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CY2017 - CY2022

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Distribution Mains Strategy

CY2017 – CY2022

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Originated By

Title	Name	Signature	Date
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EXECUTIVE SUMMARY

This document outlines the replacement strategy for Gas Distribution Mains on the Multinet Gas network.

A 30 year Mains Replacement Program was introduced by Multinet Gas in 2003 to address the 'societal risk' posed from failure of cast iron mains and resulting risk of incidents leading to loss of life or significant property damage. The objective is to decommission all cast iron (CI) mains on Multinet's low pressure network by 3033 (i.e. within 30 years).

Multinet Gas remains committed to the 30 year program and through continual review of network performance has extended mains replacement to include other materials and pressures that also pose an unacceptable 'societal risk'.

The following key programs are delivered by Multinet Gas to maintain alignment with the Network Objectives (as detailed in Section 3.1), and compliance with regulatory obligations contained in the Gas Safety Case, Gas Distribution System Code and AS 4645:

- Continuation of the 30 year program for the decommissioning of all low pressure cast iron mains by 2033;
- Targeted replacement of all remaining medium pressure cast iron mains by end 2021; and
- Targeted replacement of earliest 31 kilometres (km) of first generation high density polyethylene (HDPE) mains by end 2022.

The primary drivers for the above mentioned programs are:

- Reduction of public and maintenance personnel risk associated with 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 Un-Accounted for Gas (UAFG).

Table 0-1 provides the financial summary of the capital expenditure which is to be incurred in the calendar year period 2017 to 2022. Table 0-1 includes a breakdown of direct, overheads and cost escalators for the purpose of reconciliation with that of the overview documentations which support our forthcoming Access Arrangement submission (2018-22).

Table 0-1: Summary of Capital Expenditure ($'000)

Ref	Program	2017	2018	2019	2020	2021	2022
4.2	Low Pressure Mains Replacement	$41,120	$45,035	$42,305	$41,969	$42,746	$36,934
4.3	Medium Pressure CI Mains Replacement	-	$7,247	$4,606	$6,275	-	-
4.4	HDPE Polyethylene Replacement	-	-	-	-	$8,652	$7,225
4.5	Reactive Mains Replacement	$200	$200	$200	$200	$200	$200
	Total Direct Expenditure	**$41,320**	**$52,482**	**$47,110**	**$48,444**	**$51,598**	**$44,358**
	Overhead	$2,479	$3,149	$2,827	$2,907	$3,096	$2,662
	Subtotal	**$43,799**	**$55,631**	**$49,937**	**$51,350**	**$54,694**	**$47,020**
	Real cost escalation	-	$328	$263	$382	$593	$583
	Total Expenditure	**$43,799**	**$55,959**	**$50,200**	**$51,732**	**$55,287**	**$47,603**

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1. DOCUMENT OVERVIEW

1.1. Objectives

This document articulates Multinet Gas' approach to the management of its gas distribution mains.

It is one of several asset strategies developed and maintained for the management of Multinet Gas' existing Gas Distribution Network. It has the following objectives:

- The Strategy articulates the key areas of focus in relation to asset management, key risks, key CAPEX programs, costs and service standard outcomes for the asset group;
- It defines the linkages of the asset group to the overarching asset management strategy and underpinning asset management plan; and
- It consolidates the following existing strategy documentation that predate this strategy.
  - MG-SP-0013 Pipeworks Strategy; and
  - MG-SP-0012 Large Diameter Cast Iron Mains Replacement Strategy.

The document is intended for use by:

- Multinet Gas staff (and it's contractors); and
- Regulators – Technical, Safety and Economic.

1.2. Scope

This strategy covers the management of Multinet Gas' existing Gas Distribution Main assets. The focus of this strategy is on all gas distribution gas mains. Assets are located in inner and outer east metropolitan Melbourne, the Yarra Ranges and South Gippsland.

Gas Distribution mains for the purposes of this strategy are those defined as operating from 1.4kPa to less than 1050kPa and shall be defined as having the following pressure ranges[1];

- High Pressure 2 (HP2) – 550 to 1050kPa;
- High Pressure (HP) – 140 to 515kPa;
- Medium Pressure (MP) – 35 to 210kPa; and
- Low Pressure (LP) – 1.4 to 7kPa.

This document defines the strategy to maintain public and personnel safety, integrity and security of supply in relation to Multinet Gas' mains assets through compliance with regulation, technical, safety standards.

This strategy relates only to Multinet Gas' capital requirements in relation to distribution mains and excludes operational expenditure requirements.

The strategy excludes assets:

- Service assets – Refer Distribution Services Strategy (MG-SP-0010)
- Transmission assets – Refer to Transmission Pipelines Strategy (MG-SP-0001)
- Valves assets – Refer to Distribution Valves Strategy (MG-SP-0011)

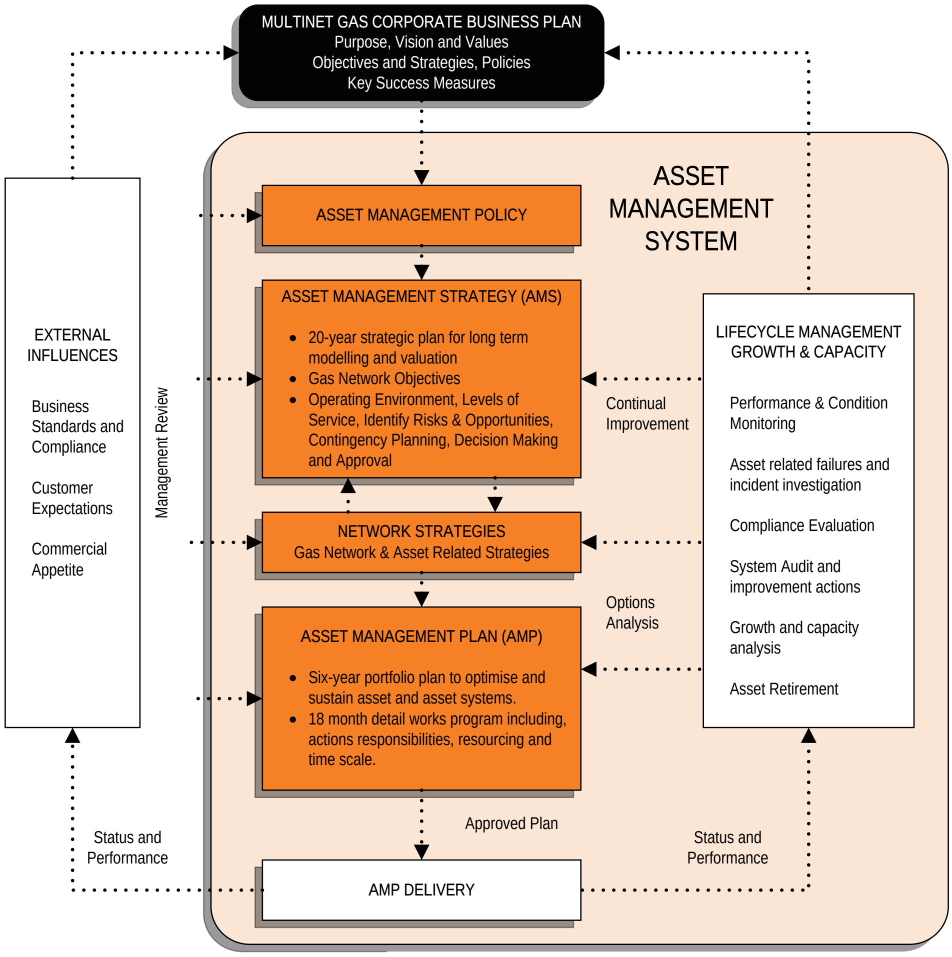
1.3. Relationship with other Key Asset Management Documents

The Distribution Mains Strategy is one of a number of key asset management documents developed and published by Multinet Gas in relation to its gas network. As indicated in Figure 1-1, Detailed Network Strategies - including the

[1] Pressure ranges sourced from Multinet Gas Engineering Standard EP-PL-7600.

Distribution Mains Strategy - informs 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 1-1: Asset Management Framework



1.4. Phasing and Financial Disclosure

All program defined within this strategy are presented in calendar years consistent with the reporting requirements of the Australian Energy Regulator (AER) and where applicable the Gas Distribution System Code (Version 11).

Where required for conversion to financial year (July to June), dollars and volumes can be estimated using a 50:50 expenditure split.

All financial figures quoted within this document - unless otherwise specifically stated - have the following characteristics:

- Real Expenditure / Cost (reference year = 2017);
- Direct Expenditure only (i.e. excludes overheads and finance costs);
- In units of $1,000 (i.e. '000);
- All years are denoted in Calendar Year format.

Total values shown in tables and referred to in the text of this document may not reconcile due to rounding.

Conversion factors used in the escalation of historic expenditure to real 2017 equivalent expenditure is provided in Table 1-1. Cumulative conversion factors have been provided by the Multinet Gas Regulatory Department.

Table 1-1: CPI Conversion Factors

	2012	2013	2014	2015	2016	2017
CPI Index - $2017	1.09619	1.07465	1.05192	1.02819	1.01296	1.00000

1.5. Data Sources

The following data sources and/or systems have been drawn upon in development of the Gas Distribution Mains Strategy:

- SAP: [ERP tool used for data collection, analysis and maintenance management of MG assets];
- GIS Base: [GE Smallworld application used for spatial data representation];
- Spatial: [ESRI ArcMap for spatial analysis];
- BI: [Business Intelligence (BI) platform used for regulatory reporting. Interfaces with SAP];
- 2011 ABS Census Dwelling data;
- COGNOS;
- AER website.

Data anomalies (e.g. missing data, outliers, and unexpected variances) may be encountered upon examination of a data sets and the gathering of statistics and other relevant information for the purposes of analysis. Where encountered and relevant they will be noted within the body of the document.

1.6. References

- AS/NZS 4645 series - Gas Distribution Networks;
- Gas Distribution System Code (Version 11);
- Victorian Natural Gas Transmission and Distribution Businesses - ODRC Asset Valuation Review 1998;
- Advisian Independent Estimates Report – Augmentation and Mains Replacement Projects, 7 November 2016;
- UK HSE report R888;
- Australian Bureau of Meteorology;
- MG-SP-0013 Cathodic Protection Strategy;
- MG-SP-0017 Un-Accounted for Gas Strategy.

1.7. Document Review

This document shall be reviewed every two (2) years or earlier if required. The next review is due on or before 31 December 2018.

2. ASSET OVERVIEW

2.1. Introduction

The Multinet Gas' distribution network encompasses all assets between the outlets of all City Gate supply points (or equivalent), and the outlet of the consumer's meter assemblies. The distribution mains network consists of approximately 9,947[2] kilometres (km) of mains operating at high, medium and low pressures. It also consists of 73 km of mains operating at High Pressure 2[3].

The majority of Multinet's gas distribution system operates at High Pressure (HP) with a minimum allowable pressure of 140kPa to a maximum of 515kPa[4]. Pressures are regulated via major facilities known as 'City Gates' or 'Field Regulators' that are feed from either the Declared Transmission System (DTS), Bass Gas (South Gippsland Towns) or the Multinet Gas' owned High Pressure 2 network.

The Medium Pressure (MP) distribution systems operate between 35kPa to 210kPa, with Field Regulators regulating gas supply typically from the high pressure networks.

The low pressure distribution systems operate up to 7kPa with District Regulators regulating gas supply typically from high and medium pressure networks.

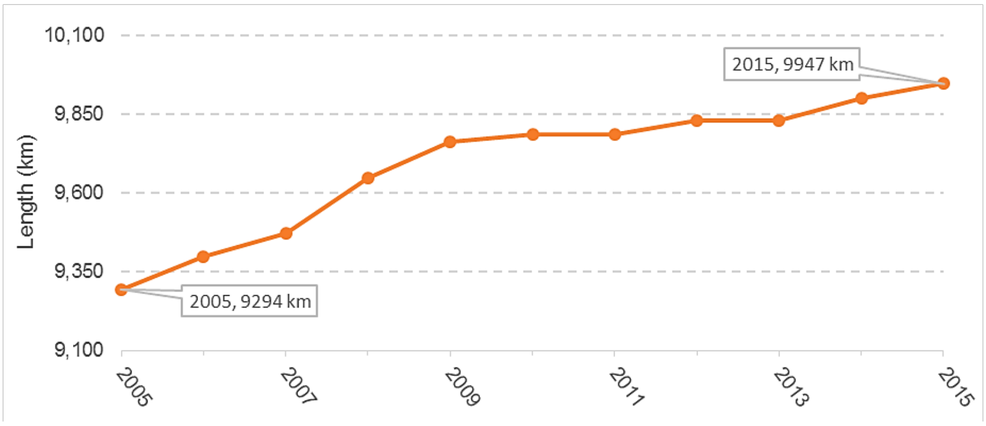
The Multinet Gas' distribution network dates back to the late 1880's and consequently consists of a variety of pipe material which at the time of installation was deemed fit for purpose. Cast iron and steel was predominantly used until the introduction of polyvinyl chloride (PVC) for low pressure like-for-like replacement program and polyethylene for high pressure networks in the 1970's. The use of PVC was phased out in the early 1990's and while coated steel is still utilised polyethylene is the dominant pipe material.

The type of material has a major bearing on the maximum allowable operating pressure (MAOP) of the network. Since cast iron can only be operated at medium[5] and low pressures, the continual replacement of cast iron mains due to its obsolescence with polyethylene pipe means that the capacity and integrity of the network is managed.

2.2. Growth

Multinet Gas' distribution network length[6], as presented in Figure 2-1, has grown at an average rate of 0.8% p.a. over the past 10 years. 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. This trend is predicted to continue as more high pressure mains are laid to service growth areas.

Figure 2-1: Total Network Length 2005-2015



[2] Mains asset data based on Gas Regulatory Report extracted on January 2015.

[3] 73km section of High Pressure 2 network is limited to a maximum operating pressure of 840kPa

[4] Gas Distribution System Code, Version 11, Schedule 2, Part A.

[5] Maximum operating pressure for Multinet Gas Medium Pressure network is 140kPa

[6] Mains length data based on annual Network Based Data report.

2.3. Asset Classification and Profiles

2.3.1. Overview

The gas distribution main age profile encompasses a broad time-span, with some of the older mains dating back to the late 1880's. Cast iron was prominent from the inception of the distribution network up until the late 1960's. Steel (both protected and unprotected) was introduced in the early 1950's with minor amounts of protected steel still used today. PVC and polyethylene made their debut in the early 1970's with PVC usage declining in the early 1990's. Polyethylene is now the prominent material with over 90% of new mains constructed from polyethylene in the last 10 years. Since its introduction in the early 1970's polyethylene polymers continue to develop with the latest generation polymer (PE100) introduced in late 2014. This latest generation exhibits greater strength, toughness, slow crack growth resistance and resistance to rapid crack propagation over that of previous generations.

Table 2-1 details the percentage allocation of gas distribution mains within the Multinet Gas network by operating pressure and material classification.

Table 2-1: Percentage of Distribution Main by Pressure and Material Classification

Pressure Tier	Cast Iron (CI)	Poly Vinyl Chloride (PVC)	Steel Un-Protected (SUP)[7]	Steel Protected (SPR)[7]	Polyethylene (PE)	Total
Low Pressure (LP)[8]	12.41%	6.29%	2.18%	1.17%	0.32%	22.37%
Medium Pressure (MP)	0.37%	0.00%	0.71%	5.06%	2.89%	9.03%
High Pressure (HP)[9]	0.00%	0.00%	0.97%	25.69%	41.19%	67.85%
High Pressure 2 (HP2)[10]	0.00%	0.00%	0.00%	0.76%	0.00%	0.76%
Total	**12.78%**	**6.29%**	**3.86%**	**32.68%**	**44.40%**	**100.0%**

2.3.2. Pressure Classification

The gas distribution network is composed of three main pressure tiers. The pressure tiers are referred to as low, medium, and high with a fourth minority pressure tier known as 'High Pressure 2' (HP2). This pressure tier accounts for less than <1% of the total distribution network.

