlier while resources were redirected to complete the AGN Victoria and Albury program (see Figure 5-2 above).

[17] 65% increase based on 2018 to 2022 actual/forecast total expenditure of $202 million.

The overall replacement volumes are therefore not a material increase on current volumes, and are considered prudent and deliverable.

MGN has the largest remaining volume of cast iron gas mains when compared to all gas networks in Australia (see Figure 5-3).

Figure 5-3: Comparison of cast iron mains remaining in Australia distribution networks at the end of 2021



At the end of 2021 there were approximately 819 km of low pressure[18] CI mains left in the network, with a further 125 km of UPS. AGN Victoria and Albury and Ausnet are expected to have removed all their low pressure CI and UPS within the next 12 months, with the other networks on a path to near completion.

When MGN commenced the low pressure mains replacement program in 2003, it committed to removing all LP CI and UPS mains from the network by 2033. We remain committed to achieving or exceeding this milestone, and have reiterated this to Energy Safe Victoria (ESV) throughout the development of this program for the next AA period.

5.5.2. Low pressure CI and UPS mains replacement by postcode

To promote efficient delivery of the CI and UPS mains replacement program, we are targeting projects by postcode. The approach allows us to proactively engage with local customers, prioritise and schedule work geographically, and optimise deployment of resources.

The costs of conducting works in different parts of the network can vary depending on network configuration, soil type, urban density and accessibility. Scheduling the CI and UPS mains replacement plan allows us to identify a unit rate for each postcode, which improves the accuracy of our expenditure forecasts.

Table 5-3 provides the volume in metres for each postcode for the next AA period. It is worth noting that some of the works incorporate minor volumes of adjacent postcode.

[18] At the beginning of the 2023 period there will be one 60m segment of Medium Pressure Cast Iron Remaining. This section is being monitored through annual leakage survey.

Table 5-3: Low pressure mains replacement program 2023/24 -2027/28 – volumes in metres

Post code	Suburb	Volumes (m)					
		2023/24	2024/25	2025/26	2026/27	2027/28	Total
3006	SOUTHBANK	0	568	1,503	935	0	3,007
3101	COTHAM, KEW	0	344	344	781	781	2,250
3103	BALWYN, BALWYN EAST	6,745	2,809	2,319	0	2,331	14,204
3122	AUBURN SOUTH, HAWTHORN, HAWTHORN NORTH, HAWTHORN WEST	0	31	31	2,548	8,127	10,737
3123	AUBURN, HAWTHORN EAST	0	3,952	3,952	8,001	21,746	37,652
3124	CAMBERWELL, CAMBERWELL NORTH, CAMBERWELL SOUTH, CAMBERWELL WEST, HARTWELL, MIDDLE CAMBERWELL	8,704	8,490	2,529	3,869	5,068	28,661
3125	BENNETTSWOOD, BURWOOD, SURREY HILLS SOUTH	10,513	0	1,836	1,836	0	14,186
3126	CAMBERWELL EAST, CANTERBURY	2,506	0	0	2,435	9,610	14,551
3127	MONT ALBERT, SURREY HILLS, SURREY HILLS NORTH	7,560	19,845	23,501	17,854	13,233	81,993
3128	BOX HILL, BOX HILL CENTRAL, BOX HILL SOUTH, HOUSTON, WATTLE PARK	10,081	11,478	2,425	1,029	0	25,014
3129	BOX HILL NORTH, KERRIMUIR, MONT ALBERT NORTH	534	534	0	0	650	1,718
3141	CHAPEL STREET NORTH, SOUTH YARRA	8,683	7,128	4,418	6,158	10,362	36,748
3142	HAWKSBURN, TOORAK	12,267	641	12,339	16,105	3,767	45,120

Post code	Suburb	Volumes (m)					
		2023/24	2024/25	2025/26	2026/27	2027/28	Total
3143	ARMADALE, ARMADALE NORTH	7,920	7,920	40	40	0	15,920
3144	KOOYONG, MALVERN, MALVERN NORTH	9,679	6,591	0	7,917	7,917	32,105
3145	CAULFIELD EAST, CENTRAL PARK, DARLING, MALVERN EAST	0	706	8,319	8,557	944	18,526
3146	GLEN IRIS	519	519	0	103	356	1,496
3163	CARNEGIE, GLEN HUNTLY, MURRUMBEENA	0	8,110	16,798	8,710	23	33,640
3165	BENTLEIGH EAST, COATESVILLE	0	0	17	17	0	34
3166	HUGHESDALE, HUNTINGDALE, OAKLEIGH, OAKLEIGH EAST	0	0	0	9,980	9,980	19,960
3181	PRAHRAN, PRAHRAN EAST, WINDSOR	0	0	0	50	152	202
3182	ST KILDA, ST KILDA WEST	3,138	5,558	2,420	1,826	7,480	20,421
3184	BRIGHTON ROAD, ELWOOD	5,476	889	0	0	0	6,365
3186	BRIGHTON, BRIGHTON NORTH, DENDY	4,989	104	6,589	8,622	24,850	45,152
3187	BRIGHTON EAST, NORTH ROAD	11	14,177	19,154	13,080	8,104	54,526
3188	HAMPTON EAST, HAMPTON NORTH	10,040	13,576	4,944	1,119	0	29,678
3189	MOORABBIN, WISHART	11,603	9,472	15,080	5,745	0	41,901
3190	HIGHETT	9,582	0	538	538	0	10,658
3204	BENTLEIGH, MCKINNON, ORMOND, PATTERSON	8,966	9,067	2,729	2,627	0	23,389
3205	SOUTH MELBOURNE	0	1,963	4,613	6,903	4,254	17,732
3206	ALBERT PARK, MIDDLE PARK	0	0	0	100	100	199

Post code	Suburb	Volumes (m)					
		2023/24	2024/25	2025/26	2026/27	2027/28	Total
3207	GARDEN CITY, PORT MELBOURNE	0	4,454	4,454	3,798	3,798	16,503
	TOTAL	**139,516**	**138,927**	**140,892**	**141,283**	**143,630**	**704,249**

Table 5-4 provides the unit rate for each postcode which in combination with annual postcode volume is used to develop annual expenditures for each postcode.

Table 5-4: Low pressure mains replacement program 2023/24 -2027/28 – unit rate per postcode, $ per metre

Postcode	Suburb	Unit rate ($/m)
3006	SOUTHBANK	[redacted]
3101	COTHAM, KEW	[redacted]
3103	BALWYN, BALWYN EAST	[redacted]
3122	AUBURN SOUTH, HAWTHORN, HAWTHORN NORTH, HAWTHORN WEST	[redacted]
3123	AUBURN, HAWTHORN EAST	[redacted]
3124	CAMBERWELL, CAMBERWELL NORTH, CAMBERWELL SOUTH, CAMBERWELL WEST, HARTWELL, MIDDLE CAMBERWELL	[redacted]
3125	BENNETTSWOOD, BURWOOD, SURREY HILLS SOUTH	[redacted]
3126	CAMBERWELL EAST, CANTERBURY	[redacted]
3127	MONT ALBERT, SURREY HILLS, SURREY HILLS NORTH	[redacted]
3128	BOX HILL, BOX HILL CENTRAL, BOX HILL SOUTH, HOUSTON, WATTLE PARK	[redacted]
3129	BOX HILL NORTH, KERRIMUIR, MONT ALBERT NORTH	[redacted]
3141	CHAPEL STREET NORTH, SOUTH YARRA	[redacted]
3142	HAWKSBURN, TOORAK	[redacted]
3143	ARMADALE, ARMADALE NORTH	[redacted]
3144	KOOYONG, MALVERN, MALVERN NORTH	[redacted]
3145	CAULFIELD EAST, CENTRAL PARK, DARLING, MALVERN EAST	[redacted]
3146	GLEN IRIS	[redacted]
3163	CARNEGIE, GLEN HUNTLY, MURRUMBEENA	[redacted]
3165	BENTLEIGH EAST, COATESVILLE	[redacted]
3166	HUGHESDALE, HUNTINGDALE, OAKLEIGH, OAKLEIGH EAST	[redacted]
3181	PRAHRAN, PRAHRAN EAST, WINDSOR	[redacted]
3182	ST KILDA, ST KILDA WEST	[redacted]
3184	BRIGHTON ROAD, ELWOOD	[redacted]

Postcode	Suburb	Unit rate ($/m)
3186	BRIGHTON, BRIGHTON NORTH, DENDY	[redacted]
3187	BRIGHTON EAST, NORTH ROAD	[redacted]
3188	HAMPTON EAST, HAMPTON NORTH	[redacted]
3189	MOORABBIN, WISHART	[redacted]
3190	HIGHETT	[redacted]
3204	BENTLEIGH, MCKINNON, ORMOND, PATTERSON	[redacted]
3205	SOUTH MELBOURNE	[redacted]
3206	ALBERT PARK, MIDDLE PARK	[redacted]
3207	GARDEN CITY, PORT MELBOURNE	[redacted]

To determine postcode unit rates, we use four methods, in order of preference as follows:

- Tender process – where practical we issue a contestable capital panel tender request to our approved service providers. We use this method where the works are sufficiently well defined to enable us to approach our service providers to provide a firm quotation and we intend to proceed with the successful tender.
- Historical rates – where the tender process is not practical, we rely on actual historical rates where we have previously undertaken work in the postcode.
- Street walks – where we have not previously undertaken works, we reviewed the new areas with a combination of street walks, data identification, similar density areas and project specific identification.
- Density – we undertake postcode density correlation to establish unit rates in similar postcodes based on actual historical rates.

Table 5-5 shows the method (or combination or methods) used to determine the unit rates for each postcode for the next AA period.

Table 5-5: Postcode unit rate estimation methods

Post code	Suburb	Unit/Rate ($/m)	Tender	Historical	Density	Street walk	Source
3006	SOUTHBANK	[redacted]					This works to be completed as part of postcode 3207.
3101	COTHAM, KEW	[redacted]	x	x			Based on two average tender rates for 3101 and 3102.
3103	BALWYN, BALWYN EAST	[redacted]	x	x	x		Based on three average tender rates (3) for postcodes 3103 and 3104 given similar densities and proximity to each other.

Post code	Suburb	Unit/Rate ($/m)	Tender	Historical	Density	Street walk	Source
3122	AUBURN SOUTH, HAWTHORN, HAWTHORN NORTH, HAWTHORN WEST	[redacted]	x	x			Based on four average tender prices (4) for Hawthorn postcode 3122.
3123	AUBURN, HAWTHORN EAST	[redacted]	x	x	x		Based on four average tender prices (4) for Hawthorn postcode 3122 given similar densities and proximity to each other.
3124	CAMBERWELL, CAMBERWELL NORTH, CAMBERWELL SOUTH, CAMBERWELL WEST, HARTWELL, MIDDLE CAMBERWELL	[redacted]	x	x			A large area is surrounding Camberwell Junction. The unit rate has been adjusted in line with the tender rate for Box Hill Central postcode 3128 Court Street Project.
3125	BENNETTSWOOD, BURWOOD, SURREY HILLS SOUTH	[redacted]	x	x	x		Based on three average tender rates for postcode 3124, 3128 and 3129.
3126	CAMBERWELL EAST, CANTERBURY	[redacted]	x	x	x		Based on three average tender rates for postcode 3124, 3128 and 3129.
3127	MONT ALBERT, SURREY HILLS, SURREY HILLS NORTH	[redacted]	x	x	x		Based on two average tender rates for 3128 and 3129, similar densities.
3128	BOX HILL, BOX HILL CENTRAL, BOX HILL SOUTH, HOUSTON, WATTLE PARK	[redacted]	x	x			Based on tender rate for Box Hill Central (Court St project). One project in Box Hill Central to be completed.
3129	BOX HILL NORTH, KERRIMUIR, MONT ALBERT NORTH	[redacted]	x	x	x		Based on tender rate for Box Hill Central (Court St project).
3141	CHAPEL STREET NORTH, SOUTH YARRA	[redacted]		x	x	x	Seven projects planned in this postcode. Two Street walks completed and density rates compared for each project as this varies greatly per project. Areas benchmarked to similar surrounding Postcodes.
3142	HAWKSBURN, TOORAK	[redacted]	x	x			Based on two average tender prices (2) for postcode 3142.
3143	ARMADALE, ARMADALE NORTH	[redacted]	x	x	x		Based on OMSA Project in this postcode and project density rates.