Table 2-2 details the operating pressure tiers and associated proportion of distribution mains length (in km) on the Multinet Gas network.

Table 2-2: Length of Mains by Pressure Classification

Pressure Tier	Operating Pressure	Length (km)	Percentage (%)
Low Pressure (LP)[8]	1.4 to 7 kPa	2,225	22%
Medium Pressure (MP)	35 to 210 kPa	898	9%
High Pressure (HP)[9]	140 to 515 kPa	6,748	68%
High Pressure 2 (HP2)[10]	550 to 1050 kPa	76	<1%
Total		**9,947**	**100%**

[7] For the purposes of classification, unprotected steel is considered mains which are uncoated and for protected steel mains are considered externally coated.

[8] Low pressure normal operating maximum is 3.5 kPa as per Multinet Gas Engineering Standard EP-PL-7600.

[9] High Pressure 1 has historically been referred to as High Pressure.

[10] High Pressure 2 is provided as a pressure category in the Gas Distribution Code Schedule 1.

2.3.3. Material Classification

The gas distribution network is composed of four material types referred to as cast iron, poly vinyl chloride, polyethylene and steel. Steel is further classified as either unprotected or protected based on either the non-existence or existence of an external protective coating and an active cathodic protection system. Mains material has a major bearing on the maximum allowable operating pressure of the network.

Table 2-3 details the material types and associated proportion of distribution mains length.

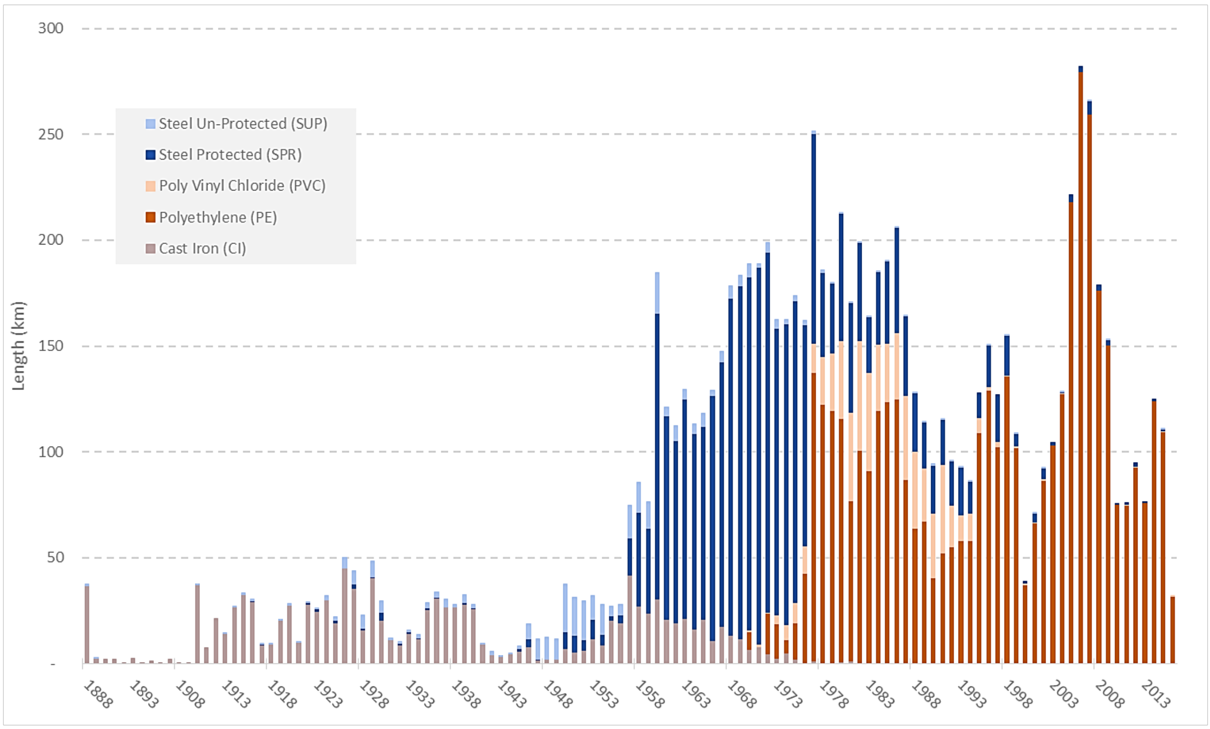
Table 2-3: Length of Mains by Material Classification

Material	Length (km)	Percentage (%)
Cast Iron (CI)	1,271	13%
Poly Vinyl Chloride (PVC)	626	6%
Steel Un-Protected (SUP)	384	4%
Steel Protected (SPR)	3,250	33%
Polyethylene (PE)	4,416	44%
Total	**9,947**	**100%**

2.3.4. Age Profile

Figure 2-2 provides an age profile by mains material type and volume based on year of installation. It provides an overview of when material types were introduced, their period of use and when their usage was phased out. Figure 2-2 shows a gas distribution network spanning 128 years with cast iron mains dating back to the late 1800's. Of note is the age spread of cast iron mains, spanning from 1800's to the early 1970's along with the sporadic use of unprotected steel from the early 1920's to early 1970's.

Figure 2-2: Asset Age Profile by Material Classification



The average age of the Multinet's gas distribution network is 38.1 years. A comparison by pressure provided in Table 2-4 shows the low pressure network on average is the oldest at over 60 years. While a comparison based on material (provided in Table 2-5) shows the cast iron network averages 80 years with the unprotected steel network averages close to 65 years. Both cast iron and unprotected steel feature heavily in the current and forthcoming mains replacement programs.

Table 2-4: Average Age Profile by Pressure

Pressure	Low	Medium	High
Average Age (years)	63.9	43.8	29.2

Table 2-5: Average Age Profile by Material

Material	Cast Iron	Polyethylene	PVC	Protected Steel	Unprotected Steel
Average Age (years)	80.8	20.2	32.3	45.0	64.7

2.3.5. Asset Life Profile

Gas distribution mains display a wear-out characteristic, with the onset of wear-out at the end of the technical life (i.e. useful life). Analysis has been conducted on the gas distribution mains utilising typical asset lives. While technical life does not constitute actual life it does provide an overall snapshot of where assets are placed in their life cycle - from either a pessimistic or optimistic standpoint. A summary of this analysis is presented below (Table 2-6). Granular detail of the model including inputs, outputs and key assumptions are located in Section 5.3.

Table 2-6 shows the total length of mains by pressure that have reached their end of technical life and are therefore classified as a "failed" main. Failures have been grouped as a summation of those occurring pre 2017, annually from 2017 to 2022 and those post 2022. From this analysis the network has 1,062 km of assets that based on technical life are deemed to have reach end of life as of the end on 2017. This information is also shown (by length and pressure) in Figure 2-3.

Table 2-6: Asset Life Summary by Pressure and Length (km)

Pressure	Failures Pre 2017	2017	2018	2019	2020	2021	2022	Failures Post 2022
Low Pressure	1,032.9	25.3	20.3	17.6	17.1	17.8	9.7	964.0
Medium Pressure	28.9	12.1	10.0	10.9	16.0	1.9	5.0	770.0
High Pressure	0.1	-	0.1	0.0	0.0	0.1	-	6,710.6
Total	**1,061.9**	**37.4**	**30.4**	**28.6**	**33.1**	**19.7**	**14.7**	**8,444.6**

Figure 2-3: Asset Life Failure Profile by Pressure Classification

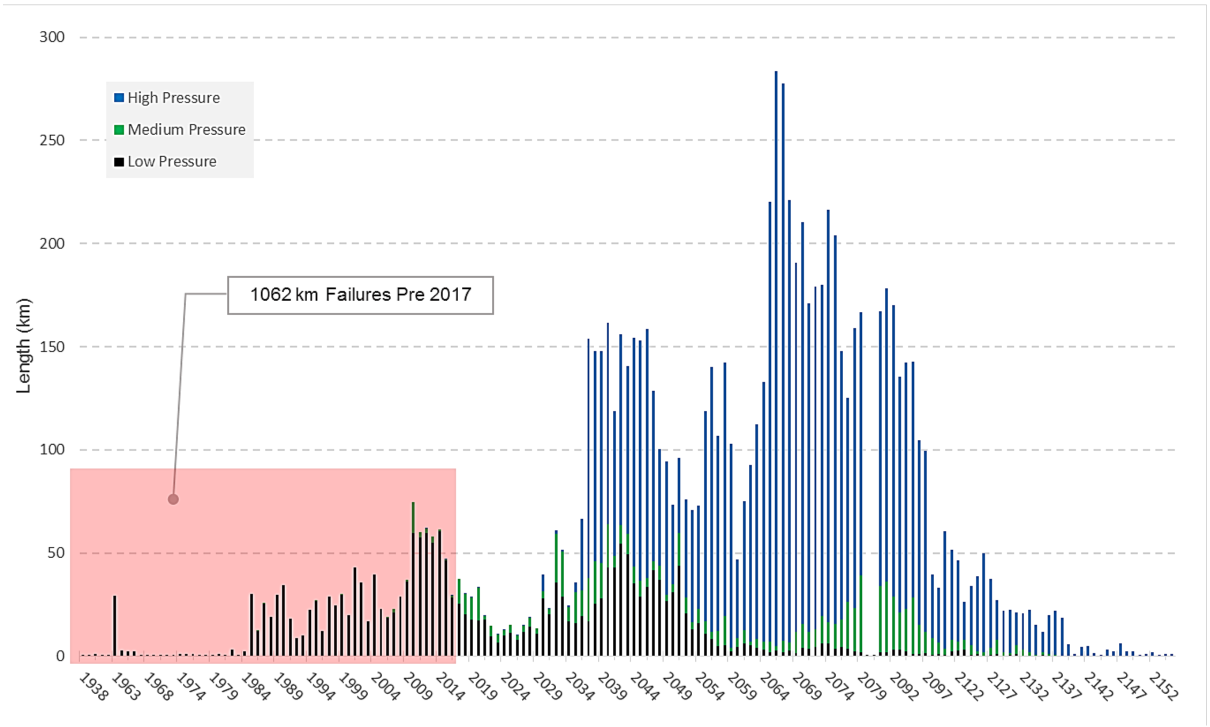


Table 2-7 details the total length of mains that have reached their end of technical life based on material type. Of the 1,062 km classified as failing prior to 2017, the vast majority (around 867 km) is cast iron with unprotected steel accounting for the remaining 195 km.

Table 2-7: Asset Life Summary by Material and Length (km)

Pressure	Failures Pre 2017	2017	2018	2019	2020	2021	2022	Failures Post 2022
Cast Iron (CI)	866.9	21.3	16.5	16.1	13.6	15.3	7.0	241.6
Polyethylene (PE)	-	-	-	-	-	-	-	4,384.8
Poly Vinyl Chloride (PVC)	-	-	-	-	-	-	-	600.7
Protected Steel (SPR)	0.3	0.7	-	-	-	-	0.5	3,154.3
Unprotected Steel (SUP)	194.8	15.4	13.9	12.5	19.5	4.4	7.2	63.2
Total	**1,061.9**	**37.4**	**30.4**	**28.6**	**33.1**	**19.7**	**14.7**	**8,444.6**

2.4. Asset Performance

2.4.1. Overview

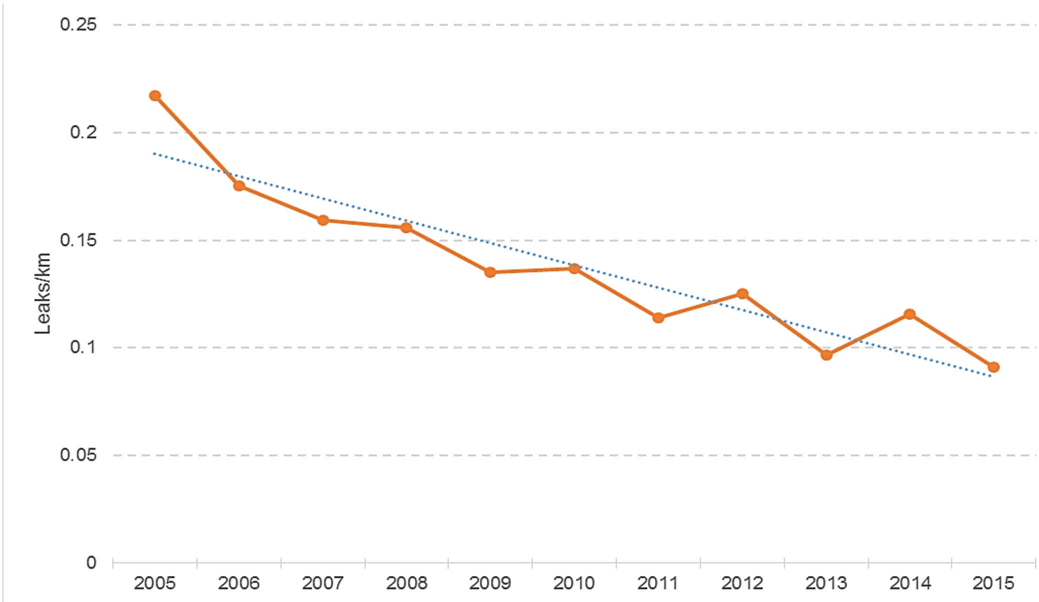
This section provides an overview of performance and integrity issues associated with mains in the Multinet Gas distribution network.

- Section 2.4.2 deals with leak incident rates from a pressure and material based analysis;
- Section 2.4.3 deals specifically with fractures volumes and fracture incident rates associated with cast iron mains;
- Section 2.4.4 deals with the emerging integrity issues with early generation polyethylene mains; and
- Section 2.4.6 deals with supply reliability from water ingress which occurs primarily on the low pressure network.

2.4.2. Leak Incident Rates

Defined as number of leaks[11] per kilometre of mains, leak incident rate can be applied on multiple levels in order to gain an idea of network performance over time. Figure 2-4 shows that Multinet Gas' leak incident rate over the total distribution network has been decreasing with time over the period of 2005 to 2015 with a 60% reduction in leak incident rate over the period. It shows the effectiveness of the mains replacement program which has resulted in over 888 km of predominately cast iron and unprotected steel replaced over the period 2005 to 2015.

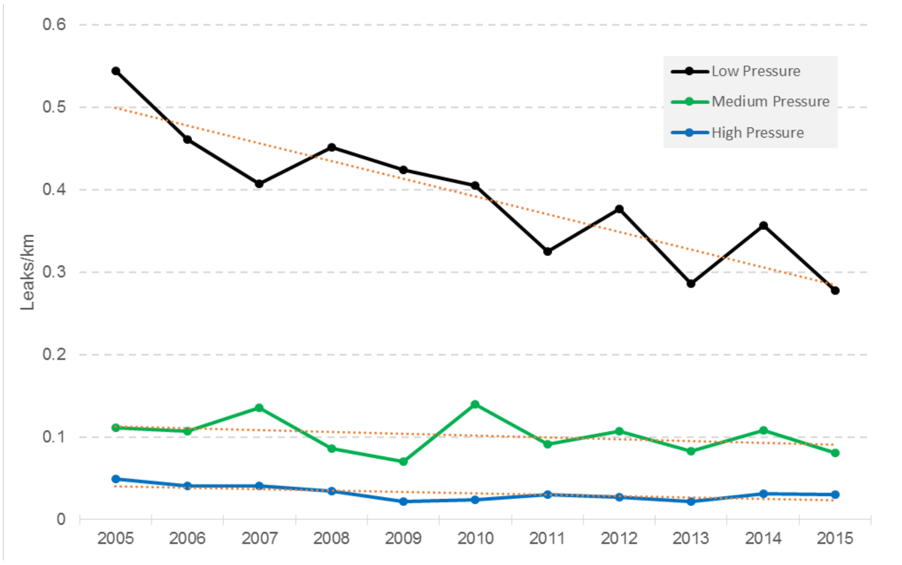
Figure 2-4: Distribution Mains Leak Incident Rate



Distribution main leak incident rates (by pressure) are presented in Figure 2-5. It shows declining leak incident rates for the low pressure network with a reduction of leak incident rate from 0.54 in 2005 to 0.28 in 2015. This 48% reduction is indicative of the improvement in network integrity and public safety resulting from the targeted and proactive replacement of the low pressure network. In relation to medium and high pressure leak incident rates, both have also declined over the period with medium pressure reducing from 0.11 to 0.08 and high pressure from 0.05 to 0.03.

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

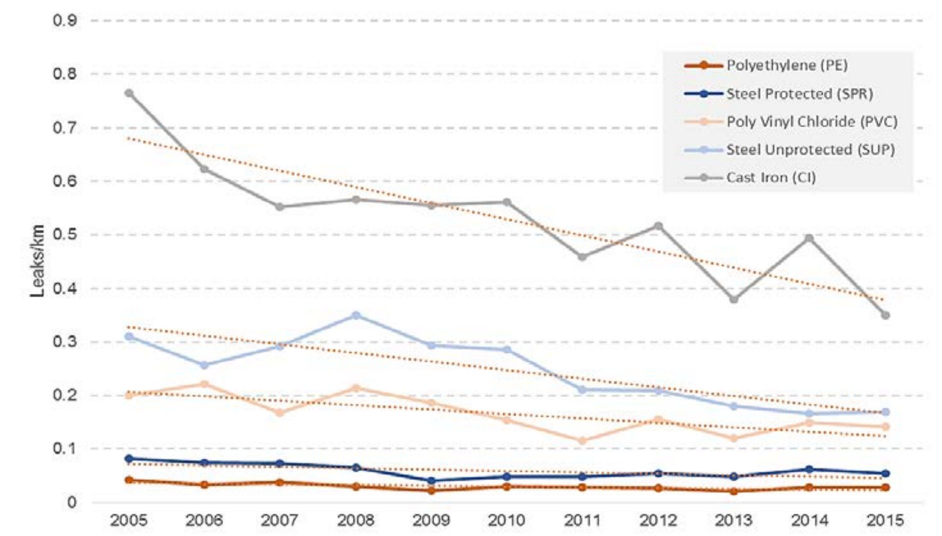
Figure 2-5: Distribution Mains Leak Incident Rate by Pressure



In relation to leak incident rates by material, as detailed in Figure 2-6, cast iron, PVC and unprotected steel have all trended down since 2005. This is consistent with the declining trend in low pressure leak incident rates given these three material types constitute over 90% of the low pressure network. In isolation cast iron has seen the largest reduction in leak incident rate over the period; a 54% reduction since 2005. Similarly unprotected steel has seen a 45% reduction over the same period. This reduction is a direct result of the targeted replacement of cast iron and unprotected steel mains.

While leak incident rates per kilometre have declined for all material types over the period 2005 to 2015, the rate for cast iron and unprotected steel remains comparatively high at 0.35 and 0.17 respectively versus 0.028 for polyethylene and 0.054 for protected steel mains. Combined, polyethylene and protected steel account for 77% of the distribution network by length.

Figure 2-6: Distribution Mains Leak Incident Rate by Material



The majority of leaks on cast iron and unprotected steel mains stem from a material or joint mode of failure, including:

- corrosion faults both of mains and associated fittings;
- mechanical joint failures of both mains and fittings, and
- fracturing of cast iron mains.

It is reasonable to expect that leak incidents will continue as these asset types continually deteriorate. This deterioration is unavoidable given the technical inability to protect these assets from corrosion and external stress loading which results in mains leaks and fracturing.

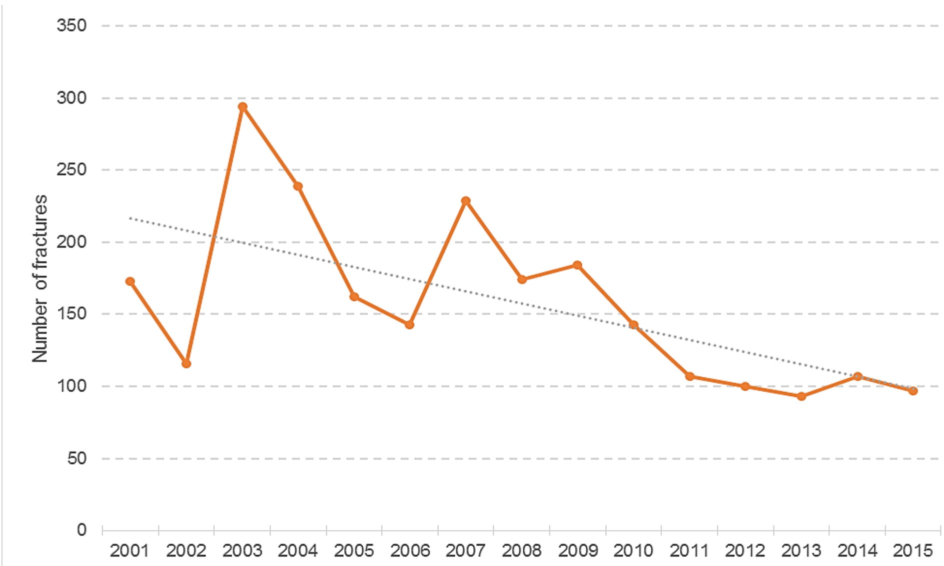
With cast iron and unprotected steel mains accounting for the highest proportion of gas leak incidents per kilometre of mains, it is prudent to focus of the proactive mains replacement program on these asset types.

2.4.3. Cast Iron Fractures

The primary failure mode of cast iron mains is brittle fracture from either a circumferential or axial fracture which is dependent on pipe diameter, external stresses, and the extent of graphitisation (a form of corrosion).

Historically, Multinet Gas' has experienced cast iron fractures on 18% of its remaining cast iron network. However, 54% of these fractures are recurring fractures on the same pipe. Although a seemingly small proportion of mains are experiencing fractures, cast iron main fractures can occur independent of age or condition of pipe making failures difficult to predict. As shown in Figure 2-7 cast iron mains fracture volumes (on average) have been declining since 2001. The 44% reduction in fracture volumes is a direct result of Multinet Gas' targeted cast iron mains replacement program.

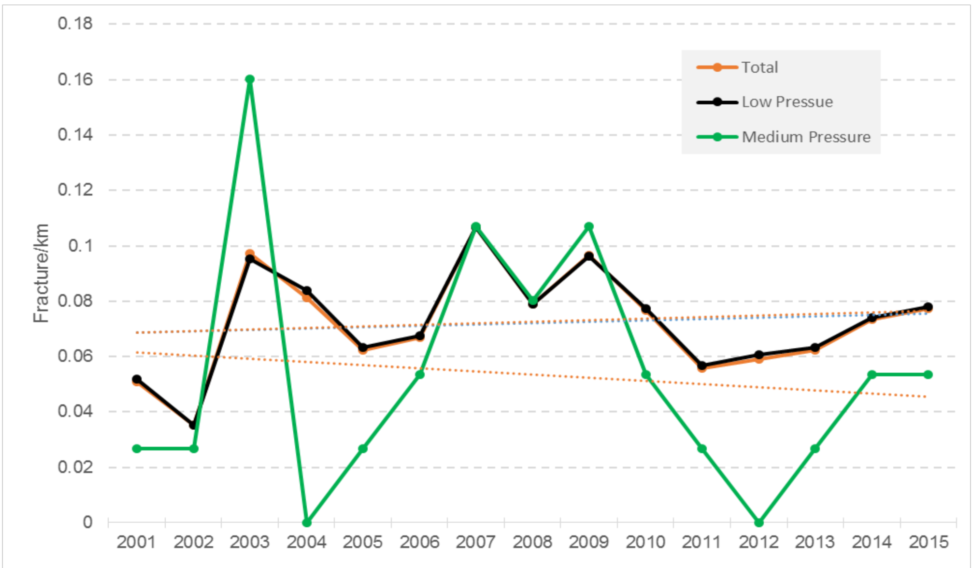
Figure 2-7: Distribution Mains Cast Iron Fracture Volumes



A fracture on cast iron compromises the integrity of the material potentially increasing the risk of further cracks and breaks on the pipe. This risk is further increased with higher operating pressures, with a catastrophic fracture on a medium pressure main resulting in an uncontrolled release of a larger volume of gas; compared to that from a low pressure fracture. Regardless of operating pressure, the risk of a cast iron mains fracture represents a hazard that impacts public and field personnel safety where there is a potential for multiple fatalities as a result of a gas explosion.

Although there has been a decline in fracture volumes, Multinet Gas' cast iron network is showing an increasing rate of fracture incidence per kilometre as shown in Figure 2-8. This 51% increase in the overall cast iron fracture incident rate for the period 2001 to 2015 suggests that the remaining in service cast iron mains are deteriorating at an increasing rate and will therefore require more prioritised replacement and/or abandonment volumes in the future in order to reverse the trend.

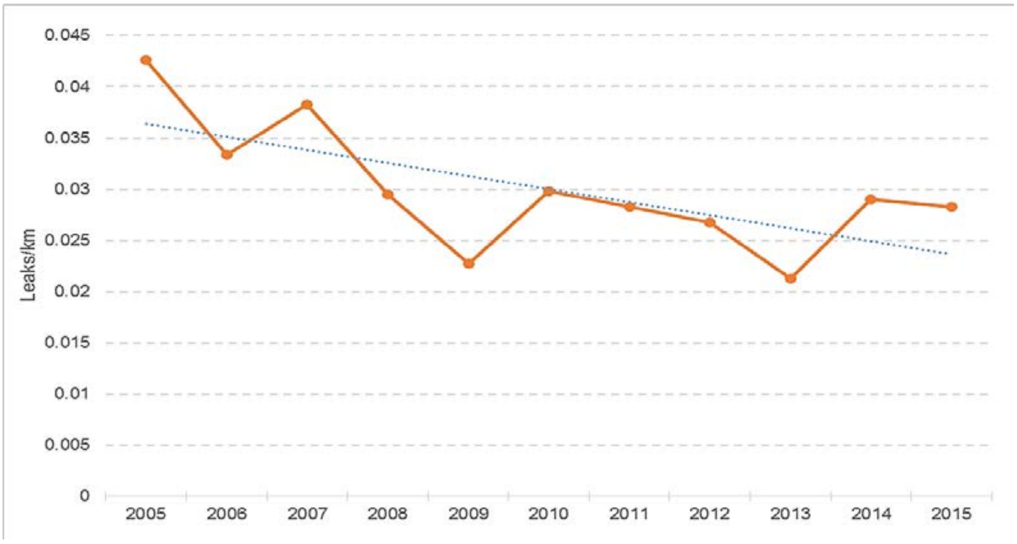
Figure 2-8: Distribution Mains Cast Iron Fracture Incident Rate



2.4.4. Early Generation Polyethylene Leaks and Fractures (Breaks)

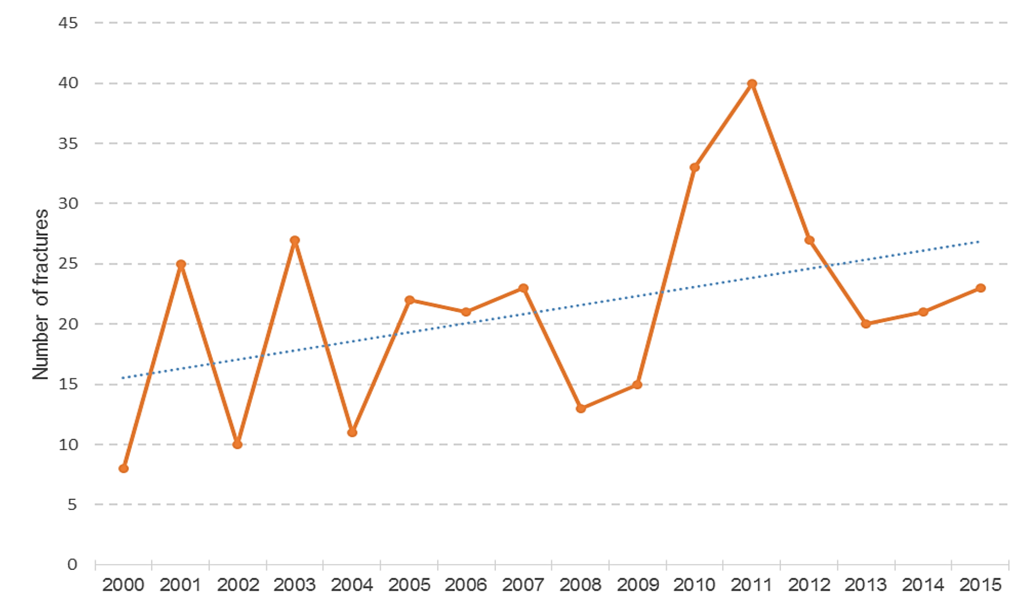
Multinet Gas' polyethylene mains network has the lowest leak incident rate per kilometre in comparison to all other material types used on the gas distribution network. This is evident in Figure 2-6 which compares leak incident rates for all material types. Figure 2-9 details polyethylene leak incident rates per kilometre from 2005 to 2015, showing a decline of 34% over the period (from 0.043 to 0.028). This decline is attributed to the increase in network proportion of newer generation polyethylene mains from new estates and main replacement programs. As stated in Section 2.3.1, these latest generation polyethylene's exhibit greater strength, toughness, slow crack growth resistance and resistance to rapid crack propagation over that of previous generations resulting mains with higher integrity and lower failure rates.

Figure 2-9: Distribution Mains Polyethylene Leak Incident Rate



Although the leak incident rate is decreasing for the overall polyethylene network there is an emerging issue with earlier generation high density polyethylene mains. Introduced in the early 1970's, these early generation polyethylene mains are experiencing brittle failures as a result of slow crack growth through the pipe wall. These brittle failures, referred to as polyethylene fractures or breaks (typically associated with previous squeeze-off operations) are increasing in volume as presented in Figure 2-10. A detailed analysis and replacement strategy for early generation high density polyethylene is provided in Section 4.4 of the Capital Program.

Figure 2-10: Distribution Mains Polyethylene Fracture[12] Volumes



2.4.5. Un-Accounted for Gas (UAFG)

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 classified as either measurement based or a fugitive emission.

Measurement based 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.

Specific to mains network leakage, gas losses from the cast iron and un-protected steel are the highest, as presented in Figure 2-6, and as a result can be considered a material contributor to UAFG.

Figure 2-11 provides the reconciled annual UAFG actual losses from the Multinet Gas metropolitan gas network over the period 2003 to 2015 and shows an increasing trend in losses with the volume doubling over the period from 1,699 terajoules (TJ) in 2003 to 3,393 TJ in 2015. This trend could be indicative, in part, to the ongoing deterioration of the remaining in service cast iron and unprotected steel mains exhibiting increasing failure rates resulting in gas losses from leakage. As stated in Section 2.4.3, any increase in mains deterioration will require more prioritised replacement and/or abandonment volumes in the future in order to reverse the trend.

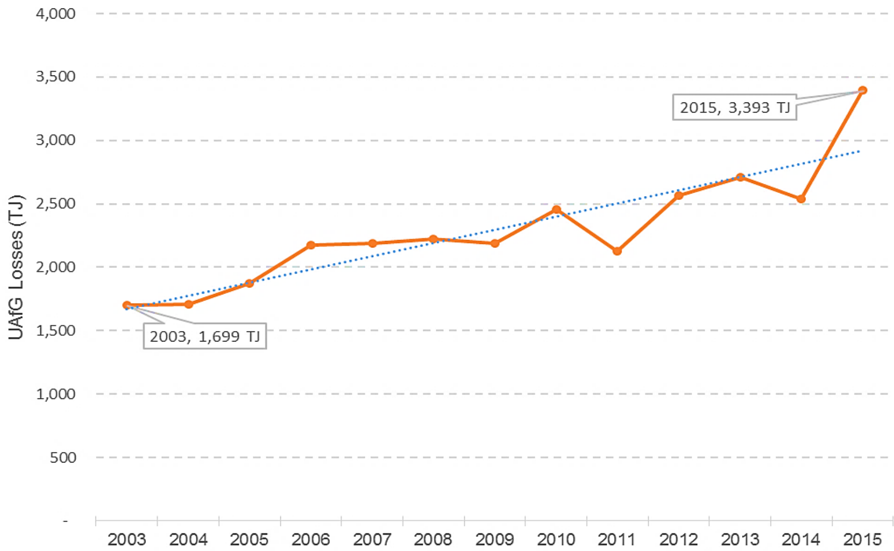
A number of strategies[13], including the proactive replacement of the cast iron and un-protected steel network, are in place aiming at reducing UAFG. It is the fugitive losses and the release of methane emissions into the atmosphere that result in an environmental impact given methane has a global warming potential 34[14] times that of carbon dioxide.