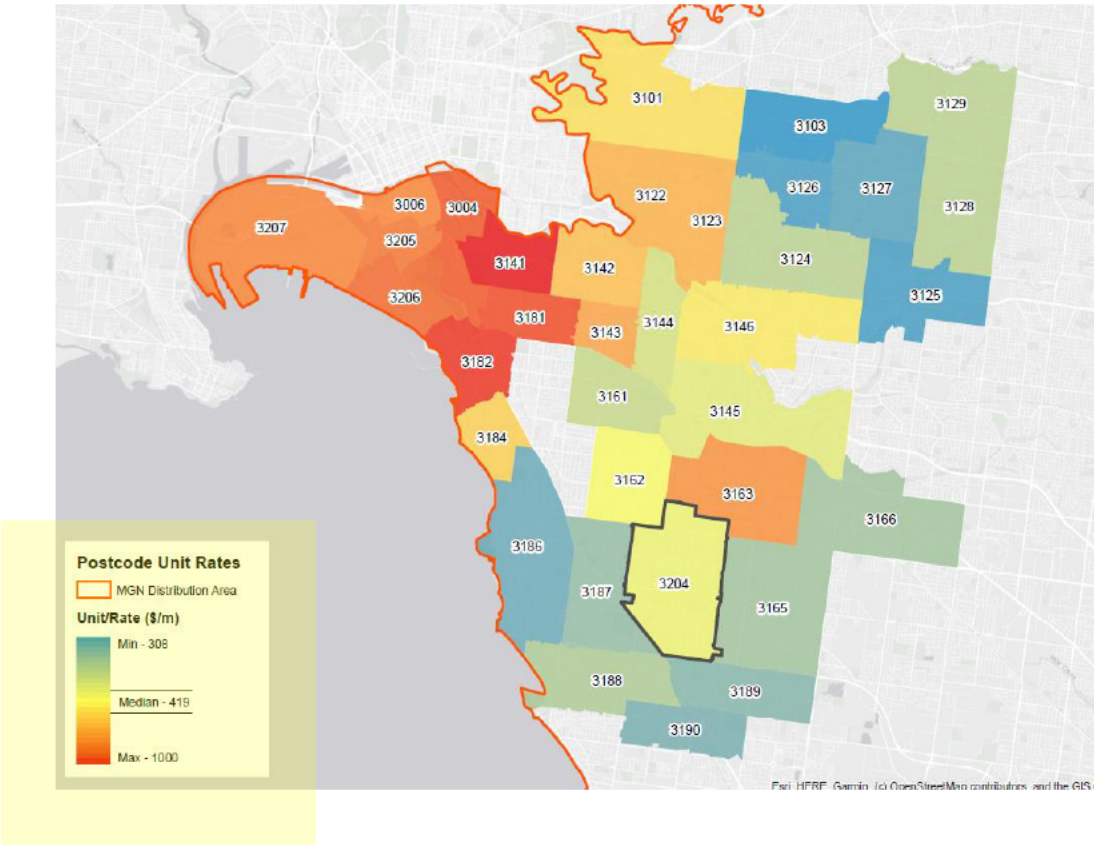
Post code	Suburb	Unit/Rate ($/m)	Tender	Historical	Density	Street walk	Source
3144	KOOYONG, MALVERN, MALVERN NORTH	[redacted]	x	x	x		Based on Malvern East Project and project density for postcode 3144.
3145	CAULFIELD EAST, CENTRAL PARK, DARLING, MALVERN EAST	[redacted]	x	x	x		Based on Malvern East Project and project density for postcode 3145.
3146	GLEN IRIS	[redacted]	x	x	x		Based on two average tender prices (2) for postcode 3145 & 3147. Rates for 3146 projects on the east side of the Monash not included as density rates on the West side of Monash higher.
3163	CARNEGIE, GLEN HUNTLY, MURRUMBEENA	[redacted]	x	x			Based on return tender price for 3163 (Watson Grove Glenhuntly).
3165	BENTLEIGH EAST, COATESVILLE	[redacted]	x	x			Based on two average tender prices (2) for postcode 3165.
3166	HUGHESDALE, HUNTINGDALE, OAKLEIGH, OAKLEIGH EAST	[redacted]	x	x	x		Based on two average tender prices (2) for postcode 3165 and project density rate.
3181	PRAHRAN, PRAHRAN EAST, WINDSOR	[redacted]		x	x		Three projects planned in this postcode. Density rates compared for each project as this varies greatly per project. Areas benchmarked to similar surrounding postcodes.
3182	ST KILDA, ST KILDA WEST	[redacted]	x	x			Based on average for project actuals in postcode 3182.
3184	BRIGHTON ROAD, ELWOOD	[redacted]	x				Based on actual tender rate for this one remaining project + 5%.
3186	BRIGHTON, BRIGHTON NORTH, DENDY	[redacted]	x	x	x		Based on average of two actuals for 3186 and 3187 plus tender rate for one project in postcode 3189.
3187	BRIGHTON EAST, NORTH ROAD	[redacted]	x	x	x		Based on average of two actuals for 3186 and 3187 plus tender rate for one project in Postcode 3190.
3188	HAMPTON EAST, HAMPTON NORTH	[redacted]	x	x	x		Based on average of two actuals for 3186 and 3187 plus tender rate for one project in postcode 3191.
3189	MOORABBIN, WISHART	[redacted]	x	x	x		Based on average of two actuals for 3186 and 3187 plus tender rate for one project in postcode 3192.
3190	HIGHETT	[redacted]	x	x	x		Based on Average of two actuals for 3186 and 3187 plus tender rate for one project in postcode 3193.

Post code	Suburb	Unit/Rate ($/m)	Tender	Historical	Density	Street walk	Source
3204	BENTLEIGH, MCKINNON, ORMOND, PATTERSON	[redacted]	x	x	x		Based on average for 3 return tenders for Wright St Bentleigh project. Reviewed similar densities and postcode proximity.
3205	SOUTH MELBOURNE	[redacted]	x	x	x		Based on two average tender prices (2) for postcode 3207 reviewed density of the projects in similar areas.
3206	ALBERT PARK, MIDDLE PARK	[redacted]	x	x	x		Based on two average tender prices (2) for Postcode 3207 reviewed density of the projects in similar areas.
3207	GARDEN CITY, PORT MELBOURNE	[redacted]	x	x	x		Based on two average tender prices (2) for this Postcode. High density rate reviewed around Cruikshank Street.

The mains replacement capex forecast includes an allowance for planned services replacements associated with the packages of work (in addition to the mains replacements). The costs of these services works are included in the unit rates and are estimated using the same methodologies.

Figure 5-4 shows a heat map of the unit rates for the 32 postcode areas that will be addressed over the next AA period.

Figure 5-4: Heat map of proposed postcode unit rates - median unit rate outlined in black



5.5.3. Recommended option

We have considered other options, including an accelerated mains replacement program, and moving to reactive replacement only. These options are discussed in 0.

However, the proposed volume of 704 km is the most prudent and efficient option because it is:

- consistent with the mains replacement volumed delivered over the current AA period;
- consistent with our vision of improving public safety by maintaining the safety and integrity of gas mains, thus reducing risks to an acceptable level;
- fulfilling a commitment to replace all low pressure mains by 2033;
- consistent with our vision of being sustainably cost effective, awarding projects to service providers based on a market pricing;
- is proven deliverable within our current resource pool; and
- aligned to good industry practice, maximising reliability, and asset integrity.

5.6. Early generation HDPE replacement program

5.6.1. Program overview

This program will decommission 86.1 km mains in Glen Waverley and Vermont, replacing them with new PE. Of these, 54.5 km are medium pressure early generation HDPE mains. These are MGN's highest risk polyethylene assets. MGN aims to replace these by 2028. This program will allow MGN to meet this target. Table 5-6 shows a breakdown of mains which this program will decommission.

Table 5-6: Early Generation Polyethylene Program Volumes (*not being replaced)

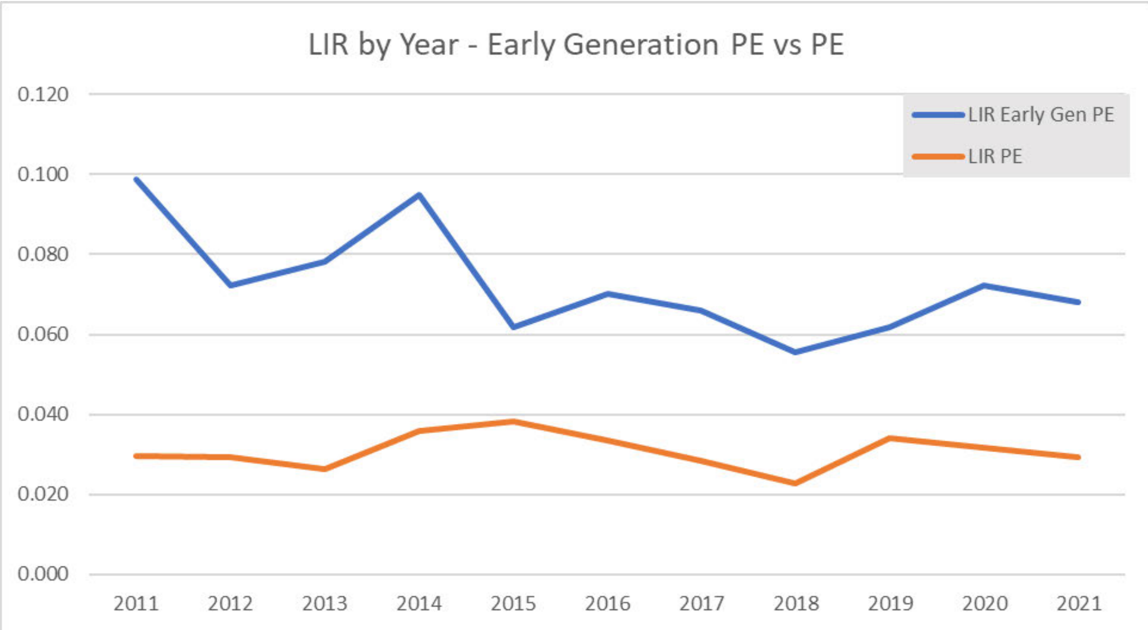
Project	Year	Early Generation PE (pre-1980) (m)	PE (1980+) (m) *	MP steel <80mm (m)	MP steel >80mm (m)	Total (m)
[redacted]	2023/24	[redacted]		[redacted]	[redacted]	[redacted]
[redacted]	2024/25	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	2025/26	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	2026/27	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	2027/28	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total		**54,468**	**4,312**	**8,519**	**18,848**	**86,147**

5.6.2. Program background

The polyethylene network has the lowest leakage incident rate of all MGNs materials. Except for the early generation HDPE mains.

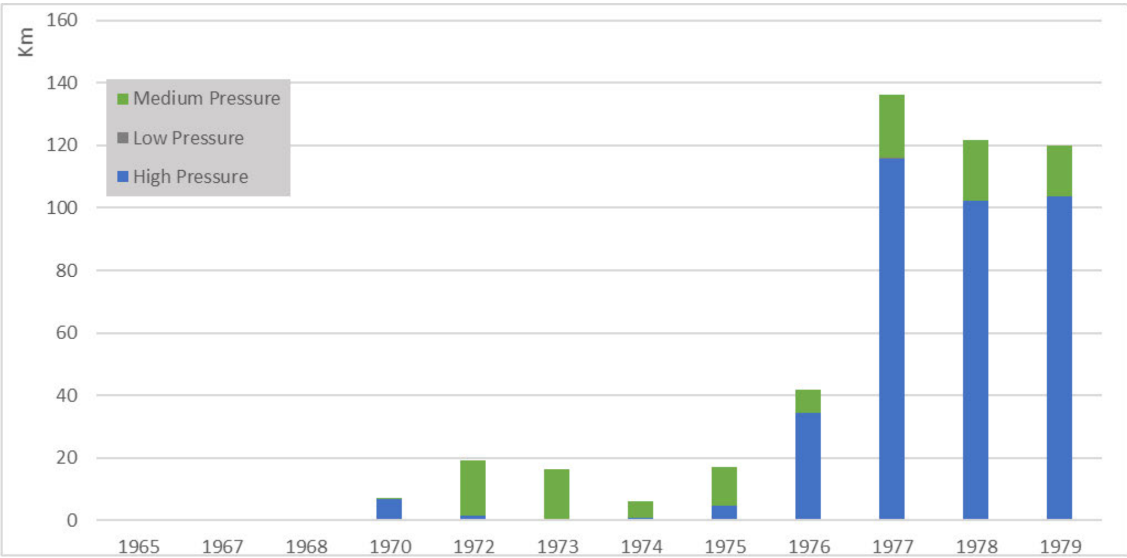
Early generation HDPE mains were installed before 1980. These mains experience slow crack growth. As a result they have a high Leakage Incidence Rate. Since 2011 the early generation PE network has had an average of 0.079 leaks/km. This is over twice that of the PE network, which averaged 0.031 leaks/km for the same period. Figure 5-5 shows the two LIRs over time.

Figure 5-5: Early generation HDPE vs PE - LIR by year



MGN has 488 km of early generation HDPE mains. They are predominantly installed on the high pressure network.

Figure 5-6: Early Generation HDPE volumes by construction year



MGN has commenced a preliminary stage of this program. A 2.3 km section of medium pressure early generation polyethylene mains has been issued for upgrade to high pressure. This project is called Annandale Cres, [redacted]. The medium pressure early generation mains are to be replaced with 1.8 km of HP PE mains.

This project was market tested through competitive tender. Four contractors submitted price for this mains renewal. With an average tender price of [redacted]. This equates to [redacted]

5.6.3. Recommended option

The project (shown in **Error! Reference source not found.**) has been designed using a 'block r eplacement' method. Five discrete sections totalling 86.1 km of medium pressure will be replaced and upgraded. The resulting mains will operate at high pressure. The project will deliver the following:

- abandonment of 54.5 km of early generation polyethylene; and
- introduction of high pressure to meet current and future supply requirements in the area.

This program has been estimated at a total cost of $36.6 million. The cost estimate is based on independent estimator pricing from [redacted], and the tendered price of Annandale Cres [redacted]

In 2016 [redacted], an independent estimator, priced two projects. Weeden Drive, Vermont South[19] and King Arthur Drive, Glen Waverley.[20] These are both early generation PE renewal projects around the Glen Waverley area. [redacted] priced these projects at [redacted] and [redacted] respectively.

This program has been priced using blended main laying unit rate. This was the average of the Annandale Cres tender price, and the two independent estimator prices. This unit rate was used to calculate the project costs. Including the grid mains, this averages to be a unit rate of [redacted] across the entire program.