[12] A specific code for squeeze off failure was introduced in 2007 into SAP ERP. Prior to this, failures of this nature were recorded under the broken mains code. The asset data used in Figure 2-10 consists of two cause codes namely 'Broken Mains' and 'Squeeze Off'.

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

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

Figure 2-11: UAFG Actual Losses Metropolitan Melbourne



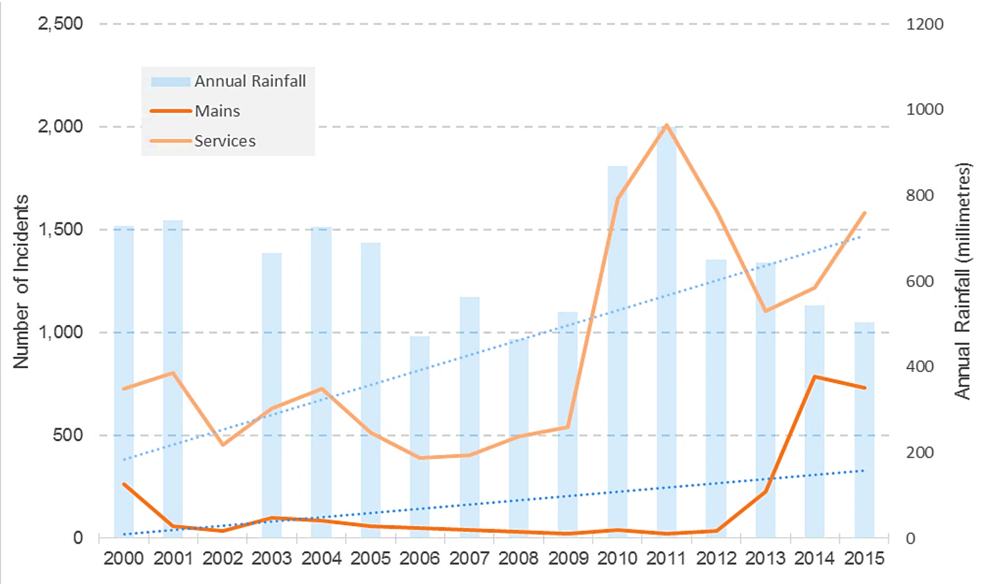
2.4.6. Supply Reliability

Water in mains and services is the primary supply reliability issue on the Multinet Gas 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 file. 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 cast iron and unprotected steel mains are key sources.

Figure 2-12 details the number of water incidents on both mains and services over the period 2000 to 2015. It shows a tripling of mains and doubling of service incidents over the period. Figure 2-12 also provides annual rainfall from a single Melbourne based weather observation station[15] which is geographically located in close proximity to part of the Multinet Gas low pressure network.

[15] Annual rainfall data sourced from the Australian Bureau of Meteorology website. Observation station 'Moorabbin Airport' which is located within the Multinet Gas low pressure network. Annual rainfall data for this station was the most complete for the period 2000 to 2015 when compared to other observation stations within the Multinet Gas low pressure distribution area. Annual rainfall for 2002 was omitted as dataset from Australian Bureau of Meteorology excluded monthly totals for the months of February and March.

Figure 2-12: Low Pressure Distribution Mains and Service Water Ingress Incidents

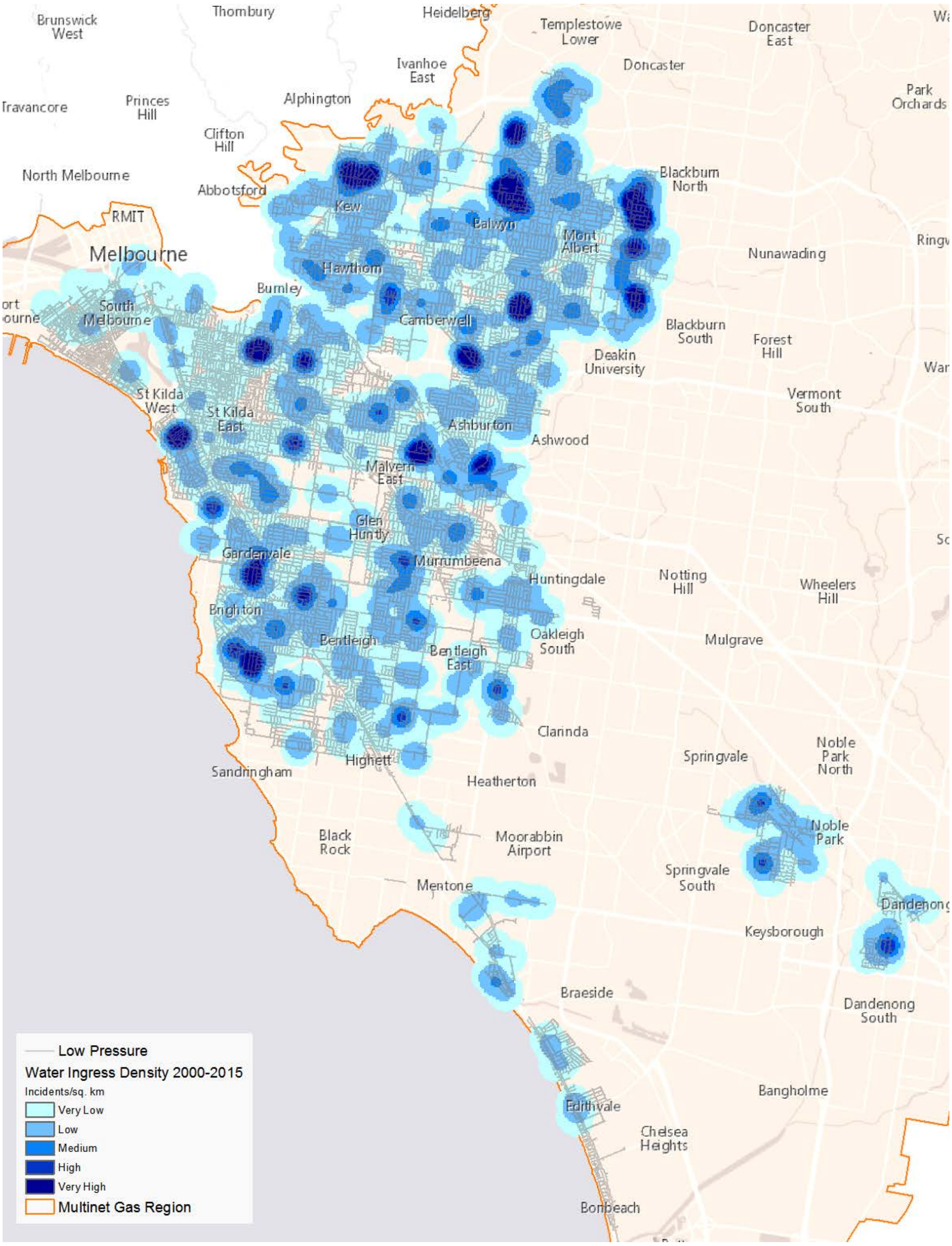


With the amount of rainfall being a contributing factor to water ingress it is worthwhile relating the annual rainfall trend to that of the incidents of water in mains and services. For service incidents a correlation is evident with the changes in annual rainfall - particular for 2010 and 2011 - which recorded the highest rainfall in the period. In contrast, 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 (as suggested by the low volumes in Figure 2-12).

Figure 2-13 provides a spatial density[16] map of cumulative water in mains incidents associated with the low pressure network over the period 2000 to 2015. High occurrences of water incidents are shown as darker blue.

[16] Density spatial map Figure 2-13 of water in mains developed with the use of ArcGIS kernel density spatial tool and water incidents attributed to mains equipment over the period 2000 to 2015. Kernel based on cell size of 50 and search radius of 500m.

Figure 2-13: Low Pressure Distribution Mains Water Ingress Density Map

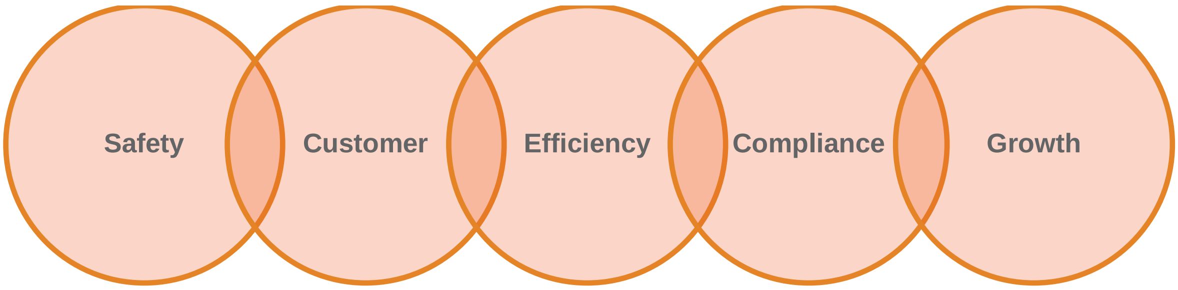


3. ASSET MANAGEMENT DRIVERS

3.1. Network Objectives

Multinet Gas has established five (5) network objectives that govern how the network is operated and maintained. This is reflected mostly in regulatory obligations and in some cases prudent and responsible behaviour, justifiable on economic grounds. Achievement of these objectives ensures sustainable and reliable operation of the gas distribution network.

Figure 3-1: Gas Network Objectives



The alignment between Gas Network objectives and the Distribution Mains Strategy is detailed below.

3.1.1. Safety – Achieve Zero Harm, while Maintaining Current Levels of Network Safety

This strategy aims to achieve a high level of personnel / public safety and reliability through proactive asset replacement. The programs aim to reduce the occurrence of failures of cast iron and unprotected steel gas mains and the consequent risk of injuries, fatalities and damage to buildings. The strategy takes into consider not only the potential for asset failure but also the risk posed on service personnel required to perform reactive maintenance on aged assets.

3.1.2. Customer – Effortless Customer Experience

This strategy aims to achieve a high level of customer satisfaction and experience by continually improving reliability of gas supply to the customer. The proactive replacement of aging assets (assets prone to water ingress resulting in outages) with high pressure polyethylene mains will result in great reliability and increased capacity.

3.1.3. Efficiency – Sustainable and Prudent Network Investment

This strategy aims to concisely outline the capital expenditure work programs from 2017 out till 2022, which coincides with the 2018 to 2022 access arrangement period. These programs intend to provide our shareholders with a sustainable return on their investment while working within regulatory allowances, technical compliance and safety standards.

3.1.4. Compliance – Maintain Regulatory and Technical Compliance

This strategy aims to ensure we maintain regulatory compliance in ensuring a reliable delivery of natural gas. It also aims to ensure processes and policies in place comply with technical obligations.

3.1.5. Growth – Seek Opportunities for New Growth

This strategy aims to deliver additional capacity on the network with the intention of increasing throughput. This allows Multinet Gas to plan and adapt to a changing industry landscape.

3.2. Lifecycle Management

3.2.1. General

In general there are four key stages relating to the lifecycle management of assets, these are planning, acquisition, operation and maintenance and decommissioning. Planning involves the overall asset management strategy in identifying the need, risk management and cost benefit analysis while acquisition involves procurement, installation and construction. Operation and maintenance deals with the day to day operating, monitoring, inspection and preventative/corrective maintenance. Sections 3.2.2 to 3.2.4 deals with these maintenance activity types in greater detail. The last stage relating to decommissioning is where the asset is deemed to have reached end-of-life and based on future operation needs is either renewed or directly replaced and abandoned. Section 3.2.5 deals with this in relation to distribution mains.

3.2.2. 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.

Above Ground Piping (Bridge) Inspection

Multinet Gas has some 55 sites where gas mains are exposed on bridge crossings. The bridges range from multilane 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 ERP 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 (4) bridge crossings require major recoating and/or support refurbishment every year.

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.

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 (4) different categories of surveying, as detailed in Table 3-1, three of which are location dependant.

Table 3-1: 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. Leakage survey is 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 pin pointing 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.

Condition Assessment Dig-Ups

Physical inspection of a sample of large diameter cast iron 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.

3.2.3. Preventive Maintenance

Preventative maintenance (or preventive maintenance) is maintenance that is regularly performed on assets to lessen the likelihood of it failing. The majority of preventive maintenance is to the coated steel network which since the mid 1970's 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[17] systems. The cathodic protection system is detailed in the MG-SP-0013 Cathodic Protection Strategy document.

Another maintenance task that is preventative with respect to preventing outages on the distribution network is syphon pumping / maintenance. This is both a planned and unplanned activity. Syphon pumping is in the majority of cases restricted to the low pressure network.

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.

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.

[17] 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.

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.

Maintain Mains Marker Post

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 3rd 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.

Maintenance of Mains on Bridges

This ongoing maintenance is classed as a preventive and is used on bridges or above ground pipework not associated with regulating installations. This type of maintenance is typically expensive due to difficulties in accessing the pipework.

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.

3.2.4. Corrective (Reactive) Maintenance - Faults and Defects

Corrective maintenance is a reactive based maintenance task performed to identify and rectify network fault(s) so that the failed or damaged assets can be restored to an operational condition.

Leak Pinpointing

Pinpointing is a task that is generated from leakage survey via a leakage ticket. Pinpointing, as the name suggests, narrows down the location of a leak such that a repair can take place if required.

Mains Repair (Leaks)

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 Repair (Third Party Damage)

This maintenance is as a result of 3rd party damages. Typical causes are lack of knowledge and caution when working near gas mains, assets location not recorded accurately and reduction or 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 that 3rd 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.

Trace Mains Stoppage

This maintenance is as a result of water ingress into the mains, which restricts or stops the flow of gas and involves the tracing of the stoppage. This activity tends to be driven by the changes in rainfall and is therefore difficult to predict with any great accuracy.

Searching for Escape

This maintenance is as a result of a public report of gas. It may or may not lead to leak detection but is still required to be attended to.

3.2.5. Decommissioning and Replacement

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.

Both the reactive and proactive replacement program for mains are detailed in Section 4 of the Capital Program.

3.3. Performance Measures

Multinet Gas has a number of key performance measures which align with the corporate and gas network objectives. Targets are reviewed and benchmarked annually. Measures are typically reported monthly based as actual, target and variance along with the annual target as a year to date cumulative actual and variance.

3.3.1. 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.

3.3.2. Asset Replacement Performance Measures

- Monthly tracking and reporting of main replacement rates against annual and 5 year regulatory targets. Current 2013 -2017 AER target is 527 km of mains laid in relation to the existing low pressure main replacement program otherwise known as ‘Pipeworks’.

3.3.3. Future Reporting Measures

- Monthly reporting of in-service mains leak incident volumes and rates per kilometre against a 5 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 in Section 4 and against 5 year regulatory period targets.

3.4. Current Issues

3.4.1. Environmental Requirements

Due to recent amendments to key environmental legislations (such as waste legislation, and most recently Cultural Heritage guidelines), Multinet Gas has re-evaluated both its environmental policies and its onsite practices.

While completing this review exercise, Multinet Gas has increased its level of awareness and recognised the risks associated with constructing and maintaining gas networks. These risks cover both environmental (i.e. waste, cultural heritage) and health and safety aspects (i.e. managing contaminates of concern during construction works).

Moving forward, Multinet Gas would like to further align itself with industry best practice. Previously, the costs required to achieve best practice may have not been accounted for, and therefore best practice became an aspirational task that project teams endeavoured to build into works on an ad hoc basis. Multinet Gas would like to take a pro-active approach to environmental mitigation and help drive industry best practice.