Figure 5-7 Early Generation HDPE cost breakdown

Project	Year	63P10 Main Renewal ($'000)	Upgradable Mains (MP-HP) ($'000)	125P10 Grid Main Laying ($'000)	Total ($'000)
[redacted]	2023/24	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	2024/25	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	2025/26	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	2026/27	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	2027/28	[redacted]	[redacted]	[redacted]	[redacted]
Total		**32,930.4**	**431.2**	**3,226.9**	**36,588.6**

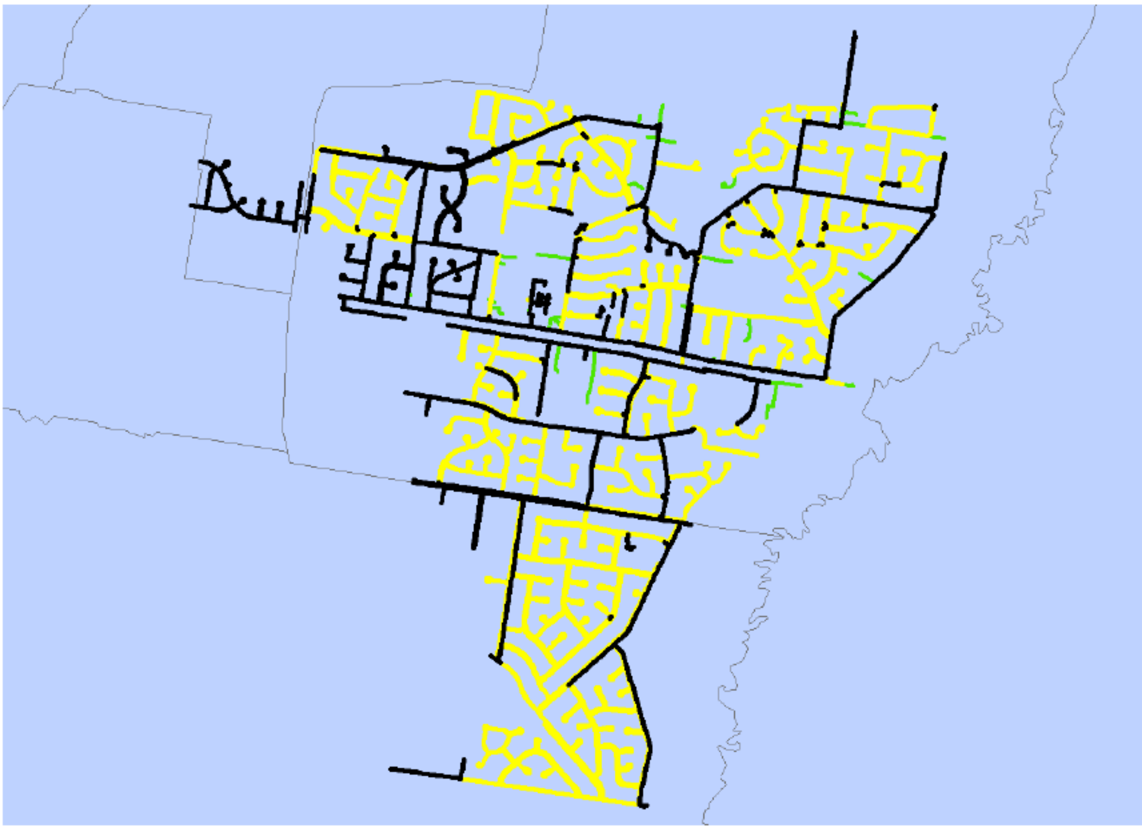
[19] MG-2016-15 Vermont Sth-Weeden Dr MP-HP Mains Renewal.pdf
[20] MG-2016-16 Glen Waverley-King Arthur Dr MP-HP Mains Renewal.pdf

We have considered other options such as: replacing all early generation polyethylene mains in the next period; conducting a like-for-like replacement program; and maintaining status quo. These options are discussed in Appendix B.

We consider the work proposed in Section 5.6.1 is the most prudent and efficient option because:

- it addressed a major asset performance issue affecting the medium and high pressure networks;
- MGN has a proven track record of delivering medium and high pressure replacement projects of this scale;
- it is consistent with our vision of improving public safety by maintaining the safety and integrity of services thus reducing risks to an acceptable level;
- it is consistent with our vision of being sustainably cost effective. By awarding projects to service providers based on a market pricing; and
- it is aligned to good industry practice, maximising reliability, and asset integrity.

Figure 5-8: Proposed Early Generation HDPE replacement program area. Mains shown in black are unprotected steel, yellow is early generation HDPE, and green is upgradable PE



5.7. [redacted] MP steel replacement program

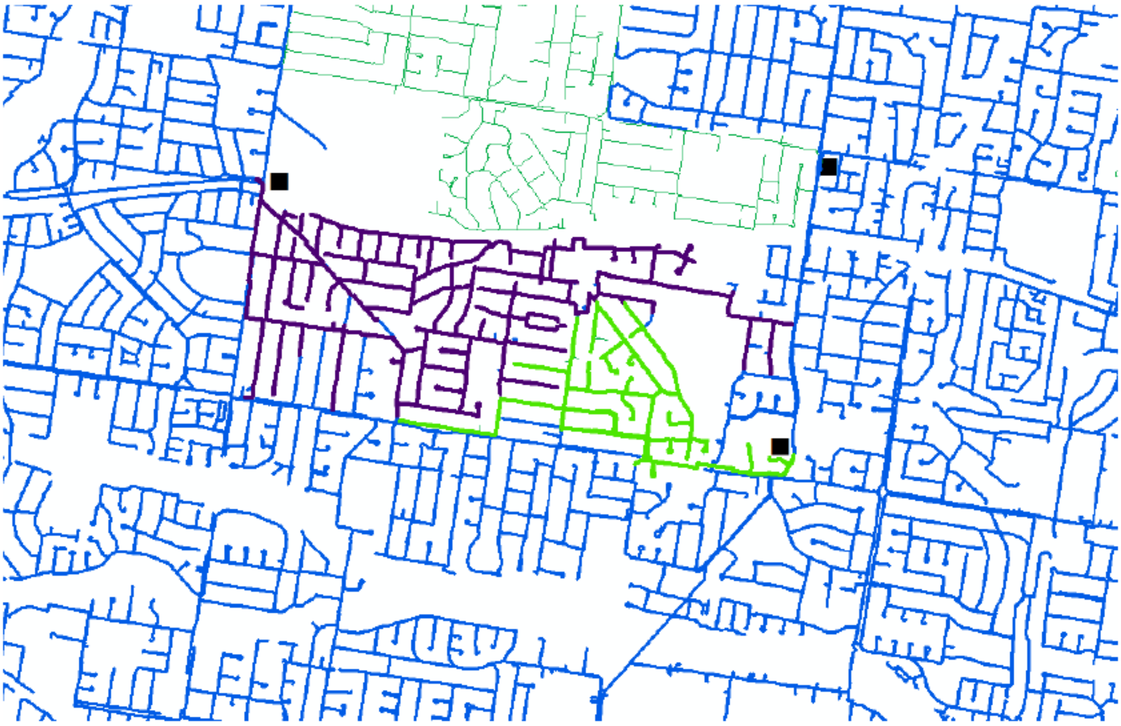
5.7.1. Program overview

Protected steel on the MGN network is generally in good condition. However, the [redacted] steel replacement program is necessary to address a poorly constructed area of steel mains where cathodic protection systems are also no longer effective in preventing corrosion. These are MGN's highest risk steel assets.

This program will replace two isolated aged steel networks. One is a medium pressure network which is surrounded by higher pressure networks and fed by a single field regulator. The other is a custom network which operates at 140kpa.

At the end of the program, both networks will be constructed to high pressure standard, and integrated into the surrounding high pressure networks. This will increase overall safety by eliminating MGN's highest risk steel assets. This will also increase reliability by removing two single-fed networks and interconnecting them with surrounding high pressure.

Figure 5-9: Overview of proposed project area surrounded by HP networks, and isolated by railway to the North. Custom 140kPa network shown in purple, isolated medium pressure network shown in bold green.



The [redacted] network was built in the 1960s and is a haphazard mixture of protected and unprotected steel designed to operate at low or medium pressure. Many of the mechanical fittings and service connections are not adequate to contain high pressure, and cathodic protection in the area has been ineffective, resulting in corrosion.

This network was previously a part of the colonial gas network. It is built from an assortment of connections and fittings that are no longer approved for use. Growth in the area means the network should be uprated to high pressure to keep pace with demand, however, the network is unsuitable for pressure above 140 kPa.

Each of the two [redacted] networks are isolated from the surrounding networks and are each supplied by single-feed ageing field regulators. Past attempts to raise pressure above 140kpa resulted in significant leakage and gas escape, meaning it cannot be interconnected with the surrounding networks in its current state. This network cannot maintain supply if it were lowered to Medium pressure.

The proposed program for the next AA period will install 24.3 km of new PE mains in [redacted] over two projects. The projects will abandon 20.9 km of steel at the end of its life, as well as 2.4 km early generation HDPE that is interconnected sporadically in the area.

Once construction is complete the network will be uprated from medium pressure to high pressure and integrated into the surrounding high pressure networks, increasing security of supply and capacity of the network for current and future customers.

Table 5-7 shows a breakdown of mains this program will decommission.

Table 5-7: [redacted] MP steel replacement volumes, in metres

Project	Year	63P10 Main Renewal (m)	Upgradable mains (MP-HP)	125P10 Grid Main Laying (m)	Total
[redacted]	2023	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	2024	[redacted]	[redacted]	[redacted]	[redacted]
Total		**20,624**	**6,323**	**3,641**	**30,588**

Table 5-8 shows the forecast expenditure on this program during the next AA period.

Table 5-8: [redacted] MP steel replacement forecast capital expenditure, $'000 real 2021

Project	Year	63P10 Main Renewal ($000)	Upgradable mains (MP-HP) ($000)	125P10 Grid Main Laying ($ 000)	Total ($ 000)
[redacted]	2023	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	2024	[redacted]	[redacted]	[redacted]	[redacted]
Total		**8,633**	**632.3**	**3,709**	**12,974**

The project has been designed around a block replacement methodology, whereby two discrete sections totalling approximately 30.6 km of medium pressure is replaced/upgraded with the resulting mains operated at high pressure.

The cost estimate is based on:

- The blended 63P10 main laying rate of [redacted] in Mount Waverley is based on:
  - Independent estimator pricing. In 2016 [redacted] priced two projects; [redacted] & [redacted] These are both early generation PE renewal projects around the Glen Waverley area.

[redacted]

- Past similar project. The tendered price of the 2021 project [redacted]. This is a 20.3km early generation PE renewal projects around the [redacted] area.

- The uprating rate of [redacted] is based on;
  - Past similar projects. A 2019 project called Rouse St, Port Melbourne included a section of MP to HP uprating. This section was priced at approximately [redacted] of uprating. This project was priced through three party competitive tender.
- The 125P10 grid main laying rate of [redacted] in [redacted] is based on:
  - Analysis of past grid main components of mains renewal project awarded through competitive tender.

This program has been priced using blended main laying unit rate, an uprating unit rate, and a grid main unit rate. Including the grid mains, this averages to be a unit rate of [redacted] across the entire program.

5.7.2. Recommended option

We have considered other options including:

- uprating the isolated area to high pressure;
- operating the network at medium pressure; and
- maintaining the status quo.

These options are discussed in Appendix C.

However, we consider the [redacted] MP steel replacement program outlined above is the most prudent and efficient option because:

- it focuses on a major asset performance issue and removes the need for an isolated network and maintenance plan;
- it will allow us to increase pressure in the area, which will allow us to maintain continuity of supply as new customers connect and peak load grows;
- MGN has a proven track record of delivering medium and high pressure replacement projects of this scale;
- it is consistent with our vision of improving public safety by maintaining the safety and integrity of services thus reducing risks to an acceptable level;
- it is consistent with our vision of being sustainably cost effective, awarding projects to service providers based on a market pricing; and
- it is aligned to good industry practice, maximising reliability, and asset integrity.

5.8. Reactive mains replacement

5.8.1. Program overview

The reactive mains replacement program is ongoing in nature. Mains need replacing when repair is not possible or cost efficient. Available materials, equipment, and techniques can limit repair of aged mains.

We apply reactive mains replacement when maintenance is unsafe or inefficient over the longer term. Leaks, corrosion, and water ingress cause ongoing maintenance issues and sometimes repairs on deteriorated assets can be ineffective, leaving replacement as the preferred solution.

Reactive replacement has increased in the past five years. The network has experienced more water ingress faults as mains reach end of life. Reactive replacement has increased network reliability and reduced maintenance costs.

The flexibility of reactive mains replacement allows for efficiency in planned replacement programs. replacing small, failed sections of mains removes the need to deliver larger projects. This allows long term planning, and an efficient low pressure replacement program.

The proposed reactive mains program for the next AA period allows for $730k per annum of piecemeal mains renewal projects outside of the planned replacement programs portfolio. This is based on historical reactive replacements undertaken over the past three years.

The work volume and expenditure will vary from year to year. This is due to nature of reactive work. Table 5-9 shows reactive mains replacement conducted over the past three years (2020 to 2022).

Table 5-9: Reactive mains replacement projects 2020 to 2022

Project	Replacement (m)	Rationale	Year	Cost ($'000)
Barkly Ave, Armadale	962	Water ingress	2020	[redacted]
Victoria Ave, Canterbury	345	Water ingress	2021	[redacted]
Grandview Rd, Brighton	1600	Water ingress	2021	[redacted]
Morokai Gr Lilydale	446	Corrosion	2021	[redacted]
Tooronga Rd, Hawthorn East	194	Water ingress	2022	[redacted]
Heather St, Hawthorn East	160	Water ingress	2022	[redacted]
James St, Surrey Hills	400	Water ingress	2022	[redacted]
Lynch Cres, Brighton	328	Water ingress	2022	[redacted]
			Total	2,184.1

The primary driver behind these projects was supply fault caused by water ingress. Historical average spend over the period was $728k, which we have used for the purpose of the forward looking forecast (see Table 5-10).

Table 5-10: Reactive mains replacement forecast expenditure, $'000 real 2021

	2023/24	2024/25	2025/26	2026/27	2027/28	Total
Reactive mains replacement	730	730	730	730	730	3,650

New mains installed are modern high pressure PE mains, however, due to the smaller scale of the projects, the reactive unit rates are typically higher than proactive replacement.

We have not conducted options analysis for the reactive mains replacement program. Due to the reactive nature of the program, it is not possible to forecast how many mains will fail during the period. Nor is it viable to cease the program and not replace failed mains. We have therefore not attempted to quantify alternative scenarios with higher or lower reactive replacements.

We consider history is the best indicator of the future for reactive replacement, noting that only the costs actually incurred for reactive replacements will be added to the capital base and recovered via regulated revenue.

Maintaining our current reactive replacement method is the most prudent course of action. This program:

- achieves our network objective of *Delivering for Customers*;
- is *Sustainably Cost Efficient* by working within industry benchmarks, and being environmentally and socially responsible;
- allows for timely risk reduction by replacing failed assets;
- reduces ongoing maintenance costs by replacing assets with a significant number of faults, that are not a part of other programs; and
- will promote lower long term costs of delivering services for customers.

5.9. Reactive services replacement

5.9.1. Program overview

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 700,000 inlet services connecting mains (typically located in the street) to customer meters located at each network user.

The reactive services replacement program provides for an allocation of capital expenditure to allow for the piecemeal replacement of services. These minor works result when reactive maintenance (i.e. repairing mains leaks, service leaks, or water ingress issues) is deemed unsafe or inefficient; considering the deteriorated condition of the asset which limits the effectiveness to repair the fault. The optimum long-term solution to manage the risk associated with leaks in services is to replace the service with PE in a compliant location.

The proposed reactive services replacement program for the next AA period is based on the historical average expenditure on replacements over the past three years (2019 to 2021). The program excludes service replacement associated with the planned mains replacement programs. It also excludes third party damages, and customer-initiated works.

Service replacements are undertaken by MGN's primary service provider under the Operations and Management Service Agreement (OMSA).

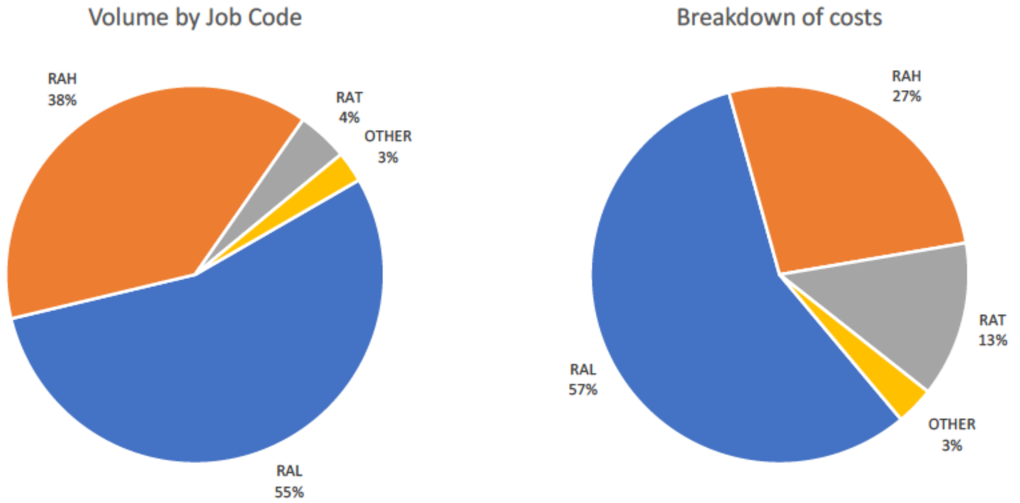
Applicable activity codes include:

- RAC Renew Service - Industrial & Commercial
- RAE Renew Service – Enlargement
- RAH Renew Service - Domestic HP
- RAL Renew Service - Domestic LP
- RAR Renew Service – Relocation
- RAT Renew Service – Trunk

- RAU Renew Service - Domestic Complex

Domestic low pressure (RAL) and domestic high pressure (RAH) service renewals combine, on average, for 93% of all service replacement volumes and approximately 84% of annual costs.

Figure 5-10: Service replacements by activity codes



In the past four years reactive services replacement has been increasing. Refer to Table -11.

Table -11: Reactive service replacement volumes and cost since 2018 ($'000 real 2021)

MAT	2018	2019	2020	2021
Services replacement	[redacted]	[redacted]	[redacted]	[redacted]
Weighted average unit rate ($)	[redacted]	[redacted]	[redacted]	[redacted]
Annual direct costs ($'000)	**556**	**594**	**1,109**	**1,596**

The annual increases are due to higher volumes of the RAH (Domestic HP) activity type. This is indicative of some HP services beginning to reach their end of life.

We have used the volumes and rates in the Table -11 to estimate the reactive program for the next AA period. The three-year average (2019 to 2021) of annual volumes ([redacted]) and average unit rate ([redacted] /service) has been adopted to estimate annual spend. We have assumed a flat spend profile. This equates to a total of $5.5 million over the five-year period (see Table 5-12).

Table 5-12: Reactive services replacement forecast capital expenditure, $'000 real 2021

	2023/24	2024/25	2025/26	2026/27	2027/28	Total
Reactive services replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Unit rate ($)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total ($'000)	**1,102**	**1,102**	**1,102**	**1,102**	**1,102**	**5,510**

We have not conducted options analysis for the reactive services replacement program. Due to the reactive nature of the program, it is not possible to forecast how many services will fail during the period. Nor is it viable to cease the program and not replace failed services. We have therefore not attempted to quantify alternative scenarios with higher or lower reactive replacements.

We consider history is the best indicator of the future for reactive replacement, noting that only the costs actually incurred for reactive replacements will be added to the capital base and recovered via regulated revenue.

Maintaining our current reactive replacement method is the most prudent course of action. This program:

- achieves our network objective of *Delivering for Customers*;
- is *Sustainably Cost Efficient* by working within industry benchmarks, and being environmentally and socially responsible;
- allows for timely risk reduction by replacing failed assets;
- reduces ongoing maintenance costs by replacing assets with a significant number of faults, that are not a part of other programs; and
- will promote lower long term costs of delivering services for customers.

5.10. HDPE assessment program

5.10.1. Program overview

This program will collect samples of HDPE mains. These will be used in our ongoing testing program with Deakin University. By testing these samples we can understand more about the condition and failure mode of these mains, and use that information to inform the priority order and replacement schedule for the remaining ~433 km of early generation polyethylene.

The HDPE assessment program will take samples of HDPE from a range of locations across the network. Focusing on high risk areas and leveraging against the our early generation HDPE replacement program where possible. MGN are targeting 20 HDPE samples per year at a total program cost of $998,000.

Anticipated program costs are shown inTable 5-13. A flat spend profile has been assumed for the purpose of preparing this forecast. We expect actual costs will naturally vary from year to year.

Table 5-13: HDPE assessment program forecast expenditure, $'000 real 2021

	2023/24	2024/25	2025/26	2026/27	2027/28	Total
HDPE assessment program	199.6	199.6	199.6	199.6	199.6	998

Introducing the HDPE assessment program is the most prudent course of action. This program:

- achieves our network objective of *Delivering for Customers*;
- is *Sustainably Cost Efficient* by working within industry benchmarks, and being environmentally and socially responsible;
- allows for timely risk reduction by replacing failed assets;
- reduces ongoing maintenance costs by providing accurate technical life expectations for the asset class; and
- will promote lower long term costs of delivering services for customers.

Appendix A LP CI and UPS options analysis

A.1 Options considered

The following options have been identified to address the risk associated with leaking and deteriorating low pressure mains.

- Option 1 – Replace 704 km of cast iron and unprotected steel mains, consistent with current replacement rates;
- Option 2 – Accelerate the program to replace 1,000 km of cast iron and unprotected steel mains; or
- Option 3 – Move to reactive replacement only.

These options are discussed in the following sections.

A.1.1 Option 1 - Replace 704 km of cast iron and unprotected steel mains

This is the option discussed in the main body of this strategy, and is consistent with historical LP CI and UPS delivery levels.

Cost assessment

The capital cost of this option is $333 million. The table below provides the planned profile of expenditure across the period, which is a balanced profile of work to achieve 704 kms.

Table Appendix 1: Cost assessment – Option 1 LP mains replacement, $'000 real 2021

Low pressure mains replacement	2023/24	2024/25	2025/26	2026/27	2027/28	Total
Volumes (km)	140	139	141	141	144	704
Expenditure ($'000)	**62,759**	**65,953**	**66,100**	**67,484**	**70,679**	**332,974**

Risk assessment

The risk event associated with these LP CI and UPS mains is a loss of containment leading to build up of gas in a building or other confined space in sufficient volumes to cause explosion if it comes into contact with an ignition source. This can cause serious harm or in extreme cases, death.

The untreated risk is rated high, primarily due to the potentially major consequences of a gas in building incident. As long as the aged CI and UPS remain in the ground, the risk of a major safety incident arising is possible in certain circumstances, and therefore rated unlikely under the MGN risk matrix. This gives rise to a high overall risk, which must be addressed as quickly as reasonably possible.

The CI and UPS mains also give rise to a high supply, reputational and compliance risk.

Table Appendix 2: Risk assessment – Untreated risk, LP mains replacement

MGN Operational Risk Matrix							
Untreated risk	**People**	**Supply**	**Environment**	**Reputation**	**Financial**	**Compliance**	**Overall Risk**
Frequency	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	High
Severity	Major	Severe	Minor	Major	Minor	Severe	
Risk Level	High	Intermediate	Low	High	Low	Intermediate	

By removing 704 km of CI and UPS mains, the residual risk is reduced to intermediate. Only once all the CI and UPS mains have been removed from the network can the risk be considered low.

Table Appendix 3: Risk assessment – Option 1 LP mains replacement

MGN Operational Risk Matrix							
Option 1	**People**	**Supply**	**Environment**	**Reputation**	**Financial**	**Compliance**	**Overall Risk**
Frequency	Remote	Remote	Remote	Remote	Remote	Remote	Intermediate (ALARP)
Severity	Major	Severe	Minor	Major	Minor	Severe	
Risk Level	Intermediate	Low	Negligible	Intermediate	Negligible	Low	

An intermediate risk outcome is an acceptable outcome over the 5-year period, as although the risk is not eliminated, we are taking all reasonable measures to remove the risk from the network at an efficient and achievable rate. The risk will continue to be intermediate ALARP, however should the asset deteriorate more quickly than planned the risk would escalate due to the likelihood increasing.

Alignment with vision objectives

The following table shows how Option 1 aligns with our vision objectives.

Table Appendix 4: Alignment with vision – Option 1 LP mains replacement

Vision objective	Alignment
Delivering for Customers – Public Safety	Y
Delivering for Customers – Reliability	Y
Delivering for Customers – Customer Service	Y
A Good Employer – Health and Safety	Y
A Good Employer – Employee Engagement	-
A Good Employer – Skills Development	-
Sustainably Cost Efficient – Working within Industry Benchmarks	Y
Sustainably Cost Efficient – Delivering Profitable Growth	Y
Sustainably Cost Efficient – Environmentally and Socially Responsible	Y

Option 1 would align with our objectives of *Delivering for Customers*, as it would reduce the risk associated with old and leaking CI and UPS mains on the network. It improves the reliability of the network by making it less susceptible to outages.

The program reduces the frequency of gas leaks and the incidents. This improves conditions for service providers, consistent with being *A Good Employer*.

The program meets industry benchmarks. All distribution businesses are working to remove their end of life cycle, unreliable gas mains. This is environmentally and socially responsible, reducing the amount of gas emitted to the environment. This aligns with our objective to be *Sustainably Cost Efficient*.

A.1.2 Option 2 – Accelerating the program to finish by 2030

This option involves the acceleration of the program to be complete by 2030. Replacing at a rate of approximately 200 km per year.

The driver for this program is simply to remove the mains from our network as quickly a practicable within resourcing constraints. The performance of CI and UPS mains continues to deteriorate, with leakage rates rising. MGN is already well behind all other Australian distribution networks in removing these high risk assets, and the urgency to get them out of the ground is increasing.

The replacement rate of 200 km per year represents the maximum we could reasonably expect to replace within the next AA period given the pool of resources available.

Cost assessment

The capital cost of this option is $473[23] million. The table below provides the planned profile of replacements across the period.

Table Appendix 5: Cost assessment – Option 2 LP mains replacement, $'000 real 2021

Low pressure mains replacement	2023/24	2024/25	2025/26	2026/27	2027/28	Total
Volumes (km)	200	200	200	200	200	1,000
Expenditure ($'000)	**94,600**	**94,600**	**94,600**	**94,600**	**94,600**	**473,000**

Risk assessment

Removing 1,000 of CI and UPS mains reduces the residual risk to intermediate.

Table Appendix 6: Risk assessment – Option 2 LP mains replacement

MGN Operational Risk Matrix							
Option 2	People	Supply	Environment	Reputation	Financial	Compliance	Overall Risk
Frequency	Remote	Remote	Remote	Remote	Remote	Remote	Intermediate (ALARP)
Severity	Major	Severe	Minor	Major	Minor	Severe	
Risk Level	Intermediate	Low	Negligible	Intermediate	Negligible	Low	

Option 2 results in the same risk outcome as Option 1 as there will still be cast iron and unprotected steel mains remaining in the network. However, the length of time that MGN would be at the intermediate risk would be decreased by approximately 2.5 years.

Alignment with vision objectives

The following table shows how Option 2 aligns with our vision objectives.

Table Appendix 7: Alignment with vision – Option 2 LP mains replacement

Vision objective	Alignment
Delivering for Customers – Public Safety	Y
Delivering for Customers – Reliability	Y
Delivering for Customers – Customer Service	Y
A Good Employer – Health and Safety	Y
A Good Employer – Employee Engagement	-

[23] $473 million is based on the average unit rate of [redacted] from Option 1 of 704 km replaced at $333 million.

Vision objective	Alignment
A Good Employer – Skills Development	-
Sustainably Cost Efficient – Working within Industry Benchmarks	N
Sustainably Cost Efficient – Delivering Profitable Growth	-
Sustainably Cost Efficient – Environmentally and Socially Responsible	Y

This would align with our objectives of *Delivering for Customers*. It will reduce the risk associated with old leaking cast iron mains on the network. It will improve the reliability of the network by making it less susceptible to outages.

The program reduces the frequency of gas leaks and the incidents. This improves conditions for service providers, consistent with being *A Good Employer*.

Increasing replacement volumes to this level is not in line with industry benchmarks. This will require an uplift in resourcing, which will potentially increase the unit rates. This would be costly and inefficient. This option therefore does not completely align with our objective to be *Sustainably Cost Efficient*.

A.1.3 Option 3 – Reactive repair and replacement only

Under this option we would cease the proactive mains replacement activities, and move to a replace/repair on failure program.

Cost assessment

There are no additional upfront costs associated if we reactively repair mains only. However, given the current and forecast failure rates, we will progressively incur greater reactive maintenance costs as leakage rates escalate.

Over the longer term, the cost of reactive response to mains failure and reactive repair of a new mains would be significantly more costly than replacement as part of a planned program of works. While it is not possible to quantify the reactive costs we would incur at this time, in our experience a project conducted reactively is around 3.2 times more expensive than one conducted proactively.[24] This assumption is consistent with the commonly accepted asset management principle that reactive asset maintenance can be around two to five times higher than proactive planned maintenance.[25]

In addition, MGN would likely incur significant financial penalties due to non-compliance with agreed service levels and regulatory/safety obligations.