Legislation is always changing, and the time taken to interpret change is always variable. New legislation has to filter down through Acts, Regulations and Guidelines and companies require time to adapt to these changes.

Issues posed by environmental constraints (such as contaminated land) may only be discovered once project planning has commenced. The nature of environmental constraints means they are only likely to be discovered following a project's inception. It is impossible to predict the full costs of environmental mitigation across a 6 year period as they cannot be accurately determined until the project planning stage.

As such it should be recognised that asset replacement works, including but not limited to mains, services and supply regulators will be impacted from such environmental requirements. These costs while considered, cannot be fully factored into project expenditure forecast without preliminary environmental due diligence.

4. CAPITAL PROGRAM – 2017 TO 2022

4.1. Overview

The mains replacement program is central in controlling the risks presented by aging and deteriorating mains. Multinet Gas has plans to complete the following annual programs to maintain its alignment with the Network Objectives (Section 3.1), and remain compliant with its regulatory obligations under the Gas Safety Case, Gas Distribution System Code and AS 4645:

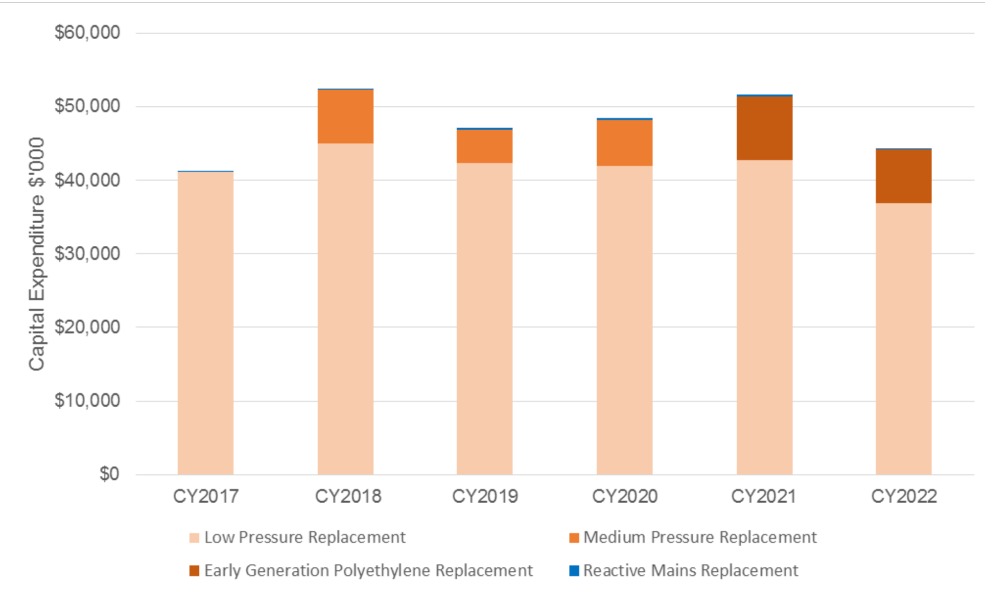
- Low Pressure Replacement Program;
- Medium Pressure Cast Iron Replacement Program;
- Early Generation High Density Polyethylene (HDPE) Replacement Program; and
- Reactive Main Replacement.

Table 4-1 and Figure 4-1 provides a breakdown of capital expenditure from 2017 to 2022 by program.

Table 4-1: Capital Expenditure Summary

Ref	Program	2017	2018	2019	2020	2021	2022
4.2	Low Pressure Mains Replacement	$41,120	$45,035	$42,305	$41,969	$42,746	$36,934
0	Medium Pressure Cast Iron Mains Replacement	-	$7,247	$4,606	$6,275	-	-
4.4	Early Generation HDPE Polyethylene Mains Replacement	-	-	-	-	$8,652	$7,225
4.5	Reactive Mains Replacement	$200	$200	$200	$200	$200	$200
	Total Expenditure	**$41,320**	**$52,482**	**$47,110**	**$48,444**	**$51,598**	**$44,358**

Figure 4-1: Capital Expenditure Summary



4.2. Low Pressure Replacement Program

4.2.1. Introduction

The principle driver for the low pressure replacement program is the ‘societal risk’ posed from failure of cast iron mains and resulting risk of incidents leading to loss of life or significant property damage. The risk associated with cast iron is quantifiable and it is accepted by both UK and US safety regulators that cast iron is an obsolete material. For Multinet Gas, 97% of its remaining cast iron mains (1,234 km) are located within the low pressure network - the focus of the mains replacement program.

In addition to the presence of cast iron, the low pressure network consists of 333 km of steel mains and while these have been further classified as either protected or un-protected from a coating perspective, for low pressure, all steel mains are considered unprotected due to the non-existence of an active cathodic protection (CP) system. Like the US, it is typical that unprotected steel is replaced along with cast iron as part of a proactive mains replacement program from a risk and efficiency perspective.

4.2.2. Failure Analysis

The primary mode of failure for cast iron mains is pipe fracture. It is catastrophic in nature and results in an uncontrolled release of gas. Cast iron mains facture 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[18] strength. The result is that the main breaks completely, typically into two pieces.

In addition to fractures, cast iron is susceptible from other forms of failures such as joint failure and corrosion. Early jointing of cast iron 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 cast iron 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.

While the major concern with cast iron is failure by fracture, graphitisation represents a concern that cannot be dismissed and supports the argument in favour of replacement and the recognition that cast iron is not a suitable material for a gas network. In addition to the risks posed from fractures of cast iron mains, 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 cast iron 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.

For unprotected steel mains the primary concern is with corrosion and the development of leaks over time. Specifically, unprotected steel 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. As stated above in Section 4.2.1, steel mains in the low pressure network are not actively cathodically protected and as such when the coating on a coated, but unprotected, 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 unprotected steel 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.

[18] 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.

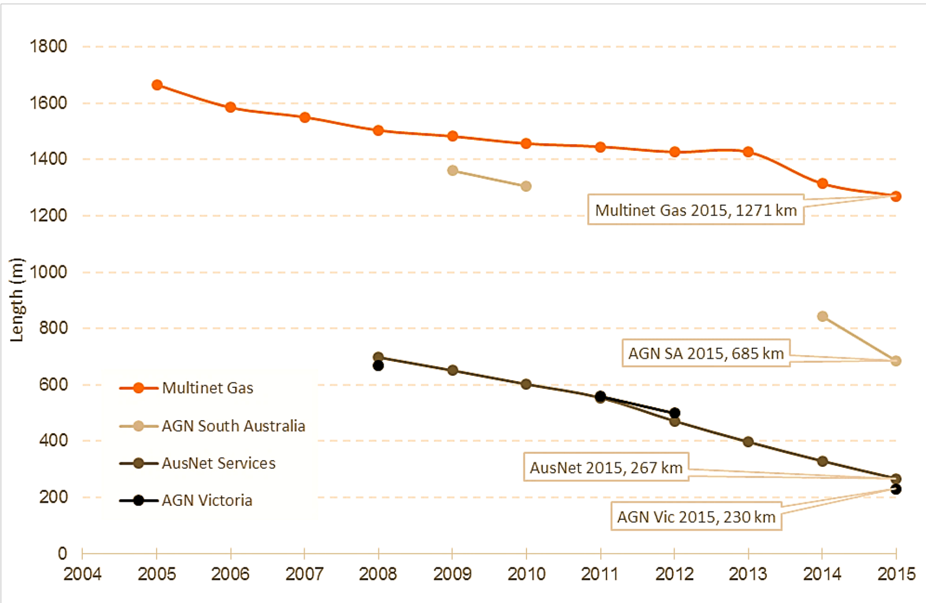
While Multinet Gas' cast iron and unprotected steel mains replacement program is smaller in comparison with UK and US based accelerated mains replacement programs, it addresses proportionally the same risks given the asset composition, age and failure conditions.

As previously stated in Section 2.4.2 in relation to leak incident rates, while rates per kilometre have declined for all material types over the period 2005 to 2015, the rate for cast iron and unprotected steel still remains relatively high at 0.35 and 0.17 leak incidents per kilometre respectively. Additionally in Section 2.4.3 it was stated that overall cast iron fracture incident rates have increased by 51% for the period 2001 to 2015 and are currently tracking just under 0.08 fracture incidents per kilometre. This increase suggests that the remaining in service cast iron mains are deteriorating at an increasing rate and will therefore require more prioritised replacement and/or abandonment volumes in the future in order to reverse the trend.

4.2.3. Volumes

Multinet Gas has the largest remaining volume of cast iron gas mains when compared to all gas networks in Australia with respect to the current status of their proactive replacement programs. At the end of 2015 Multinet Gas had approximately 1,271 km of aging cast iron. In comparison (as represented in Figure 4-2), AGN in South Australia had 685 km remaining; AusNet Services and Australian Gas Networks (both Victorian based), have 267 and 230 km respectively remaining. This places Multinet Gas in the position of having the greatest volume of "at risk" cast iron gas distribution assets in Australia. As noted in Section 4.2.1 above, of the 1,271 km of cast iron remaining, 1,234 km or 97% is located within the low pressure network.

Figure 4-2: Distribution Main Cast Iron Length Comparison



Multinet Gas has adopted a 30 year initiative for its low pressure mains replacement, which commenced in 2003 and is schedule to be completed in 2033. Figure 4-3 below provides an overview of the historical replacement volumes up to and including 2016 along with the forecasted volumes for the remaining period from 2017 to 2033. Historically (from 2003) annual replacement rates have varied from a low of 21 km in 2010 to a high of 168 km in 2006. The average replacement rate over the 14 year period was 83 km per annum.

Forecasting replacement volumes

In order to forecast future replacements a target needs to be established. Given the primary driver of the mains replacement program is safety there is a strong argument to adopt a mains failure rate target. However, adopting a replacement rate based on maintaining or improving rates of asset failure for mains is subject to the methodology for the reporting failures which are based on leak detections. This would require a process of systematic leakage surveys of the low pressure mains network to quantify and track failure rates against agreed targets. While technically possible, this method would result in increased operational expenditure in order to survey the entire low pressure network along with the repairs of detected leaks. Given the premise for the low pressure program is the complete replacement of the network by method of 'block' renewal to high pressure, the volume of replacement should be driven by the ability to meet rates of replacement and geographically prioritise replacement around failure rates while taking into consideration network constraints. The 2033 target is therefore used as a key milestone and forms the basis for the future rates of replacement. The following options are discussed as possible forecast rates of replacement taking into consideration current regulatory targets to end of 2017, and the continuing 2033 target:

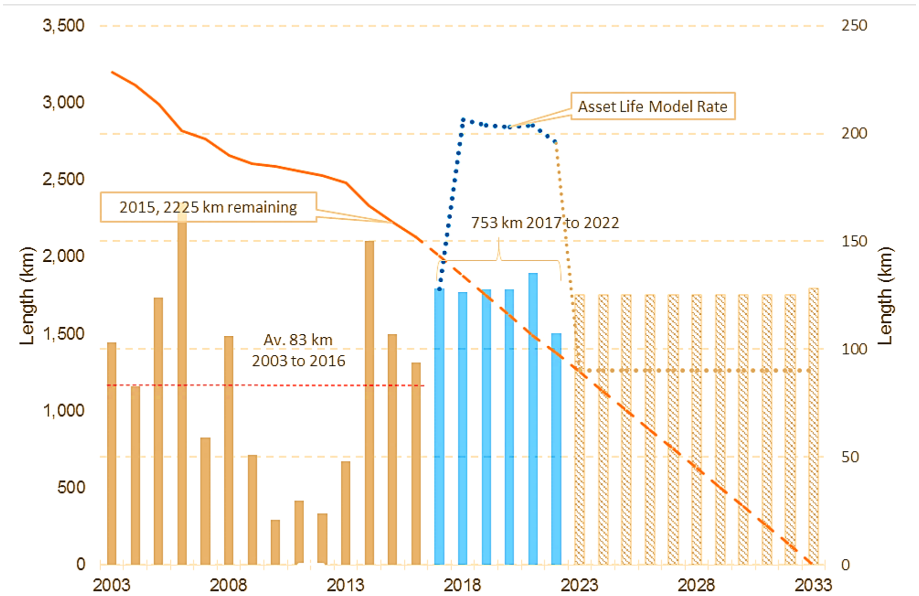
A. Adopting the historical rate of 85 km per annum post 2017;

B. Adopting the derived asset life failure volumes from 2018 to 2011 with the remainder (post 2022) volumes being an average to meet the 2033 removal target; or

C. Adopting the average (straight line) of the remaining low pressure network (post 2017) to achieve with a 2033 removal target – 125 km per annum.

For the purposes of analysis and derivation, volumes are based on the premise that the current regulatory replacement target of 527 km for the period 2013 to 2017 will be met and therefore provides a committed volume for 2017 of 128 km. This 2017 program of works is detailed in Section 4.2.7 and upon completion will see the remaining length of low pressure reduced to approximately 2,003 km.

Figure 4-3: Low Pressure Mains Replacement Volumes[19]



Utilising the above remaining low pressure length, the option of adopting a 85 kilometre rate (Option A) would in effect see the low pressure replacement program timeline extend from 2033 to 2040. While this approach is highly achievable (from a delivery perspective - based on historical rates), the extension in timeframe would undoubtedly result in increased deterioration of the remaining low pressure assets directly resulting in an increased risk of incidents from asset failures along with increased operational expenditure.

In considering replacement rates based on the asset life analysis and resulting volumes (Option B, as detailed in Section 2.3.5), it should be noted that it is based on the premise that mains have reached 'likely' end-of-life and replacement is undertaken on a 'like for like' basis as a piece meal approach. The resulting replacement rate would require the 'early failures' of 1,033 km along with discrete failure volumes from 2017 to 2022 (detailed in Table 2-6), to be replaced over the five year period from 2018 to 2022. To achieve this the annual replacement rate would need to be accelerated to around 200 km per annum for a five year period and then drop to 90 km for the remaining timeframe from 2023 to 2033. This replacement rate is shown in Figure 4-3. This approach would require, from a historical viewpoint, an annual rate of replacement larger than has been achieved previously. While technical and

[19] Volume of replacement for 2013 is based on length data as recording in SAP ERP at June 2013. Data not available at end 2013 due to MG (7/13) contract. The resulting value used in 2014 will therefore include a proportion of 2013. This is a data anomaly.

physically achievable, it would not be deliverable under a ‘like for like’ program which is seen as an inefficient delivery model for large replacement rates.

Analysing the option of adopting an average replacement rate based on a 2033 target results in an average annual replacement rate of 125 km for the period from 2018 to 2033. This is based on a remaining low pressure length of 2,003 km at the end of 2017 which takes into account the committed 128 km for 2017. The resulting volume of replacement, as provided in Figure 4-3, for the period 2017 to 2022 is 753 km.

A rate of replacement averaging 125 km per annum (Option C) for the period 2017 to 2033, having regard the long term safety of the gas network, is seen as an efficient and prudent volume of mains replacement. While the proposed rate of 125 km is 50% greater than the 14 year average of 83 km since 2003, it is only 25% greater than the average replacement rates over the last four years and aligns with volume of replacement being undertaken in 2017. This volume of replacement will provided a steady rate of replacement benefiting in a stable work load for external service providers. In order to ensure the delivery of the program and meet the increased volumes going forward, the following initiatives are being implemented:

- The establishment of an 18 month rolling capital program which will enable greater visibility of the pipeline of projects and will provide suitable timelines to enable planning, investigation and design to take place well in advance of the construction delivery schedules; and
- The extension of the existing service delivery panel to incorporate additional tier one contractors, which will benefit with an increased workforce and competitive pricing.

4.2.4. Prioritisation

Prioritisation of the replacement of low pressure mains is based on:

- Primarily on fracture incident rates related to cast iron mains; and
- Secondarily on leak incident rates.