Risk assessment

Option 3 would do little or nothing to address the untreated risk associated with these mains. The residual risk would therefore remain high.

Table Appendix 8: Risk assessment – Option 3 LP mains replacement

	MGN Operational Risk Matrix						
Option 3	People	Supply	Environment	Reputation	Financial	Compliance	Overall Risk

[24] For example, this is typically due to the additional premia for faster acquisition of long lead time materials, emergency response, labour costs, additional traffic management/permit costs, resource scheduling, etc.
[25] Marshall Institute, Omega engineering, ARMS reliability.

Frequency	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	Unlikely	High
Severity	Major	Severe	Minor	Major	Minor	Severe	
Risk Level	High	Intermediate	Low	High	Low	Intermediate	

Alignment with vision objectives

The following table shows how Option 3 aligns with our vision objectives.

Table Appendix 9: Alignment with vision – Option 3 LP mains replacement

Vision objective	Alignment
Delivering for Customers – Public Safety	N
Delivering for Customers – Reliability	N
Delivering for Customers – Customer Service	N
A Good Employer – Health and Safety	N
A Good Employer – Employee Engagement	-
A Good Employer – Skills Development	-
Sustainably Cost Efficient – Working within Industry Benchmarks	N
Sustainably Cost Efficient – Delivering Profitable Growth	N
Sustainably Cost Efficient – Environmentally and Socially Responsible	N

Option 3 would not align with our objectives of *Delivering for Customers*. It does not address public safety concerns, diminishes reliability as the network continues to deteriorate. More outages and leaks will occur due to the age of existing assets.

It would also negatively impact employee health and safety due to the volume of additional callouts. These can be unsafe, gaseous areas. This would not be consistent with being *A Good Employer*.

This option would draw resources to managing a deteriorating network. It would bring MGN further from industry benchmarks as the network continues to deteriorate. Other distributors have completed their mains replacement programs. It is not environmentally or socially responsible given the additional leakages that will occur on the network. This option does not align with our objective to be *Sustainably Cost Efficient*.

NPV assessment

We have completed an NPV analysis that compares the long term cost to customers of various timing options for completing the 1,360 km cast iron and unprotected steel program. This analysis demonstrates that a reduction in volumes of 100 km over the AA period would save customers approximately [redacted] per customer per year over the life of the project. However, this would result in the high safety risk associated with corroded mains persisting for the additional two years that it would take to complete the project. We do not consider the relatively minor customer cost savings from decelerating the program is appropriate or prudent given the risks.

In addition, the NPV also shows that should the program be accelerated to a rate of 200 km per year (for a forecast completion by 2030 per Option 2), the additional levy to customers would be approximately [redacted] per customer per year. Although we consider this the optimum safety outcome, we believe that the proposed rate of replacement in Option 1 (141km per year) is prudent and deliverable.

Appendix B Early generation HDPE mains options analysis

B.1 Options considered

The following options have been identified to address the risk associated with the brittle fracture and deterioration or early generation HDPE mains:

- Option 1 – Replace 55 km of early generation HDPE and 27 km of legacy embedded steel mains, rationalise to high pressure and connect into adjacent networks;
- Option 2 – Replace all 488 km of early generation HDPE mains;
- Option 3 – Replace 55 km of early generation polyethylene mains without replacing the embedded legacy steel mains; or
- Option 4 – Reactive repair only.

These options are discussed in the following sections.

B.1.1 Option 1 - Replace 55 km of early generation polyethylene and 27 km of legacy embedded steel mains, rationalise to high pressure and connect into adjacent networks

This is the option discussed in the main body of this strategy.

Cost assessment

The capital cost of this option is $36.6 million. The table below provides the planned profile of replacements and testing across the period.

Table Appendix 10: Cost assessment – Option 1 HDPE mains $'000 real 2021

Program name	2023/24	2024/25	2025/26	2026/27	2027/28	Total
Early generation HDPE replacement 55 km plus MP steel	3,010	5,415	7,036	9,429	11,698	36,588
Total	**3,010**	**5,415**	**7,036**	**9,429**	**11,698**	**36,588**

The risk event associated with these HDPE mains is that pipelines crack due to squeeze off failure, resulting in sudden release of gas that can gather in a building or other confined space in sufficient volumes to cause explosion if it comes into contact with an ignition source. This can cause serious harm or in extreme cases, death.

While the potential severity of the risk associated with a safety incident remains major, the HDPE is not yet in as poor condition as CI and UPS mains, therefore the likelihood of the risk event is remote. This gives rise to an intermediate risk. Under our risk management framework, which is based on AS 4645, we must take action to reduce any intermediate risks to low, or if low is not achievable quickly, manage the risk to as low as reasonably practicable (ALARP) in the interim.

If we do not take any action, the intermediate risk is not considered ALARP.

Table Appendix 11: Risk assessment – Untreated risk HDPE mains

MGN Operational Risk Matrix							
Untreated risk	People	Supply	Environment	Reputation	Financial	Compliance	Overall Risk
Frequency	Remote	Remote	Remote	Remote	Remote	Remote	Intermediate (not ALARP)
Severity	Major	Minor	Trivial	Severe	Minor	Severe	
Risk Level	Intermediate	Negligible	Negligible	Low	Negligible	Low	

While the granularity of the risk matrix means undertaking the works program in Option 1 will not reduce the risk rating below intermediate, it will reduce it to ALARP. The modest mains replacement being proposed is a prudent and efficient risk mitigation exercise, aligned with good practice and reduces the risk as low as reasonably practicable until all the early generation HDPE mains can be removed.

Table Appendix 12: Risk assessment – Option 1 HDPE mains

MGN Operational Risk Matrix							
Option 1	People	Supply	Environment	Reputation	Financial	Compliance	Overall Risk
Frequency	Remote	Remote	Remote	Remote	Remote	Remote	Intermediate (ALARP)
Severity	Major	Minor	Trivial	Severe	Minor	Severe	
Risk Level	Intermediate	Negligible	Negligible	Low	Negligible	Low	

Alignment with vision objectives

The following table shows how Option 1 aligns with our vision objectives.

Table Appendix 13: Alignment with vision – Option 1 HDPE mains

Vision objective	Alignment
Delivering for Customers – Public Safety	Y
Delivering for Customers – Reliability	Y
Delivering for Customers – Customer Service	Y
A Good Employer – Health and Safety	Y
A Good Employer – Employee Engagement	-
A Good Employer – Skills Development	-
Sustainably Cost Efficient – Working within Industry Benchmarks	Y
Sustainably Cost Efficient – Delivering Profitable Growth	Y
Sustainably Cost Efficient – Environmentally and Socially Responsible	Y

Option 1 would align with our objectives of *Delivering for Customers*, as it would address the risk associated with the poorest performing HDPE on the network to ALARP. It improves the reliability of the network by making it less susceptible to outages.

The program reduces the frequency of gas leaks and the incidents. This improves conditions for service providers, consistent with being *A Good Employer*.

The program meets industry benchmarks. Prudent asset managers remove their highest risk assets and use the opportunity to better understand the entire asset class to inform future asset management plans and strategies. This is environmentally and social responsible, reducing the amount of gas emitted to the environment. This aligns with our objective to be *Sustainably Cost Efficient*.

B.1.2 Option 2 - Replace all 488 km of early generation HDPE mains

This option replaces all of the early generation HDPE mains still in service on the network. The portfolio of projects would replace approximately 488 kms of mains to efficiently capture embedded steel within the project areas.

Cost assessment

The preferred program above comes at a unit rate of [redacted] Applying this unit rate to the entirety of the remaining early generation HDPE mains would result in a program cost of $212 million. This would have to be phased to increase over the period due to the significant resource requirements, which could only be increased at a reasonable rate.

Table Appendix 14: Cost assessment – Option 2 HDPE mains, $'000 real 2021

Program name	2023/24	2024/25	2025/26	2026/27	2027/28	Total
Early generation HDPE replacement 488 km plus MP steel	35,000	40,000	45,000	53,000	54,000	212,000

Risk assessment

Option 2 would all but eliminate the risk event as no more early generation HDPE would be in the MGN network.

Table Appendix 15: Risk assessment – Option 2 HDPE mains

	MGN Operational Risk Matrix						
Option 2	People	Supply	Environment	Reputation	Financial	Compliance	Overall Risk
Frequency	Hypothetical	Hypothetical	Hypothetical	Hypothetical	Hypothetical	Hypothetical	
Severity	Major	Minor	Trivial	Severe	Minor	Severe	Low
Risk Level	Low	Negligible	Negligible	Negligible	Negligible	Negligible	

Alignment with vision objectives

The following table shows how Option 2 aligns with our vision objectives.

Table Appendix 16: Alignment with vision – Option 2 HDPE mains

Vision objective	Alignment
Delivering for Customers – Public Safety	Y
Delivering for Customers – Reliability	Y
Delivering for Customers – Customer Service	Y
A Good Employer – Health and Safety	Y
A Good Employer – Employee Engagement	N
A Good Employer – Skills Development	-
Sustainably Cost Efficient – Working within Industry Benchmarks	N
Sustainably Cost Efficient – Delivering Profitable Growth	N
Sustainably Cost Efficient – Environmentally and Socially Responsible	Y

This would align with our objectives of *Delivering for Customers*. It will eliminate the risk associated with early generation HDPE mains on the network. It will improve the reliability of the network by making it less susceptible to outages.

The program reduces the frequency of gas leaks and the incidents. This improves conditions for service providers, consistent with being *A Good Employer*.

Increasing replacement volumes to this level is not in line with industry benchmarks. This project will require a significant uplift in resourcing, which will increase the unit rates and make the overall portfolio of replacement works unachievable. This would be costly and inefficient. This option therefore does not completely align with our objective to be *Sustainably Cost Efficient*.

B.1.3 Option 3 – Replace 55 km of early generation polyethylene mains without replacing the embedded legacy steel mains

This option would replace the early generation HDPE mains in a like-for-like replacement. The legacy steel in poor condition that is embedded in the network would remain in situ and connected to the newly laid PE.

The condition of the steel in this area is such that the pressure cannot be rationalised to high pressure as doing so would result in multiple leaks, asset failure and costly reactive repairs. This solution will leave the Glen Waverley and Vermont network isolated from the surrounding high pressure networks, unable to accommodate any network growth due to reduced capacity, and at an increased risk of loss of supply

Cost assessment

The estimated direct capital cost of this option is $25.6 million, comprised of $23.1 for the mains replacement (based on [redacted]) and $2.5 million for the additional mains laying connections to tie the in situ steel back into the new PE.

Table Appendix 17: Cost assessment – Option 3 HDPE mains, $'000 real 2021

Program name		2023/24	2024/25	2025/26	2026/27	2027/28	Total
Early generation HDPE replacement, no MP steel replacement	Volume (m)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Costs ($'000)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Additional Polyethylene to Steel Connections	Costs ($'000)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total		**2,973**	**5,484**	**4,836**	**5,206**	**7,097**	**25,595**

Risk assessment

Undertaking the works program in Option 3 will not address the risk to ALARP. While removing the HDPE will reduce the risk to some extent, the presence of the poor condition MP steel means the risk is not being reduced to as low as reasonably practicable. These steel mains a currently susceptible to corrosion and leaks, and will only continue to deteriorate if left in the ground.

Table Appendix 18: Risk assessment – Option 3 HDPE mains

	MGN Operational Risk Matrix						
Option 3	**People**	**Supply**	**Environment**	**Reputation**	**Financial**	**Compliance**	**Overall Risk**
Frequency	Remote	Remote	Remote	Remote	Remote	Remote	Intermediate (not ALARP)
Severity	Major	Minor	Trivial	Severe	Minor	Severe	
Risk Level	Intermediate	Negligible	Negligible	Low	Negligible	Low	

Alignment with vision objectives

The following table shows how Option 3 aligns with our vision objectives.

Table Appendix 19: Alignment with vision – Option 3 HDPE mains

Vision objective	Alignment
Delivering for Customers – Public Safety	N
Delivering for Customers – Reliability	N
Delivering for Customers – Customer Service	N
A Good Employer – Health and Safety	N
A Good Employer – Employee Engagement	-
A Good Employer – Skills Development	-
Sustainably Cost Efficient – Working within Industry Benchmarks	N
Sustainably Cost Efficient – Delivering Profitable Growth	N
Sustainably Cost Efficient – Environmentally and Socially Responsible	N

Option 3 would not align with our objectives of *Delivering for Customers*. It does remove the risk associated with the HDPE, however the legacy poor condition steel remaining in the system would not address public safety concerns, diminishes reliability as the network continues to deteriorate. More outages and leaks will occur due to the age of existing assets.

It would also negatively impact employee health and safety due to the volume of additional callouts. These can be unsafe, gaseous areas. This would not be consistent with being *A Good Employer*.

This option does not align with our objective to be *Sustainably Cost Efficient* as the project would require replacement teams to conduct additional connection activities when re-connecting the old steel mains back into the newly laid PE. The legacy steel mains will also need replacing in the near future, and MGN would have to excavate and perform replacement works again the same location, frustrating customers and completing two separate replacement projects at more expense. The area would also not be able to accommodate any pressure increase, due to excessive leakage of the steel mains, which would leave the network misaligned with the networks around it, therefore leaving it stranded at a lower pressure.

This option would also draw resources to managing a deteriorating steel network. It is not environmentally or socially responsible given the additional leakages that will occur on the network.

B.1.4 Option 4 – Reactive repair only

Under this option we would only replace the early generation HDPE mains when significant gas leaks occur. This entirely reactive program would likely result in increasing supply outages and leakage as the network reaches the end of its technical life.

Cost assessment

There are no additional upfront capital costs associated if we reactively repair mains only. However, given the current and forecast failure rates, we will progressively incur greater reactive maintenance operational costs as leakage rates escalate.

Over the longer term, the cost of reactive response to mains failure and reactive repair of a new mains would be significantly more costly than replacement as part of a planned program of works. While it is not possible to quantify the reactive costs we would incur at this time, in our experience a project conducted reactively is around 3.2 times more expensive than one conducted proactively. This assumption is consistent with the commonly accepted asset management principle that reactive asset maintenance can be around two to five times higher than proactive planned maintenance.

In addition, MGN would likely incur significant financial penalties due to non-compliance with agreed service levels and regulatory/safety obligations.

Risk assessment

Option 4 would do little or nothing to address the untreated risk associated with these mains. The residual risk would therefore remain intermediate (not ALARP).

Table Appendix 20: Risk assessment – Option 4 HDPE mains

MGN Operational Risk Matrix							
Option 4	**People**	**Supply**	**Environment**	**Reputation**	**Financial**	**Compliance**	**Overall Risk**
Frequency	Remote	Remote	Remote	Remote	Remote	Remote	Intermediate (not ALARP)
Severity	Major	Minor	Trivial	Severe	Minor	Severe	
Risk Level	Intermediate	Negligible	Negligible	Low	Negligible	Low	

Alignment with vision objectives

The following table shows how Option 4 aligns with our vision objectives.

Table Appendix 21: Alignment with vision – Option 4

Vision objective	Alignment
Delivering for Customers – Public Safety	N
Delivering for Customers – Reliability	N
Delivering for Customers – Customer Service	N
A Good Employer – Health and Safety	N
A Good Employer – Employee Engagement	-
A Good Employer – Skills Development	-
Sustainably Cost Efficient – Working within Industry Benchmarks	N
Sustainably Cost Efficient – Delivering Profitable Growth	N
Sustainably Cost Efficient – Environmentally and Socially Responsible	N

Option 4 would not align with our objectives of *Delivering for Customers*. It does not address public safety concerns, diminishes reliability as the network continues to deteriorate. More outages and leaks will occur due to the age of existing assets.

It would also negatively impact employee health and safety due to the volume of additional callouts. These can be unsafe, gaseous areas. This would not be consistent with being *A Good Employer*.

This option would draw resources to managing a deteriorating network. It would bring MGN further from industry benchmarks in proactively managing deteriorating assets. It is not environmentally or socially responsible given the additional leakages that will occur on the network. This option does not align with our objective to be *Sustainably Cost Efficient*.

Appendix C [redacted] MP steel mains option analysis

C.1 Options considered

The following options have been identified to address the risk associated with the isolated poor condition steel network in [redacted]. The options considered are:

- Option 1 – Install new PE mains to replace failing mains, rationalise 30km to high pressure, and connect into the surrounding adjacent networks;
- Option 2 – Increase the current network to high pressure, and connect into the surrounding adjacent networks; or
- Option 3 – Do nothing, and reclassify the network to medium pressure.

These options are discussed in the following sections.

C.1.1 Option 1 - Complete the preferred program

This is the option outlined in the main body of this document. It will see all 20.9 km of poor condition MP steel replaced with new PE, as well as 2.4 km of early generation HDPE interspersed in the network.

Cost assessment

The capital cost of this option is $12.97 million. The program will be delivered in two stages, in 2023 and 2024 as shown in the table below.

Table Appendix 22: Cost assessment – Option 1 [redacted], $'000 real 2021

Project	Year	63P10 Main Renewal ($000)	Upgradable mains (MP-HP) ($000)	125P10 Grid Main Laying ($ 000)	Total ($ 000)
[redacted]	2023	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	2024	[redacted]	[redacted]	[redacted]	[redacted]
Total		**8,633**	**632.3**	**3,709**	**12,974**

Risk assessment

The risk event is that a steel main in the [redacted] area loses containment and leads to a build-up of gas, which ignites and has the potential for life threatening injuries or fatality. With the haphazard mixture of protected and unprotected steel in the [redacted] network and many of the fittings and service connections being unknown, combined with the knowledge that corrosion is now occurring due to ineffective cathodic protection, we consider this has become a credible risk that must be addressed proactively. The following table shows the untreated risk.

Table Appendix 23: Risk assessment – Untreated risk, [redacted]

MGN Operational Risk Matrix							
Untreated risk	People	Supply	Environment	Reputation	Financial	Compliance	Overall Risk
Frequency	Remote	Remote	Remote	Remote	Remote	Remote	Intermediate (not ALARP)
Severity	Major	Minor	Trivial	Severe	Minor	Severe	
Risk Level	Intermediate	Negligible	Negligible	Low	Negligible	Low	

Undertaking the works in Option 1 reduces the risk to low, as all the high risk MP steel in [redacted] will have been removed from the network.

Table Appendix 24: Risk assessment – Option 1 [redacted]

MGN Operational Risk Matrix							
Option 1	People	Supply	Environment	Reputation	Financial	Compliance	Overall Risk
Frequency	Hypothetical	Hypothetical	Hypothetical	Hypothetical	Hypothetical	Hypothetical	Low
Severity	Major	Minor	Trivial	Severe	Minor	Severe	
Risk Level	Low	Negligible	Negligible	Negligible	Negligible	Negligible	

Alignment with vision objectives

The following table shows how Option 1 aligns with our vision objectives.

Table Appendix 25: Alignment with vision – Option 1 [redacted]

Vision objective	Alignment
Delivering for Customers – Public Safety	Y
Delivering for Customers – Reliability	Y
Delivering for Customers – Customer Service	Y
A Good Employer – Health and Safety	Y
A Good Employer – Employee Engagement	-
A Good Employer – Skills Development	-
Sustainably Cost Efficient – Working within Industry Benchmarks	Y
Sustainably Cost Efficient – Delivering Profitable Growth	Y
Sustainably Cost Efficient – Environmentally and Socially Responsible	Y

Option 1 would align with our objectives of *Delivering for Customers*, as it would reduce the risk associated with the poorest condition of steel on the network. It improves the reliability of the network by increasing network pressure and connecting into the surrounding networks, making it less susceptible to outages.

The program reduces the frequency of gas leaks and the incidents. This improves conditions for service providers, consistent with being *A Good Employer*.

The program meets industry benchmarks. Prudent asset managers remove their highest risk assets and strive to standardise their network pressure to facilitate interconnectedness and security of supply resilience. This is environmentally and socially responsible, reducing the amount of gas emitted to the environment. This aligns with our objective to be *Sustainably Cost Efficient*.

C.1.2 Option 2 – Increase the current network to high pressure and connect into the surrounding adjacent networks

No mains replacement activities would be undertaken, however we would raise the network pressure above 140kPa and interconnect with the surrounding high pressure networks which typically operate around 300 kPa. This would standardise the area to high pressure and remove the need to continue operating the poor condition regulator set.

Increasing pressure has been attempted in the past, however, it resulted in multiple gas escapes across the steel sections due to their poor condition and unknown jointing techniques. This highlighted the poor condition of the network. Leaks already exist but are currently at a manageable level. However, leaks will escalate over time, even more so if the pressure is increased.

Cost assessment

As this network is already technically classified as a HP network, costs associated with this option of boosting network pressures would be negligible. However, increased gas leakage and uncontrolled escapes will result in escalating reactive maintenance and ultimately reactive mains replacement, which would cost significantly more than planned works.

Risk assessment

Due to the increasing number and significance of the gas escapes this option would increase the risk above the current untreated risk. In particular, the likelihood/frequency of safety incidents would increase, giving rise to a high overall risk.

Table Appendix 26: Risk assessment – Option 2, [redacted]

MGN Operational Risk Matrix							
Option 2	People	Supply	Environment	Reputation	Financial	Compliance	Overall Risk
Frequency	Occasional	Occasional	Occasional	Occasional	Occasional	Occasional	High
Severity	Major	Minor	Trivial	Severe	Minor	Severe	
Risk Level	High	Low	Low	Intermediate	Low	Intermediate	

Alignment with vision objectives

The following table shows how Option 2 aligns with our vision objectives.

Table Appendix 27: Alignment with vision – Option 2 [redacted]

Vision objective	Alignment
Delivering for Customers – Public Safety	N
Delivering for Customers – Reliability	N
Delivering for Customers – Customer Service	N
A Good Employer – Health and Safety	N
A Good Employer – Employee Engagement	-
A Good Employer – Skills Development	-
Sustainably Cost Efficient – Working within Industry Benchmarks	N
Sustainably Cost Efficient – Delivering Profitable Growth	N
Sustainably Cost Efficient – Environmentally and Socially Responsible	N

Option 2 would not align with our objectives of *Delivering for Customers*. It does not address public safety concerns as it would result in more outages and leaks to occur on the network.

It would also negatively impact employee health and safety due to the volume of additional callouts. These can be unsafe, gaseous areas. This would not be consistent with being *A Good Employer*.

Although this option would standardise the interconnectedness of the network and rationalise the area to high pressure, the additional security of supply by having multiple network feeds into the area would be negated by the increasing safety risks and maintenance disruptions caused by excessive gas leaks.

It is not environmentally or socially responsible given the additional leakages that will occur on the network. This option does not align with our objective to be *Sustainably Cost Efficient*.

C.1.3 Option 3 – Do nothing and reclassify the network to medium pressure

This option involves maintaining the [redacted] single fed isolated network(s) in its current state, and reclassifying to an MAOP of 140 kPa.

Note that the cathodic protection systems have already proved ineffective and the network would continue to progressively deteriorate. The pressure would not allow for network growth and security of supply would continue to be substandard.

Cost assessment

Maintaining the network as is will not incur any capital costs. However the flow on effect of this option will lead to increased operational costs associated with leaks and escapes. It will also continue to incur maintenance costs associated with supply regulators supplying the network. It could also potentially lead to an increase of reactive maintenance work in this area.

Risk assessment

Option 3 would not address the untreated risk. The overall risk rating would therefore remain intermediate and not ALARP.

Table Appendix 28: Risk assessment – Untreated risk, [redacted]

MGN Operational Risk Matrix							
Untreated risk	**People**	**Supply**	**Environment**	**Reputation**	**Financial**	**Compliance**	**Overall Risk**
Frequency	Remote	Remote	Remote	Remote	Remote	Remote	Intermediate (not ALARP)
Severity	Major	Minor	Trivial	Severe	Minor	Severe	
Risk Level	Intermediate	Negligible	Negligible	Low	Negligible	Low	

Alignment with vision objectives

The following table shows how Option 3 aligns with our vision objectives.

Table Appendix 29: Alignment with vision – Option 3

Vision objective	Alignment
Delivering for Customers – Public Safety	N
Delivering for Customers – Reliability	N
Delivering for Customers – Customer Service	N
A Good Employer – Health and Safety	N
A Good Employer – Employee Engagement	-
A Good Employer – Skills Development	-
Sustainably Cost Efficient – Working within Industry Benchmarks	N
Sustainably Cost Efficient – Delivering Profitable Growth	N
Sustainably Cost Efficient – Environmentally and Socially Responsible	N

Option 3 would not align with our objectives of *Delivering for Customers*. It does not address public safety concerns, diminishes reliability as the network continues to deteriorate. More outages and leaks will occur due to the age of existing assets.

It would also negatively impact employee health and safety due to the volume of additional callouts. These can be unsafe, gaseous areas. This would not be consistent with being *A Good Employer*.

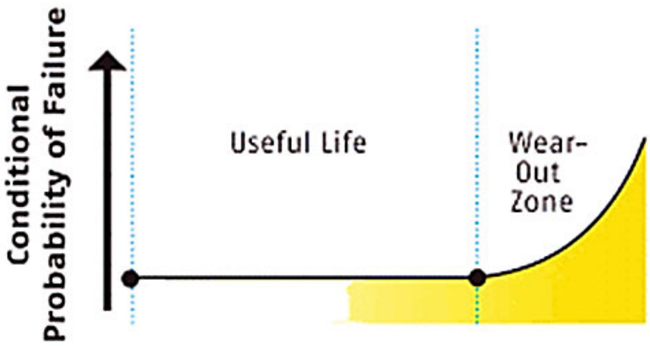
This option would draw resources to managing a deteriorating network(s), which are both sole supplied by ageing regulator sets. Having a single feed into a network is not good industry practice, especially when the surrounding networks are high pressure and the area can be standardised. It would bring MGN further from industry benchmarks in proactively managing deteriorating assets.

Option 3 is not environmentally or socially responsible given the additional leakages that will occur on the network. This option does not align with our objective to be *Sustainably Cost Efficient*.

Appendix D Technical life model

The Technical Life Model assigns a life to all distribution mains segments currently within the gas distribution network. The lives for each material group are based on a 'likely' expected or useful life and is typified by conditional probability of failure profile as shown in the figure below.

Conditional probability of failure

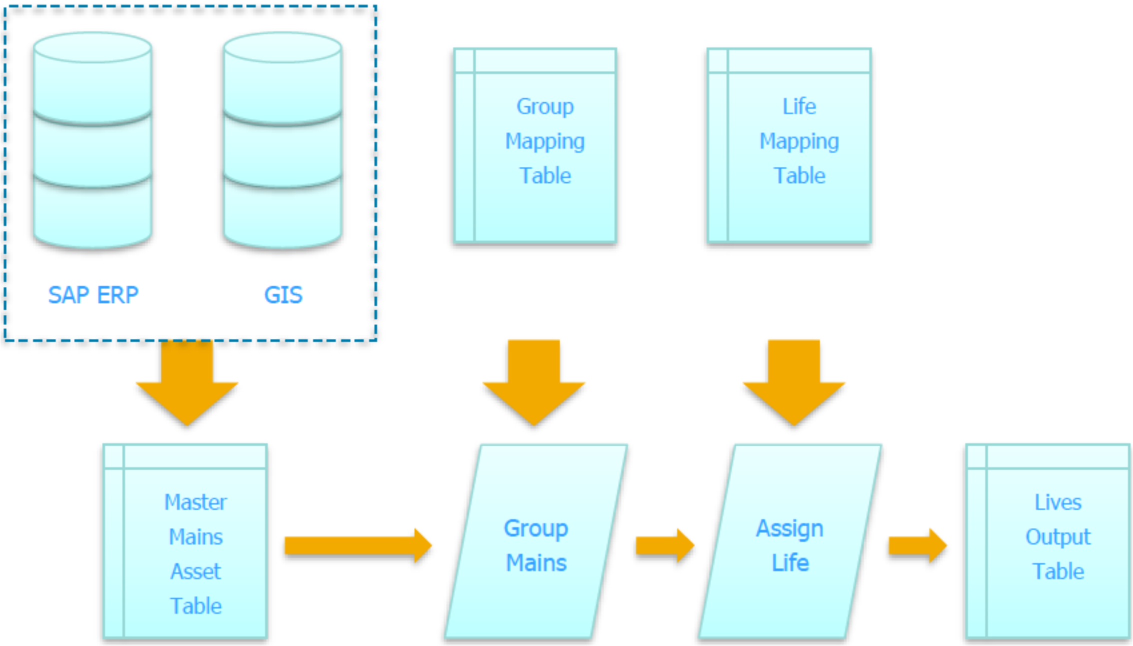


For the purposes of modelling, a simplistic approach of a likely life is taken rather than a pessimistic/optimistic life analysis. Where the main segment is deemed based on the life assigned to have already failed it will be categorised as 'early failure'.