Incident rates are aggregated at a postcode level and the overall program is prioritised having regard for:

- The availability or provision of high pressure assets;
- Synergies with the removal of the medium pressure cast iron mains;
- Existing and future supply constraints; and
- In general the practice of working inwards from the outer boundary of the low pressure network.

The resulting post code priority list, ordered by historical fracture and leak incident rates is provided in the Appendix 5.6, Table 5-21. This information is additionally provided in spatially form as both a post code priority map and density map[20] in Figure 4-4 and Figure 4-5. This prioritisation is used to develop the program of works for the 2017-2022 period as detailed in Section 4.2.7.

[20] Density spatial maps as provided in Figure 4-4 and Figure 4-5 of are developed with the use of ArcGIS kernel density spatial tool and fracture/leak incidents attributed to mains equipment over the period 2005 to 2015. Kernel based on cell size of 50 and search radius of 500m.

Figure 4-4: Low Pressure Distribution Mains Fracture by Post Code and Density Map

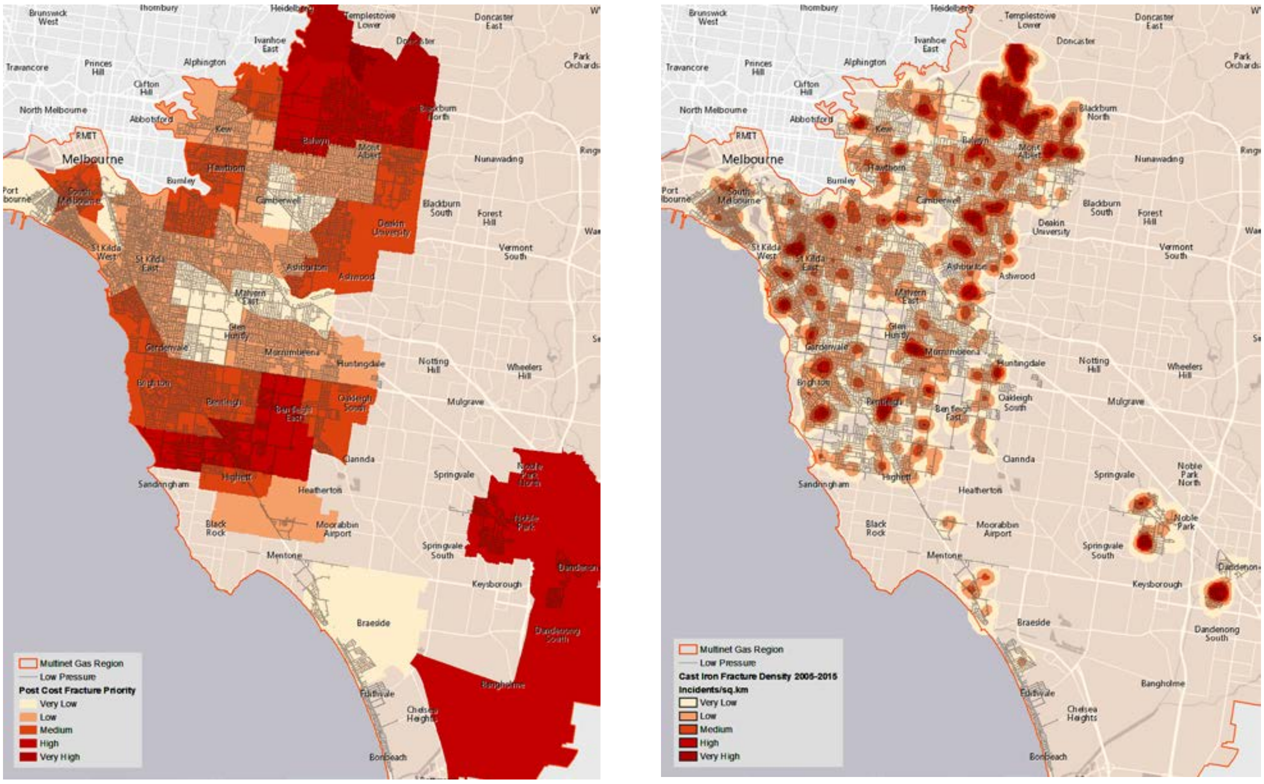
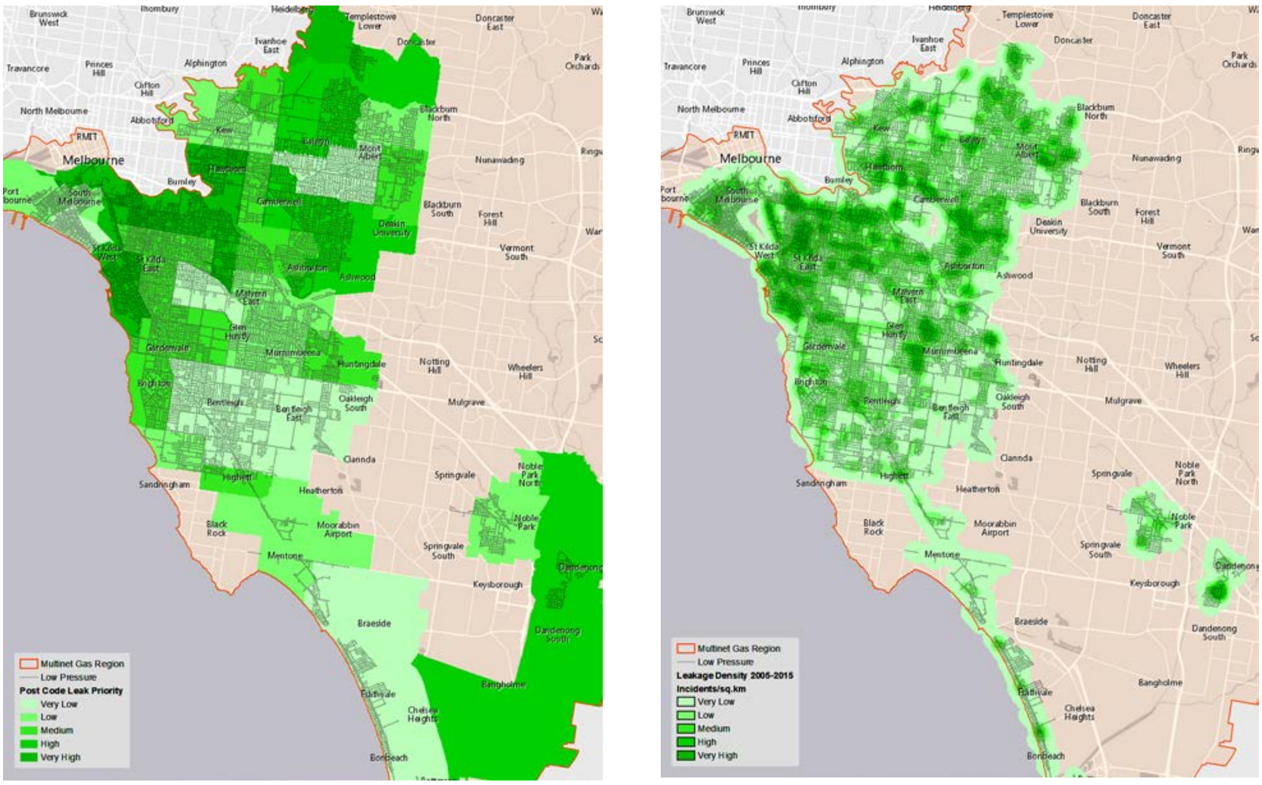


Figure 4-5: Low Pressure Distribution Mains Leaks by Post Code and Density Map



4.2.5. Scope

The low pressure mains replacement program targets the replacement of large volumes of cast iron and unprotected steel assets. The program will provide for the complete decommissioning of the remaining low pressure gas distribution network, considered a medium to long term program, scheduled for completion in 2033. It covers proactive replacement of low pressure mains and associated consumer service installations with high pressure assets.

4.2.6. Business Drivers and Strategic Alignment

The primary drivers for this program are:

- To align with Multinet's Gas Network objectives to achieve safety and regulatory compliance;
- To maintain and improve safety by reducing the incidence of gas leaks, to the extent practicable, thereby mitigating the 'societal risk' posed from failure of cast iron mains and resulting risk of incidents leading to loss of life or significant property damage;
- To maintain the integrity of customer service by:
  - eliminating outages due to water ingress;
  - eliminating supply losses arising from leak repair works; and
  - eliminating poor pressure (or loss of supply) at the customer connection point due to peak demand on low pressure mains.
- To maintain compliance with Multinet's Gas Safety Case which requires Multinet to minimise, as far as practicable, the hazards and risk to the safety of the public and customers of gas supply, including the risk of property damage;
- To maintain Multinet's capability to meet levels of demand in those areas where low pressure mains are unable to satisfy peak demand and/or allow for the connection of new customers;
- To reduce environment impacts from methane emissions associated with UAFG; and
- To deliver in the most efficient manner based on a low to high pressure block renewal which is proven within the industry as the most efficient methodology for this type of proactive replacement.

In addition to the above drivers, the removal of all low pressure mains will enable existing specialised stop off and plugging equipment referred to as Wask 312 and Iris Equipment to become redundant. This equipment, while still in use, is highly specialised especially in the case of the Iris Equipment. The Iris Equipment is also only available from a single service provider in Victoria, putting the gas network at risk in both emergency and planned stop-off and plugging operations.

4.2.7. Works Program

The capital expenditure forecast and volumes for the low pressure mains replacement program is summarised in Table 4-2.

Table 4-2: Expenditure Forecast – Low Pressure Replacement Program

Program		2017	2018	2019	2020	2021	2022
Low Pressure Mains Replacement	Length (m)	127,993	126,435	127,702	127,824	135,363	107,381
	Total Expenditure	**$41,120**	**$45,035**	**$42,305**	**$41,969**	**$42,746**	**$36,934**

For the purposes of clarity the works program for the replacement of the low pressure network is outlined in two sections:

- Works for the 2017 period; and
- Works for the 2018 to 2022 (forthcoming regulatory) period.

The 2017 works program is committed in the sense they are either awarded to a service provider for construction or externally out for formal quotation. The 2018 to 2022 works program is provided as proposed with projects at the conceptual stage.

2017 Works Program

The 2017 program of works for the low pressure replacement consists of 10 prioritised projects (Table 4-3), which will enable the current regulatory target of 527 km for the period 2013 to 2017 to be met.

The 2017 expenditure has been derived from a number of sources linked to the stage of the project. Where pricing from a tender is available, the estimating sourced is marked as a *Two Party Tender*. Projects that are in post codes where historical unit rates are available or, are works where similar construction methodologies and material types are utilised; the basis for estimating is provided and the reference project noted. Projects in postcodes where no recent historical unit rates are available have been independently estimated. Further explanation and rational for unit rate deviation is provided in Section 5.4.

Table 4-3: Expenditure Forecast – Low Pressure Replacement Program 2017

Post Code	Project	Length (m)	Cost ($'000)	Unit/Rate ($/m)	Estimate Source
3129	Nelson Road, Box Hill North[21]	6,652	[redacted]	[redacted]	[redacted]
3195	Elm Gr Parkdale[22]	15,000	[redacted]	[redacted]	[redacted]
3128	Monash St Box Hill South	10,750	[redacted]	[redacted]	[redacted]
3174	Stella Ave Noble Park	9,350	[redacted]	[redacted]	[redacted]
3175	Tarene St Dandenong	9,700	[redacted]	[redacted]	[redacted]
3129	Wimmera St Box Hill North	13,200	[redacted]	[redacted]	[redacted]
3104	Balwyn Nth Grid Main[23]	3,500	[redacted]	[redacted]	[redacted]
3124	Prospect Hill Grid Main	7,000	[redacted]	[redacted]	[redacted]
3104	Bulleen Grid Main	4,500	[redacted]	[redacted]	[redacted]
3166	Oakleigh Upgrade	48,341	[redacted]	[redacted]	[redacted]
Totals		**127,993**	**$41,120**	**-**	**-**

2018-2022 Works Program

The 2018 to 2022 program of works for the low pressure network consists of a total of 625 km of replacement, covering 27 post codes with 44 individual projects. The average replacement over the five year period is 125 km. Due to variances in the length of individual projects, annual volume totals vary slightly over the 5-year period with a high 135 km of replacement forecast 2021, and a low of 107 km forecast for 2022.

Table 4-4 provides the volume in metres for each postcode for the period 2018 to 2022. It is worth noting that some of the works incorporate minor volumes of adjacent postcodes

[21] Referred to also as Balwyn Nth-Mont Albert Pt1 #16-122

[22] Referred to also as Parkdale-Mordialloc Stage 2

[23] Referred to also as Greythorn Road, Balwyn North Grid Main.

Table 4-4: Forecast – Low Pressure Replacement Program 2018-2022 - Volumes

Post Code	Suburb	2018	2019	2020	2021	2022	Total
3128	Box Hill, Box Hill Central, Box Hill South, Houston, Wattle Park	-	-	10,735	19,194	120	30,049
3129	Box Hill North, Kerrimuir, Mont Albert North	-	4,054	602	18,962	1,060	24,678
3104	Balwyn North, Greythorn	16,775	9,656	1,425	7,880	-	35,736
3175	Bangholme, Dandenong, Dandenong East, Dandenong North, Dandenong South, Dunearn	12,256	-	-	-	-	12,256
3174	Noble Park, Noble Park East, Noble Park North	9,575	19,594	-	-	-	29,169
3122	Auburn South, Hawthorn, Hawthorn North, Hawthorn West	18,443	8,328	11,768	-	-	38,539
3101	Cotham, Kew	-	17	854	7,197	14,734	22,802
3146	Glen Iris	13,641	7,106	1,288	16,068	-	38,103
3147	Ashburton, Ashwood	6,348	5,947	8,515	3,562	-	24,372
3145	Caulfield East, Central Park, Darling, Malvern East	2,410	-	907	-	-	3,317
3125	Bennettswood, Burwood, Surrey Hills South	5,333	12,846	18,823	55	10,655	47,712
3207	Garden City, Port Melbourne	10,148	-	-	-	-	10,148
3184	Brighton Road, Elwood	9,283	8,472	6,304	-	2,175	26,234
3192	Cheltenham, Cheltenham East, Cheltenham North, Southland Centre	9,603	-	-	-	-	9,603
3190	Highett	795	13,544	2,952	-	-	17,291
3189	Moorabbin, Wishart	-	15,810	13,766	14,292	8,610	52,478
3188	Hampton East, Hampton North	-	225	19,502	7,662	2,397	29,786
3187	Brighton East, North Road	-	17	-	8,824	7,946	16,787
3186	Brighton, Brighton North, Dendy	11,825	-	1,270	-	16,783	29,878
3103	Balwyn, Balwyn East	-	-	18,426	2,378	12,373	33,177
3127	Mont Albert, Surrey Hills, Surrey Hills North	-	-	-	-	15,127	15,127
3165	Bentleigh East, Coatesville	-	15,075	10,687	-	-	25,762
3204	Bentleigh, McKinnon, Ormond, Patterson	-	24	-	18,954	5,695	24,673
3006	Southbank	-	6,987	-	-	-	6,987
3102	Kew East	-	-	-	10,335	-	10,335
3142	Hawksburn, Toorak	-	-	-	-	5,874	5,874
3182	St Kilda, St Kilda West	-	-	-	-	3,832	3,832
Total		**126,435**	**127,702**	**127,824**	**135,363**	**107,381**	**624,705**

Table 4-5 provides the unit rate for each postcode which in combination with annual postcode volume is used to develop annual expenditures for each postcode. Further explanation and rational for unit rate deviation is provided in Section 5.4.

Table 4-5: Forecast – Low Pressure Mains Replacement Program 2018-2022 – Unit Rate

Post Code	Suburb	Unit/Rate ($/m)
3128	Box Hill, Box Hill Central, Box Hill South, Houston, Wattle Park	[redacted]
3129	Box Hill North, Kerrimuir, Mont Albert North	[redacted]
3104	Balwyn North, Greythorn	[redacted]
3175	Bangholme, Dandenong, Dandenong East, Dandenong North, Dandenong South, Dunearn	[redacted]
3174	Noble Park, Noble Park East, Noble Park North	[redacted]
3122	Auburn South, Hawthorn, Hawthorn North, Hawthorn West	[redacted]
3101	Cotham, Kew	[redacted]
3146	Glen Iris	[redacted]
3147	Ashburton, Ashwood	[redacted]
3145	Caulfield East, Central Park, Darling, Malvern East	[redacted]
3125	Bennettswood, Burwood, Surrey Hills South	[redacted]
3207	Garden City, Port Melbourne	[redacted]
3184	Brighton Road, Elwood	[redacted]
3192	Cheltenham, Cheltenham East, Cheltenham North, Southland Centre	[redacted]
3190	Highett	[redacted]
3189	Moorabbin, Wishart	[redacted]
3188	Hampton East, Hampton North	[redacted]
3187	Brighton East, North Road	[redacted]
3186	Brighton, Brighton North, Dendy	[redacted]
3103	Balwyn, Balwyn East	[redacted]
3127	Mont Albert, Surrey Hills, Surrey Hills North	[redacted]
3165	Bentleigh East, Coatesville	[redacted]
3204	Bentleigh, McKinnon, Ormond, Patterson	[redacted]
3006	Southbank	[redacted]
3102	Kew East	[redacted]
3142	Hawksburn, Toorak	[redacted]
3182	St Kilda, St Kilda West	[redacted]

Table 4-6 provides the expenditure for each postcode for the period 2018 to 2022 and is developed from the volumes and unit rate for each postcode.

Table 4-6: Forecast – Low Pressure Mains Replacement Program 2018-2022 – Expenditure

Post Code	Suburb	2018	2019	2020	2021	2022	Total
3128	Box Hill, Box Hill Central, Box Hill South, Houston, Wattle Park	-	-	[redacted]	[redacted]	[redacted]	[redacted]
3129	Box Hill North, Kerrimuir, Mont Albert North	-	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
3104	Balwyn North, Greythorn	[redacted]	[redacted]	[redacted]	[redacted]	-	[redacted]
3175	Bangholme, Dandenong, Dandenong East, Dandenong North, Dandenong South, Dunearn	[redacted]	-	-	-	-	[redacted]
3174	Noble Park, Noble Park East, Noble Park North	[redacted]	[redacted]	-	-	-	[redacted]
3122	Auburn South, Hawthorn, Hawthorn North, Hawthorn West	[redacted]	[redacted]	[redacted]	-	-	[redacted]
3101	Cotham, Kew	-	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
3146	Glen Iris	[redacted]	[redacted]	[redacted]	[redacted]	-	[redacted]
3147	Ashburton, Ashwood	[redacted]	[redacted]	[redacted]	[redacted]	-	[redacted]
3145	Caulfield East, Central Park, Darling, Malvern East	[redacted]	-	[redacted]	-	-	[redacted]
3125	Bennettswood, Burwood, Surrey Hills South	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
3207	Garden City, Port Melbourne	[redacted]	-	-	-	-	[redacted]
3184	Brighton Road, Elwood	[redacted]	[redacted]	[redacted]	-	[redacted]	[redacted]
3192	Cheltenham, Cheltenham East, Cheltenham North, Southland Centre	[redacted]	-	-	-	-	[redacted]
3190	Highett	[redacted]	[redacted]	[redacted]	-	-	[redacted]
3189	Moorabbin, Wishart	-	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
3188	Hampton East, Hampton North	-	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
3187	Brighton East, North Road	-	[redacted]	-	[redacted]	[redacted]	[redacted]
3186	Brighton, Brighton North, Dendy	[redacted]	-	[redacted]	-	[redacted]	[redacted]
3103	Balwyn, Balwyn East	-	-	[redacted]	[redacted]	[redacted]	[redacted]
3127	Mont Albert, Surrey Hills, Surrey Hills North	-	-	-	-	[redacted]	[redacted]
3165	Bentleigh East, Coatesville	-	[redacted]	[redacted]	-	-	[redacted]
3204	Bentleigh ,McKinnon, Ormond, Patterson	-	[redacted]	-	[redacted]	[redacted]	[redacted]
3006	Southbank	-	[redacted]	-	-	-	[redacted]
3102	Kew East	-	-	-	[redacted]	-	[redacted]
3142	Hawksburn, Toorak	-	-	-	-	[redacted]	[redacted]
3182	St Kilda, St Kilda West	-	-	-	-	[redacted]	[redacted]
Totals		**$45,035**	**$42,305**	**$41,969**	**$42,746**	**$36,934**	**$208,988**

4.3. Medium Pressure Cast Iron Replacement Program

4.3.1. Introduction

As with the low pressure program, the principle driver of the medium pressure replacement program is the 'societal risk' posed from failure of cast iron mains and resulting risk of incidents leading to loss of life or significant property damage. The risk associated with cast iron is a quantifiable risk and it is accepted by both UK and US safety regulators that cast iron is an obsolete material.

For Multinet Gas 3% of its remaining cast iron mains, which equates to 33 km, are located within the medium pressure network. This program is seen as a high priority given the higher consequence from a medium pressure failure relative to a similar failure on a low pressure cast iron main.

4.3.2. Failure Analysis

As stated in Section 4.2.2, the primary mode of failure for cast iron mains is pipe fracture. It is catastrophic in nature and results in an uncontrolled release of gas. Cast iron 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[24] strength. The result is that the main breaks completely, typically into two pieces.

In comparison to the low pressure cast iron network, the medium pressure cast iron network consists of a higher proportion of larger diameter mains, greater than 150mm diameter (55% in the medium pressure vs 14% in the low pressure above 150mm). Typically cast iron mains greater than 150mm in diameter have a much greater wall thickness and as a result are less susceptible to failure from pipe fracture given the increased beam strength. However, while these larger diameter medium pressure cast iron mains have a lower probability of failure from fracture, in the case of Multinet Gas they are all deemed critical supply[25] mains and are all located within the inner urban areas of metropolitan Melbourne. This combination of higher operating pressures; critical supply and high density geographic location places these assets as "high risk" from a consequence perspective in comparison to that of the overall low pressure cast iron network. Additionally, these large diameter medium pressure cast iron mains present a challenge in stopping and plugging operations. Due to their higher operating pressures (typically 35 kPa and above) and larger diameters, speciality equipment known as 'Iris Stop Equipment' must be employed for all repair and alternation works. This equipment is also only available from a single service provider in Victoria putting the gas network at risk in both emergency and planned stop off and plugging operations.

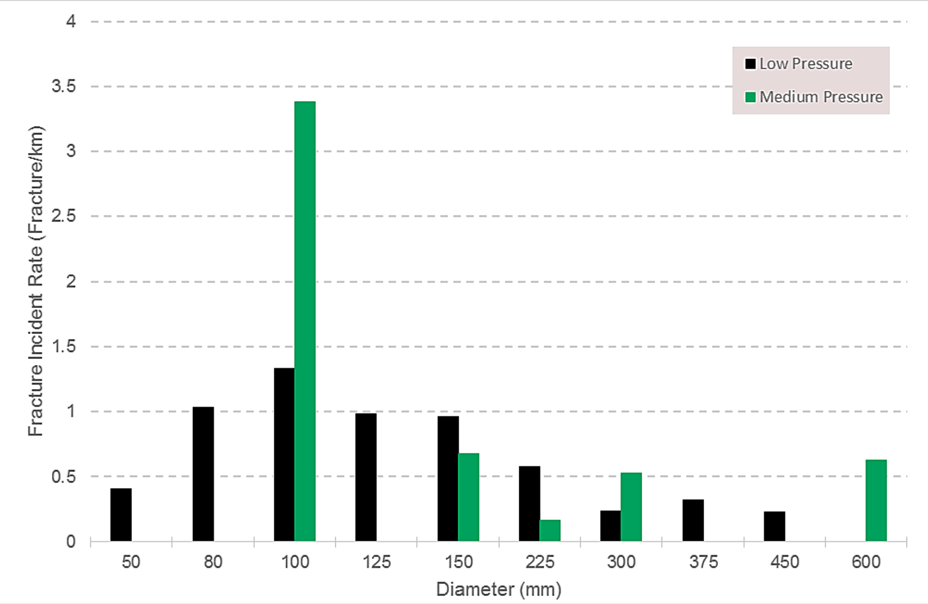
In relation to smaller diameter cast iron mains in the medium pressure network, main of 150mm in diameter or less, account for 45% of medium pressure cast iron. These smaller diameters are more susceptible to fracture based on lower beam strength to that of the larger mains and while they only account for a small proportion (less than 2% of the entire cast iron network), their fracture rates are similar if not higher for similar sized mains operating at low pressure. In the case of the 100mm diameter medium pressure cast iron mains, the fracture incident rate is 3.4, around 4 times the average fracture incident rate of 0.8 for cast iron low pressure.

Fracture incident rates for each diameter and pressure for cast iron from 2001 to 2015 is shown in Figure 4-6.

[24] 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.

[25] Also referred to as Trunk or Backbone mains.

Figure 4-6: Cast Iron Fracture Incident Rate Comparison by Pressure



4.3.3. Volumes and Prioritisation

The program will deliver the replacement / abandonment of the remaining 33 km of Multinet's medium pressure cast iron. The rate of medium pressure cast iron replacement will vary annually over the period, striking a balance between risk (resulting from further failures) and synergies with that of the low pressure replacement program. In general, prioritisation of the replacement of the medium pressure cast iron mains would be based on:

1. Fracture incident rates related to the medium pressure cast iron mains;
2. Immediate and future high pressure supply requirements; and
3. Achieving efficiencies via synergies with that of the low pressure replacement program.

However, in considering the above and factoring in the mix of locations and discreetness of each remaining section of cast iron, a balanced approach to prioritisation has needed to be adopted. This is provided in Table 4-7 which describes individual project details including the network, a brief description, diameter(s), length, project type and scheduled year. Project type is used to categorise projects as either discrete (D) where a scope and individual project estimate is provided or as combined with a low pressure project (L) resulting in complete abandonment on completion.

Table 4-7: Medium Pressure Cast Iron Prioritisation

Project	Network	Description	Dia. (mm)	Length (m)	Project Type	Due
Thompson Road, Bulleen 3105	M07	The completion of the LP to HP mains replacement capex program in the Bulleen and Kew area has reduced the demand on this MP main. As a result this section can be renewed and will be completed as part of the project known as 'Bulleen Grid Main' Refer to 2017 low pressure works in Table 4-3	300	2,218	D	2017
Bulleen Road, Balwyn North 3104	M07	This 2.5 km section of 450mm cast iron is an extension of the section in Thompson Road, Bulleen, separated by the steel crossing of the Eastern Freeway. Works included within the project known as 'Bulleen Grid Main' Refer to 2017 low pressure works in Table 4-3	450	2,548	D	2017
Clayton South 3169	M17	This project is based on 4.1 km section of medium pressure mains consisting of 3.2 km of cast iron. This project has been prioritise	100/150	3,201	D	2018

Project	Network	Description	Dia. (mm)	Length (m)	Project Type	Due
		based on the high fracture incident rate of 100mm medium pressure cast. Refer to Appendix 5.5.1.				
Graham Street, Port Melbourne 3207	M12	Consists of 7 km of cast iron located within Port Melbourne and Albert Park area. 3 km to be replaced as grid main to support low pressure replacement projects in Port Melbourne scheduled for 2018 to 2022. Refer to Appendix 0.	150/300	7,166	D	2018
Aughtie Drive, St Kilda 3128	M13	Consists of 5.5 km of large diameter cast iron stretching from St Kilda, through Elwood/Balaclava to Elsternwick. 4 km to be replaced as grid main to support low pressure replacement projects in Elwood and St Kilda scheduled for 2018 to 2022. Refer to Appendix 5.5.4.	450/600	5,527	D	2019
Like for Like	Various	Consists of 8.1 km of medium pressure, size for size replacement, known as 'Like for Like'. Provides the most efficiently delivery methodology to replacement dispersed lengths of cast iron mains. Refer to Appendix 5.5.2.	100/150	8,082	D	2020
Linda Crescent, Hawthorn 3122	M25	This 851m section of large diameter cast iron, the total of which is located in Riversdale Road, Hawthorn, is schedule to be abandoned as part of the low pressure project known as 'Linda Cr, Hawthorn'. Schedule for 2020, this is the final part of the replacement program of post codes 3122 totalling 39 km from 2018 to 2020.	225	851	L	2020
Ashburton Road, Glen Iris 3146	M15	This 3.1 km section of large diameter cast iron, the majority of which is located in Summerhill Road, Glen Iris, is schedule to be abandoned as part of the low pressure project known as 'Ashburton Rd, Glen Iris'. Schedule for 2021, this is the final part of the replacement program of post codes 3146 and 3147 totalling 62 km from 2018 to 2021.	225/300	3,075	L	2021
Total				**32,668**		

4.3.4. Scope

The medium pressure mains replacement program will target the replacement of Multinet Gas' remaining volume of cast iron operating at medium pressure. The program will complete the decommissioning of the remaining medium pressure gas distribution network and is considered a short term program scheduled for completion end 2021. It includes proactive replacement of medium pressure cast iron mains and, where applicable, associated consumer service installations with high pressure assets.

4.3.5. Business Drivers and Strategic Alignment

The primary drivers for this program are:

- To align with Multinet's Gas Network objectives to achieve safety and regulatory compliance;
- To maintain and improve safety by reducing the incidence of gas leaks, to the extent practicable, thereby mitigating the 'societal risk' posed from failure of cast iron mains and the resulting risk of incidents leading to loss of life or significant property damage;
- To maintain the integrity of customer service by eliminating supply losses arising from leak repair works;
- To maintain compliance with the Gas Safety Case which requires Multinet Gas to minimise (as far as reasonably practicable) the hazards and risk to the safety of the public and customers of gas supply, including the risk of property damage;
- To reduce environmental impacts from methane emissions associated with UAFG; and
- To maintain our capability to meet levels of demand in areas where medium pressure mains are unable to satisfy peak demand and/or allow for the connection of new customers.

Along with the above drivers, the removal of all medium pressure mains will enable existing specialised stop-off and plugging equipment referred to as Bag Tube and Iris Equipment to become redundant. This equipment, while still in use, is highly specialised especially in the case of the Iris Equipment. The equipment is also only available from a single service provider in Victoria putting the gas network at risk in both emergency and planning stop off, and plugging operations.

Consideration has gone into ensuring the delivery of this program is undertaken efficiently, and Multinet Gas will adopt a variety of methods which includes:

- synergies with the low pressure replacement program;
- renewal of large diameter medium pressure mains that can be utilised for future high pressure grid mains;
- block renewal where existing medium pressure cast iron mains are concentrated; and
- 'like for like' or piece meal replacement where the surrounding assets are still deemed within their useful life.

4.3.6. Works Program

The medium pressure mains replacement program aims to replace all cast iron mains operating at medium pressure.

The summarised works program is shown in Table 4-8, and includes the expenditure and volumes associated with the 4 discrete projects in the program.

Refer to Appendix 5.5 for details of each discrete project including high level scope, estimate and spatial map of the project.