D.1 Methodology

The model takes master mains asset data including pressure, material code, diameter, length and installation year from the SAP ERP and the GIS system to produce a master main asset table. This data is then processed to apply a material grouping based on existing material type. The final process is to apply the technical life based on material group, utilising diameter and date installed for particular materials such as cast iron and protected steel. The final output table is a combination of the technical life and the master main asset table for each mains segment. This process is depicted in the figure below.

Technical life model flow chart



Mains data is extract from SAP ERP and GIS. The following table shows an example of a mains data record.

Table Appendix 30: Example mains record

Equipment No.	Pressure	Material code	Diameter (mm)	Length (m)	Installation Year
26000001	LP	C2	100	105	1953

To assign technical lives, distribution mains are mapped into six groups. The grouping matches mains asset data with extended factors such as material code, jointing type and protection type (both cathodic and coating). Grouping is based around the material code that is assigned to each main.

Table Appendix 31: Example Mains Record Grouping

Equipment No.	Group	Pressure	Material code	Diameter (mm)	Length (m)
26000001	CI-LJ	LP	C2	100	105

The 'failed year' is determined by the addition of the 'installation year' and the assigned 'technical life'. In the example below, the technical life for a cast iron lead jointed main of diameter 100 mm is 75 years. This provides a failed year of 2028 (1953+75).

Table Appendix 32: Example mains life output record

Equipment No.	Group	Pressure	Material code	Diameter (mm)	Length (m)	Installation Year	Technical life	Failed year
26000001	CI-LJ	LP	C2	100	105	1953	75	2028

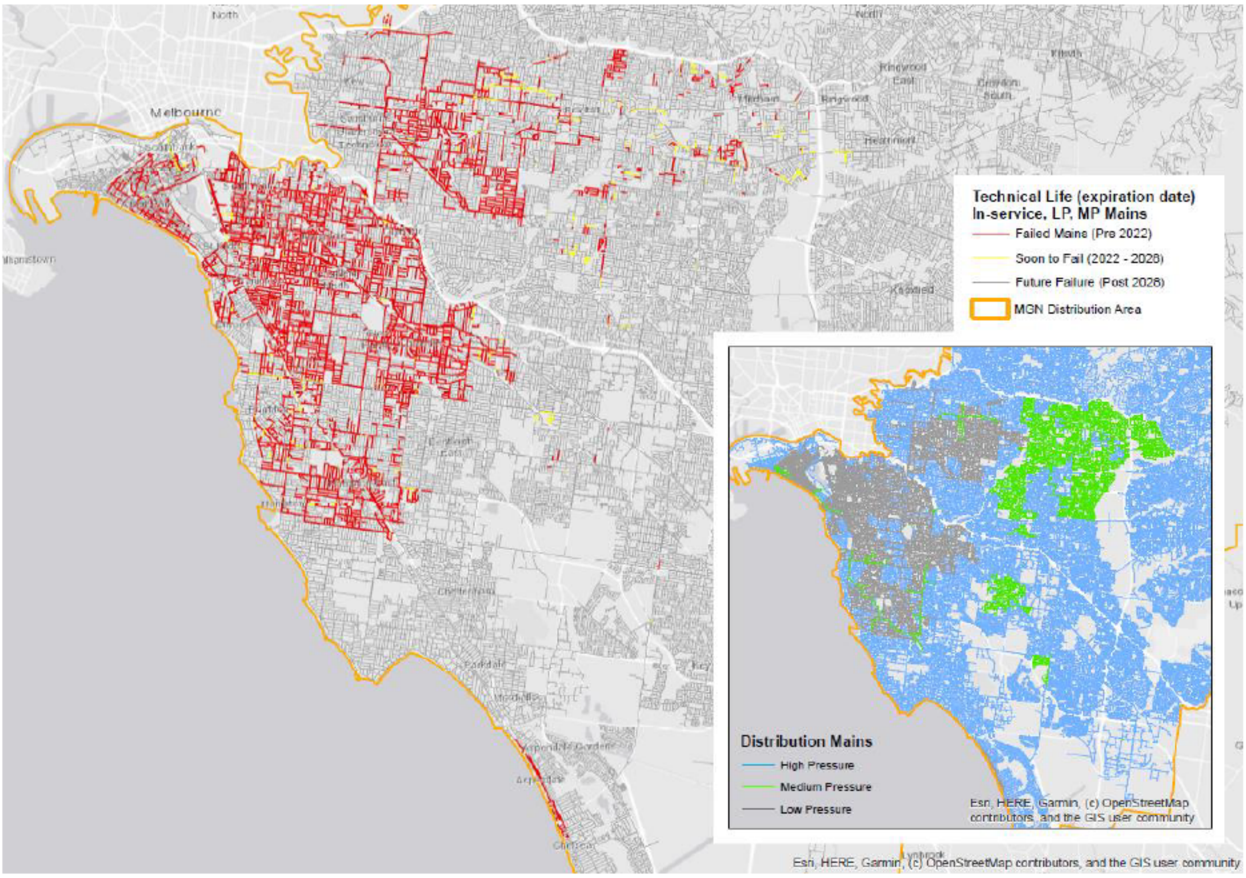
D.2 Technical life of assets

The map below, provides an overview of the categorised failed mains based on technical life for the entire MGN Gas Distribution Network. Mains have been categorised into one of three groups:

- Failed (red);
- Soon to fail (yellow); and
- Future failure (grey) ,

These categories are derived from a main's listed date of technical failure. Failed mains include in-service mains where the date of technical failure was prior to 2022 and has subsequently already passed. Soon to fail mains are forecast to fail during the period covered by this strategy (2022 – 2028). Mains categorised as future failures have a technical failure date post 2028. Comparing the technical life visualization with the inset map (distribution of all mains), there is a correlation in location between the concentration of failed and soon to fail mains, with the location of the LP and MP networks.

Map of mains categorised by their end of technical life date



The following table provides the technical lives for each material group including an asset group description, wall thickness range, coating type, diameter range and reference.

Table Appendix 33: Technical lives

Asset Group	Wall Thickness/Coating	Diameter Range	Technical Life	Reference
Cast iron main lead joint	Thin	0-225 mm	75	GHD
	Medium	250 -300 mm	100	GHD
	Thick	375-900 mm	120	GHD
Cast iron main mechanical joint	Thin	0-225 mm	50	GHD
	Medium	250-300 mm	70	GHD
	Thick	375-900 mm	80	GHD
Unprotected steel			60	GHD
Protected steel – Pre 1930	Pre' 1930 Aspb/Bit		100	D. J. Bartlett
Protected Steel – 1930 to 1949	Coal Tar		110	
Protected Steel – 1950 to 1969	Coal Tar Enamel		110	
Protected Steel – 1970 to 1979	Coal Tar Enamel		120	
Protected Steel – 1980	Extr. PE		140	
PVC			60	GHD
PE			60	GHD

Appendix E Material type classification

E.1 General

The following pipe material detail is provided in addition to the information already provided in the asset overview and specific program sections.

The range of pipe types and operational pressures reflect the growth of the gas industry in Victoria from the late 1800s with several independent utilities distributing coal gas, through the formation of the Gas and Fuel Corporation until the mid-1960s and introduction of natural gas in the late 1960s. The current environment with three distribution companies resulted from dis-aggregation of the Gas and Fuel Corporation. The improvements in pipe technology and pipe materials are also reflected in the diverse range of assets in the network.

The distribution networks, operated by the independent gas companies, some from the 1890s, consisted mainly of low pressure cast iron mains till the late 1940s to early 1950s. The installation of medium pressure and high pressure coated steel mains commenced only in the 1950s. The plastic mains, polyethylene for high pressure mains and PVC for repairs to low pressure CI lines, commenced in the mid 1970s.

The cast iron mains originally laid by the pioneering companies were lead/hemp jointed. In the 1950s to 1960s the lead/hemp joint was superseded by the mechanical compression joints with rubber seals. These lines were operated at <7 kPa as the joints were not capable of sustaining higher pressures.

The lead/hemp joint integrity deteriorated further with the introduction of natural gas in the late 1960's as the moisture free natural gas dried out the hemp, reducing the sealing properties. Repair to the cast iron lines in the post 1970 period was through size for size replacement by PVC pipe. While PVC pipe jointing was by solvent-cement adhesive bonding, cast iron to PVC transition was via mechanical/O-ring compression fittings. Extension of the cast iron network was also mainly through PVC pipe.

The high pressure mains laid since the 1950s have traditionally been steel pipe, coated for corrosion protection. Coal tar enamels, in the form of wrappings reinforced with glass fibre, were the first form of coatings used. Plasticised coal tar was an improvement introduced in the 1960s. Coal tar enamels were superseded altogether by polyethylene coatings in the mid-1970s.

Apart from coatings, a program for elimination of stray current instituted in the early 1970s and cathodic protection, introduced in the mid 1970s, had a significant effect on arresting corrosion of steel mains.

Since the early 1970s polyethylene (PE) pipe has been used as mains for sizes 50 mm and below. They effectively replaced the use of coated steel in those sizes. These pipes were made from PE 63 resin until 1997 and from polyethylene 80 resin since 1998. In 1990, the use of polyethylene pipes (made from PE 80 resin) for sizes 100 mm and above commenced on a trial basis, and since 1997 both coated steel and polyethylene has been used for distribution mains for sizes 100 mm and above, the choice of pipe dependant on the risk assessment and financial considerations.

As PE is, and has been for the past 10 to 20 years, the preferred material for most distribution mains (63 mm and below), the growth in the gas distribution network in metropolitan Melbourne has been largely through polyethylene pipe. However as MGN inherited much of the older parts of Melbourne, where most of the cast iron pipes and other pipes that have been in service for over 50 years, most of the older pipes in Victoria are within the MGN boundary limits.

E.2 Classification of mains

Pipe type	Typical service pressure	Approximate period of installation	Method of jointing pipe lengths
Cast Iron-Lead joint	LP[26]	1890 to 1950	Socket-Spigot + lead / hemp
Cast Iron-Mechanical Jointed	LP	1945 – 1975	Socket-spigot +0-Ring / mechanical
Coated Steel-Screwed Joint	MP	1950 to 1980	Mechanical / screw
Coated Steel-Welded Joint	MP and HP	1950 to present	Oxy-acetylene + arc welding
Bare steel, GAS. Iron-Screwed Joint	LP and MP	1945 to 1965	Mechanical / screw
Poly Vinyl Chloride	LP	1970 to 1997	Socket-spigot + solv. cement
Polyethylene SDR 9.9/SDR 11	LP/MP and HP	1975 to present	Fusion welding[27]
Polyethylene (pre 1980) CI.250/CI 500	LP/MP and HP	1975 to 1980	Fusion welding

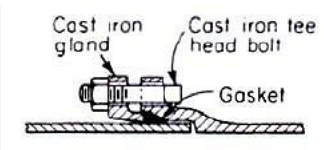
E.2.1 Cast iron

Cast irons generally contain more than 2% carbon. The corrosion resistance of ordinary grades of cast iron is similar to that of mild steel in the same environment.

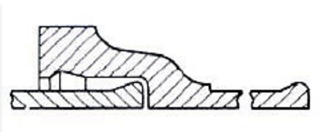
Buried grey-cast-iron gas pipes can be subject to a number of mechanisms of deterioration, including for example, "carbonisation" or "graphitisation", pitting- corrosion eventuating in perforation, stray-current passage, attack by the metabolites of sulphate-reducing bacteria, and joint-deterioration due to relative movement of spigot and socket leading to gas-leakage and the attack of the joint sealing-surfaces, or to degradation of the hemp of the earlier hemp-lead joint seals. Different ground environments or conditions may predispose the cast iron pipe to one or more of these mechanisms consecutively or even concurrently.

Cast iron is broken into two types, that which is lead jointed and that which is mechanical jointed as shown in the following figure.

Cast iron joint types



Typical Mechanical joint



Typical bell-and-spigot joint

E.2.2 Ductile iron

[26] Used also at the lower end of the MP operating range.
[27] Also used in coils>100m, reducing the need for jointing.

Ductile iron as the name suggests has improved ductility over that of cast iron pipe. This pipe has similarities with that of cast iron in relation to failure mechanisms.

E.2.3 Wrought iron

Wrought iron has lower carbon content than that of cast iron. his allows wrought iron to be welded, but with some difficulty. This is not possible with cast or ductile iron. Unprotected wrought iron is also more susceptible to corrosion than that of cast iron. Wrought iron mains that currently exist in the network are galvanised externally but not protected internally. This has produced maintenance issues in the past with dust in the mains. Residual corrosion deposits from coal gas days or corrosion caused by water in pipes eventually turns to dust, which invariable block the service regulator filters. This maintenance becomes expensive in domestic situations where large numbers of regulators require ongoing repair or replacement.

Wrought Iron is classed similarly to that of Unprotected Steel.

E.2.4 Asbestos / Fibro Cement

According the information provided by the GIS, there are no longer any asbestos cement mains within the MGN natural gas distribution network.

E.2.5 Poly Vinyl Chloride

Poly Vinyl Chloride (PVC) was used extensively from 1970 to 1997 in the replacement of cast iron mains in like-for-like replacements. PVC is only rated for operation at low pressure in the MGN network but is used at high pressures in other gas distribution networks. PVC is joined by the use of glue and therefore is susceptible to joint failure which, gives rise to leaks and allows water to ingress into the network. Some of the benefits of PVC are the low cost relative to steel and polyethylene, it does not corrode and its resistance to impact.

Due to the policy of laying mains to high pressure standard the usage of PVC is now minimal. PVC is now replaced at an earlier age than might be normally required due to augmentation requirements when replacing cast iron mains in the vicinity.

E.2.6 Polyethylene

PE mains since their introduction in the 1970s now accounts for a large proportion of the total distribution mains in the network. 50mm imperial and 63mm metric polyethylene is used in at least 90% of all mains extension and replacement work. It can operate at high pressure and is not susceptible to corrosion. Joining techniques are either mechanical (compression) or fusion with fusion making up the majority and mechanical used only for repairs and joining dissimilar material types (ie steel, cast iron, PVC). PE is available in a large range of sizes. The largest size used in the distribution network is 250 mm.

Some of the advantages of polyethylene are its ability to come in coils, its high operating pressure, low cost of installation, manual handling due to its light weight material and squeeze-off capabilities. Disadvantages are it requires a bedding material when laid to restrict point loading and requires a location based risk assessment for large diameter before construction. This risk assessment determines if polyethylene can be used and if that is the case what protection if any is required.

Due to the variance in polyethylene over the last 30 years it should be explained what different types of mains exist and how they could affect the operation of the network. The following is a summary of the type of mains used in polyethylene up to the present time.

PE Up to 63mm NB (Small diameter PE)

- 1970 to 1997 – these mains were manufactured from a PE63 high density polymer. They were operated at low, medium, and high pressure depending on the class rating. The class rating changed from 200 kPa to 250 kPa and from 450 kPa to 575 kPa in the late 1970's (1977) following a change in the safety factor used to calculate the MAOP (Maximum Allowable Operating Pressure). Butt, socket and saddle fusion made up the majority of joining techniques. Heating plates were operated at 270ºC. Issues with these types of mains are they tend to become brittle over time and leaks from prior squeeze-offs are a common occurrence.

- 1997 to 2014 – 1997 saw the phasing out of high density polyethylene which required these mains to be manufactured from a medium density PE80 polymer. The class ratings remained the same as the safety factor was increased. Class 250 pipe or what is now known as SDR 17.6 pipe was also phased out with only exception a 32S (32mm NB) pipe which came in a coil. The joining of high and medium density mains was of major concern. This saw numerous tests carried out with the outcome that welding temperatures were changed from 270ºC to 210ºC.
- 2014 to Present – This period saw PE80 phased out and the introduction of PE100. The most common main now laid in the distribution network is a series 2, 63mm, medium density, PE100, SDR 11, polyethylene main.

110mm and greater (Large Diameter Polyethylene)

- 1970 – This saw two trials conducted with 3" and 4" PE mains. These mains were manufactured from a high density PE63 (50), SDR 17.6, manually butt fused in coils. Issues such as joint pull-out and pipe alignment saw to it that these types of mains where never used in the network. The trials mains may still exist in the network.
- 1993 to 1994 – This saw the re-emergence of LDPE mains. These mains were now manufactured in a medium density PE80 polymer. Mains were laid in SDR17.6 at low and medium pressures. The pressure rating of some mains was restricted due to the installation of John Valves. Trials also began in with LDPE Mains in SDR 11 at high pressure. This was restricted to 110 mm and 160 mm mains.
- 1995 to 2014 – This period saw the phasing out of SDR 17.6 mains with only the 250 mm low pressure mains still used in small quantities. Two additional sizes were introduced, 125mm and 180mm. These mains compare nearly equally with that of 4" and 6" steel. 160 mm PE mains have been totally replaced with 180 mm while 110 mm and 125 mm are still both used.
- 2014 to Present – Similar to small diameter polyethylene, PE100 was introduced into the large diameter series of pipes in 2014.

Maintenance issues

Most of the maintenance performed on polyethylene occurs from third party damage. Escapes are rectified depending on the leak by squashing-off and replacing the section. This has been the standard practice since the commencement of PE mains. There are now issues arising with escapes that are generated using the squash-off jacks after a period. This is a direct result of over- squeezing the main and up until recently there was no requirement for limit-stops on the equipment. From further research and the analysis of escapes from over- squeezing, limit-stops have been shown to dramatically decrease the chance of a leak generating from a pipe squeeze. As part of the maintenance of polyethylene mains, all squeeze-off equipment are now fitted with limiting stops.

E.2.7 Unprotected Steel (Galvanised Iron)

This piping system is based on bare steel and galvanised iron pipes that have been joined by having threads cut into the ends and screwed into joining couplings. It is considered that the galvanising will be of considerably reduced effectiveness in reducing corrosion when buried. This form of piping system is susceptible to corrosion from its environment especially at the threaded joints where the pipe cross-section will have been reduced by thread cutting.

The life of this type of piping system is governed very much by the corrosive effects of the surrounding soil. Pitting corrosion will be the predominant mode of deterioration for these pipes. The galvanised pipe will not behave very different to uncoated pipe, as the galvanising would dissolve within 5 to 10 years exposing the bare metal to pitting corrosion. Bare or galvanised steel pipe is therefore regarded as having a relatively short life.

E.2.8 Protected steel

Coated steel in both screwed and welded are dependent on the corrosion protection coating. The coatings are regarded as having an effectively indefinite life. The main cause of degradation of the pipe coating is third party damage. The effective life of this piping system is determined by the faults in the corrosion protection coating. The coatings that have been used have very long effective lives (~100 years). However it is recognised that pin hole defects will be unavoidable in any type of coating. The cathodic protection of the pipe will effectively prevent corrosion through the pinholes. Therefore any deterioration of coated steel pipe will occur only in the absence of cathodic protection, through perforations or damaged sections of the coating.

Screwed joints are seen as a vulnerable part of the system in that the pipe wall has been reduced by the threading operation and the corrosion protection depends on field-applied corrosion protection coating at the joints. On the assumption that there is the potential for leaks at the joins the effective life of screwed jointed pipe has been slightly reduced.

Glossary and definitions

The table below is a comprehensive list of asset management terminology and acronyms commonly used at AGIG. Note not all these terms may appear in this document.

Term	Meaning
AA	Access arrangement
ACIF	Australian Construction Industry Forum
AEMO	Australian Energy Market Operator: Responsible for the administration and operation of the wholesale national electricity market in accordance with the National Electricity Code.
AER	Australian Energy Regulator: Responsible for the economic regulation of energy networks.
AGIG	Australian Gas Infrastructure Group
AGN	Australian Gas Networks
AHC	Australian Hydrogen Centre
ALARP	As low as reasonably practicable
AMP	Asset Management Plan
AMS	Asset Management Strategy
ARS	Ancillary Reference Service - Standard services offered by Multinet Gas at fixed charges
AS/NZ	Australian/New Zealand Standards
AUS EX	Australian Program for the Certification of Equipment for Explosive Atmospheres
Available testing	Testing of a non-faulty meter returned from the field less than 10 years old from purchase or repair tested in a meter testing facility before being re-installed in the field to complete its in-service life.
Capex	Capital expenditure
Cathodic protection	Prevention of corrosion by application of direct electric current to the surface of a metal.
Cathodic protection unit (CPU)	A device providing cathodic protection current, powered from an external energy source. Such energy sources include mains power, solar, etc. Cathodic protection units require permits and registration in accord with the Electricity Safety (Cathodic Protection) Regulations 2009
Cathodically protected (Distribution) area	An electrically isolated area within the distribution system, of size convenient and practicable for assessing and maintaining the effectiveness of corrosion protection

Term	Meaning
CI	Cast iron
Coating quality survey	A survey conducted by traversing directly above a coated main along its length using equipment and techniques designed to identify any defects in the coating. Methods in common use include "Pearson" and Direct Current Voltage Gradient (DCVG)
Coil (Electromagnetic coil) Survey	An electromagnetic tracing technique for locating points of failed insulation or electrical contact to other metallic structures.
Corrosion	The deterioration of metal caused by its electrochemical reaction with its environment
CP	Cathodic Protection
CPU	Cathodic Protection Units
CTM	Custody Transfer Meter. A large capacity meter installed at every injection point from the DTS to MGN's network.
Current AA period	Jan 2018 to June 2023
Data logger	Interval metering equipment that counts pulses from the mechanical meter index and records gas volume.
Direct Current Voltage Gradient (DCVG) Survey	A type of coating quality assessment survey conducted by traversing above the pipeline using equipment that applies pulsating DC electrical signals to identify coating defects.
Drainage Bond	An electrical connection via cable from a point in the distribution system to tram or train substations to prevent adverse effects from stray currents. These installations include equipment to control the direction and magnitude of current flowing.
DTS	Declared Transmission System
EDMI	Meter manufacture and supplier to MGN
EFT	Economic Feasibility Test
Electrical isolation	The electrical separation of structures to be protected from other structures and/or electrical systems. This is achieved by the installation of insulating flanges, monolithic insulating joints and insulating couplings
ESV	Energy Safe Victoria. A government body responsible for the safety and technical regulation of energy networks in Victoria.
FIRB	Foreign Investment Review Board
FLE	Field Life Extension. Alternative name for Sample Testing Program/in-service compliance testing of diaphragm meters <30m3/hr.

Term	Meaning
Flow corrector	Interval metering equipment which can correct gas flow to energy with the help of live pressure and temperature values.
FY	Financial year
Galvanic (Sacrificial) anode	A block of metal which provides protection by preferentially sacrificing itself instead of allowing the steel to corrode.
Gas meter	Mechanical device (usually) used to measure the volumetric flow rate of gas that passes the device. The volume of energy that passes through the meter is dependent on both gas pressure and temperature when the volume is measured
GDSC	Gas Distribution System Code
GFC	Gas and Fuel Corporation
GFCV	The Gas and Fuel Corporation of Victoria
GIS	Geographic Information System
GJ	Giga Joule, 1 Giga Joule = 1,000,000 Joules
GPC	Group Pressure Control
GPRS	General Packet Radio Services
GSC	Gas Safety Case
GSM	Global System for Mobile Communications
HDPE	High density polyethylene
HP	High pressure (140 to 515 kPa)
HP2	High pressure 2 (600 to 1050 kPa)
I&C	Industrial and Commercial
IEC EX	International Electrotechnical Commission System for certification to Standards Relating to Equipment for Use in Explosive Atmospheres
ILI	In line inspection
Interval meter site	Installation which is large enough (with respect to gas usage) to warrant the use of hourly metering data via a data logger of flow corrector.
IO	Input output
kPa	KiloPascals

Term	Meaning
L&G	Landis & Gyr – Meter manufacture and supplier to MGN
Large meter	Meter with capacity greater than >10 sm^3/hr.
LP	Low pressure (1.4 to 7 kPa)
MAOP	Maximum allowable operating pressure
Meter family	A group of the same meter brand and type installed in the same calendar year.
Meter type	Refers to the technique employed to measure gas flow i.e. Rotary, Turbine, Diaphragm.
MG	Multinet Gas
MGN	Multinet Gas Networks
MHQ	Maximum Hourly Quantity
MIBB	Market Information Bulletin Board
MP	Medium pressure (35 to 210 kPa)
MPE	Maximum Permissible Error
NATA	National Association of Testing Authorities
NCC	Network Control Centre
Next AA period	July 2028 to June 2028
NGL	National Gas Law
NGR	National Gas Rules
NMI	National Measurement Institute
Non-reference Service	Non-standard services offered by MGN provided at fair and reasonable cost.
OEM	Original Equipment Manufacturer
OMSA	Operational and Management Services Agreement between MGN and Service Provider
Opex	Operating expenditure
PE	Polyethylene
PIG	Pipeline Inspection Gauge
PMC	Periodic meter change

Term	Meaning
PVC	Poly vinyl chloride
RAB	Regulated asset base
RF	Radio Frequency
RTU	Remote Telemetry/Terminal Unit
Sample testing program	Annual program whereby sample meters from each meter family population are tested as per AS/NZS 4944 to determine their on-going or extension to their in-service life in the field
SAP	An Enterprise Resource Planning tool which used recording asset data and maintenance management.
SCADA	Supervisory control and data acquisition
SEPP	State Environment Protection Policy
Shared assets	Shared network assets – for example, Mains in the street
SIOS	SCADA Input Output Schematic
sm^3/hr	Standard cubic meters per hour (either Gas or Air).
Small meter	Meter with capacity less than 10 sm^3/hr. Normally used for Residential (domestic) purposes.
SMS	Safety Management Study
Spot potential reading	A measurement of pipe-to-soil potential taken at a given location at a particular point in time. Such readings can be used to assess protection status where potentials do not vary with time. However, in circumstances where potentials fluctuate due to telluric or stray current influences, recordings of potential over a period of time (usually 24 hours) are necessary
Stray current electrolysis	Is the effect of stray currents on buried metallic structures
Tariff D	Tariff D applies to customers using greater than 10,000 GJ a year or more than 10 GJ MHQ.
Tariff L	Tariff L is open to customers who consume more than 1,000 GJ per annum or less than 10,000 GJ per annum and have an MHQ demand of less than 10 GJ per hour.
Tariff V	Applies to customers using less than 10,000 GJ a year and less than 10 GJ MHQ.
Test point	A conveniently located termination point for electrical cables connecting to a buried pipeline. This allows measurement of the pipeline potential, and is the principal method of assessing the effectiveness of corrosion protection. Test points are also required for coating quality surveys and electromagnetic coil surveys to investigate losses in protection
Thyristor drainage unit (TDU)	Electrical equipment, usually installed in tram or train substations, to provide sufficient negative voltage for drainage bonds to be effective. The output voltage of TDUs is normally controlled so as to vary in accord with substation load

Term	Meaning
TJ	Terajoule
TP	Transmission Pressure (Pressure Range: Above 1050 kPa)
UAFG	Unaccounted for gas
UPS	Unprotected steel
Variable conductance drainage bond (VCDB)	Electronic equipment used to control the current in a drainage bond. The output current of VCDBs is normally controlled to maintain a set level of protection on a structure
Victorian Electrolysis Committee (VEC)	The Victorian Electrolysis Committee comprises membership of all parties affected by or causing stray current electrolysis. It is responsible for co-ordination of testing and adjustment required to maintain effective protection from stray currents and to control interference between adjacent cathodic protection systems. It is also responsible for administration of cathodic protection permits and regulations under the authority of Energy Safe Victoria.