Table 4-8: Forecast – Medium Pressure Cast Iron Capital Program 2018-2022 – Expenditure and Volumes

Program		2017	2018	2019	2020	2021	2022	Total
Clayton South, MP Block Renewal	Total	-	[redacted]	-	-	-	-	[redacted]
	Length (m)	-	[redacted]	-	-	-	-	[redacted]
Medium Pressure Like for Like	Total	-	-	-	[redacted]	-	-	[redacted]
	Length (m)	-	-	-	[redacted]	-	-	[redacted]
Graham Street, Port Melbourne	Total	-	[redacted]	-	-	-	-	[redacted]
	Length (m)	-	[redacted]	-	-	-	-	[redacted]
Aughtie Drive, St Kilda	Total	-	-	[redacted]	-	-	-	[redacted]
	Length (m)	-	-	[redacted]	-	-	-	[redacted]
Total Expenditure		**-**	**$7,247**	**$4,606**	**$6,275**	**-**	**-**	**$18,128**

4.4. Early First Generation High Density Polyethylene Replacement Program

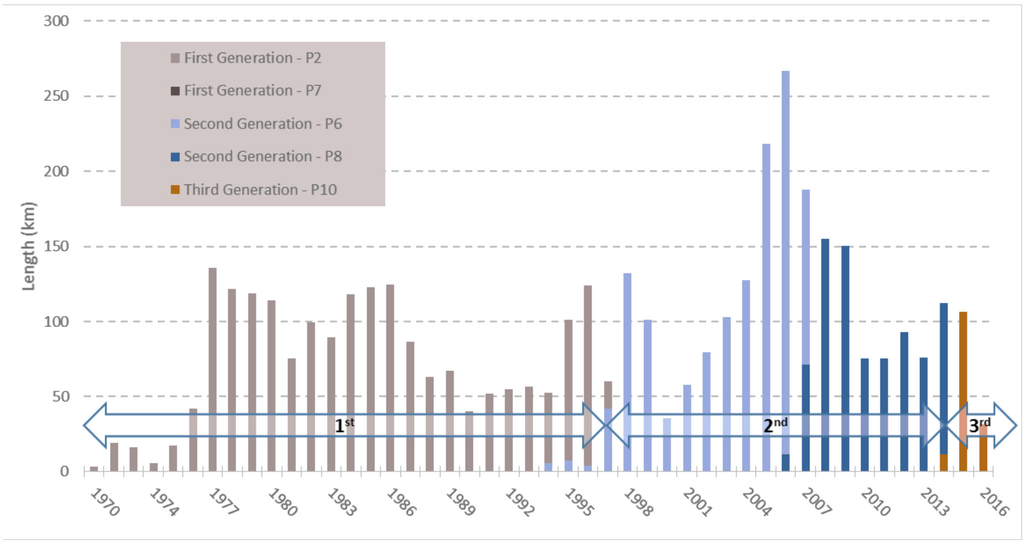
4.4.1. Introduction

Multinet Gas' distribution network consists of 4,416 km of polyethylene mains making up 44% of the total length of the distribution gas mains in the network. Polyethylene is the current dominant material of choice for Multinet and gas distribution companies worldwide, due to its flexibility, strength and low unit cost per metre. It is therefore considered - in the majority of applications - a highly cost effective solution when compared to traditional mains materials like steel.

In relation to asset performance, Multinet Gas' polyethylene mains network has the lowest leak incident rate per kilometre of any material on Multinet's gas distribution network. Leak incident rates for polyethylene mains have been less than 0.05 leaks/km/year from 2005 to 2015, and are comparable (if not slightly lower) of those for protected steel over the same period (Figure 2-6). Trends indicate polyethylene leak incident rates have reduced from 0.045 leaks/km/year in 2005 to just under 0.03 leaks/km/year in 2015. While this movement could be interpreted as an overall improvement in leak incident rates, it should be noted that the total length of the polyethylene network increased by 49%[26] (1,462 km) over the same period. As a result, the leak incident rate is considered that of a dynamic dataset and should be taken as a general indication of overall network performance. However, this is not directly comparable to that of static materials like cast iron, PVC and unprotected steel which are not used for network growth initiatives.

To better assess polyethylene performance, analysis is required by generation, which is typically defined by changes in material properties such as density, tensile strength, flexibility, ductility, slow crack growth resistance etc. The first generation of polyethylene mains were Type 50 and Type 63 High Density Polyethylene (HDPE); with a long term design stress of 5 MPa and 6.3 MPa respectively. Developments in polymers have resulted in second and third generation polyethylene pipes introduced, known as Medium Density Polyethylene (MDPE) or PE80B, and High Performance Polyethylene (HPPE) or PE100. Each generation has improved material properties when compared to the earlier, including improved flexibility, ductility, slow crack growth resistance and crack propagation resistance. Early or first generation polyethylene mains have properties which offer limited resistance against severe environmental and operating conditions.

Figure 4-7: Polyethylene Generation by Year



In relation to Multinet Gas, the first generation of polyethylene was introduced in the early 1970's. They were classified as Class 250 and Class 575 for operation at medium and high pressure respectively. The main difference between the class ratings is the variation in wall thickness with Class 250 having a thinner wall thickness than that of the Class 575 of the same nominal bore size. Class 250 and Class 575 mains were assigned Gas and Fuel Corporation material codes[27] of P2 and P7. The second generations (medium density polyethylene) were phased in around the mid 1990's and assigned material codes of P6 and P8. Currently in use is the third generation which was introduced in late 2014 and is referred to as P10. Figure 4-7 provides a summary of polyethylene material code and generation by length and installation year.

4.4.2. Failure Analysis

The general mode of field failure for polyethylene is brittle, slow crack growth through the pipe wall. These cracks can initiate at microscopic stress-raising flaws, inherent in the basic pipe product, or more likely from defects. Failure can also occur prematurely with mains damaged in squeeze-off operations where very high localised plastic deformations occurred from "over-squeezing". These squeeze–off failures are referred to as polyethylene fractures or breaks.

Analysis of polyethylene breaks between 2000 and 2015 indicate an increase in the volume of breaks (Figure 2-10). Further investigation of leak and break incident rates against the installed year of polyethylene mains shows high

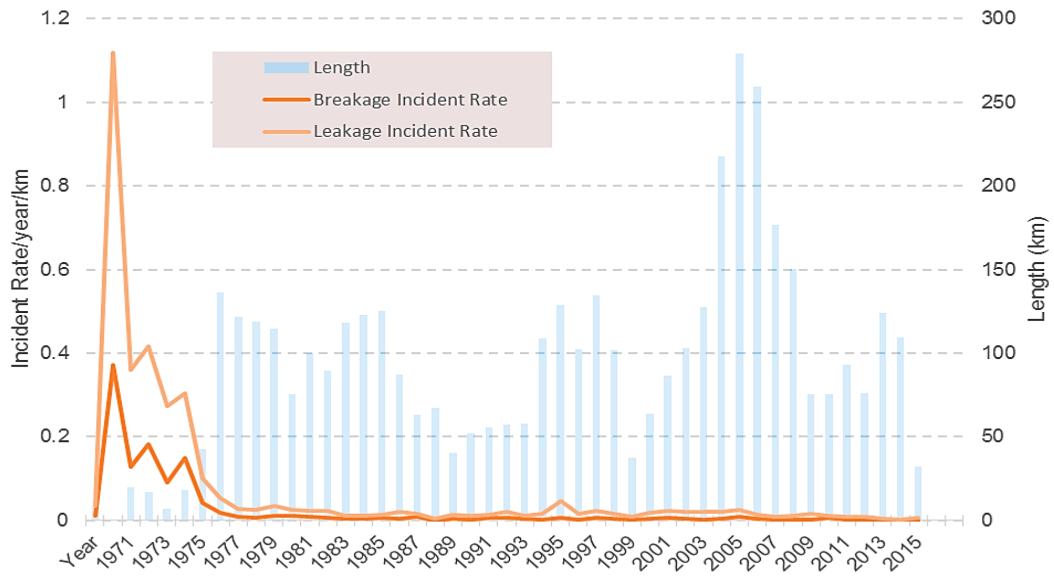
[26] Percentage change in polyethylene from 2005 of 49% based on polyethylene network length of 2,954 km in 2005 to 4,416 km in 2015.

[27] These material code, introduced by the Gas and Fuel Corporation are still in use by Multinet Gas. Refer to Table 5-5 for a complete description of material codes.

incident rates associated with early or first generation polyethylene mains (Figure 4-8), specifically those installed from the early 1970 to mid-1970 (pre 1976).

These first generation polyethylene mains have leak incident rates ranging from 0.2 leaks/km/year to 1.1 leaks/km/year, which is comparable to those for cast iron and unprotected steel (Figure 2-6). Based on these investigations, early installed first generation polyethylene mains have been identified for proactive replacement.

Figure 4-8: Polyethylene Leak and Break Incidents Rates by Year and Length Installed by Year

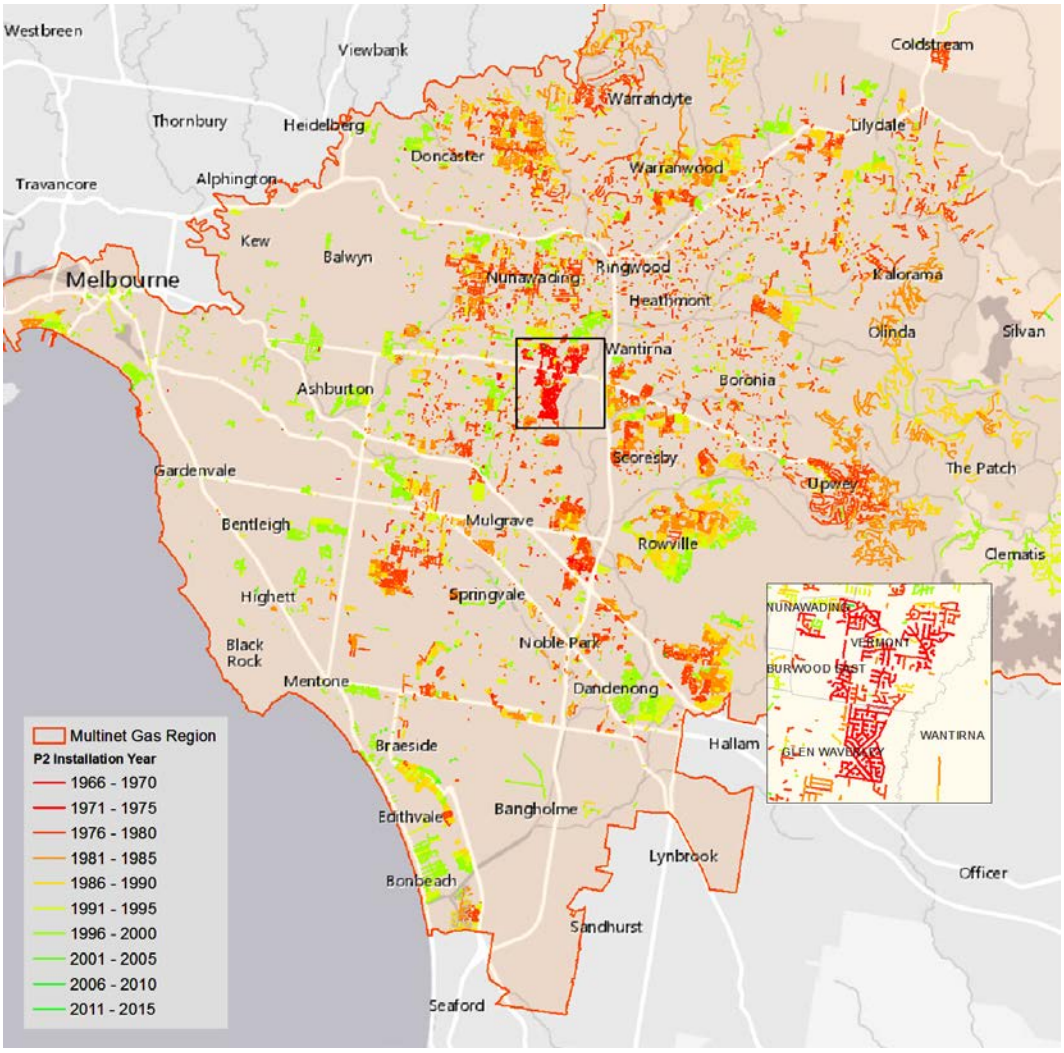


4.4.3. Volume and Prioritisation

To establish volume and prioritisation for the proactive replacement of early installed first generation polyethylene mains, a spatial dataset was developed to identify the geographic location of polyethylene mains according to their age (generation) and fault history (leak and break incident rates). Analysis was limited to that of the first generation polyethylene, categorised as material code P2[28]. Figure 4-9 provides a spatial map overview of the Multinet Gas distribution area for first generation polyethylene mains by year of installation. The spatial map shows the geographic concentration of the earliest (pre 1976) generation polyethylene mains in the postcodes of Glen Waverley 3150 and Vermont 3133. Pre 1976 mains account for around 60 km of the total polyethylene network with 48 km or around 80% of pre 1976 polyethylene being concentrated within these two postcodes.

[28] First generation P7 was excluded from spatial analysis as it accounts for a total of only 50m.

Figure 4-9: Spatial Map First Generation Polyethylene (P2) by Year Installed



Prioritisation of the replacement of early generation polyethylene mains is based on:

1. Breakage incident rates related to polyethylene mains; and
2. Leak incident rates.

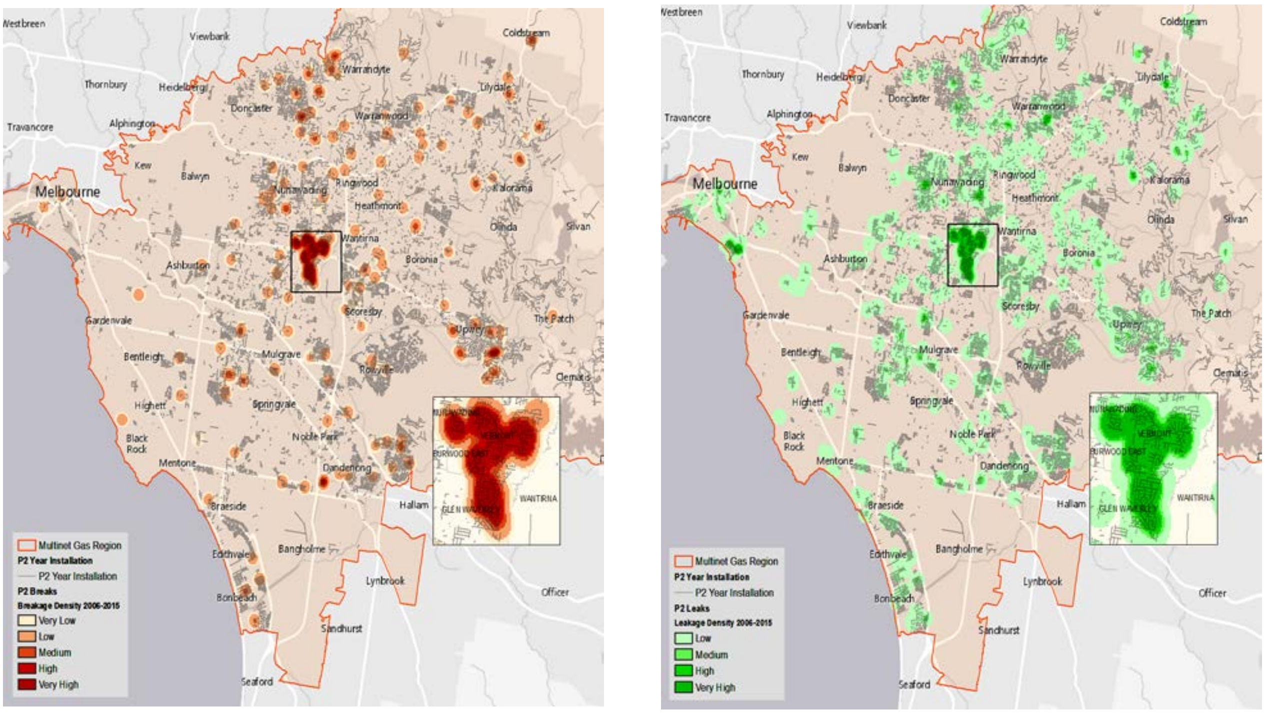
Incident rates, both breaks and leaks, are spatially mapped in Figure 4-10[29], which provides a clear picture of the concentration of historical early generation polyethylene failures within each postcode (Glen Waverley 3150 and Vermont 3133). Taking into consideration the geographic location of failures and having regard for:

- the availability or provision of high pressure assets;
- existing and future supply constraints; and
- the priority and volume of work for the low pressure and medium pressure cast iron programs.

The early generation polyethylene program has been developed to replace 31 km of early generation polyethylene scheduled in 2021 and 2022 as detailed in Section 4.4.6.

[29] Density spatial maps as provided in Figure 4-10 are developed with the use of ArcGIS kernel density spatial tool and break/leak incidents attributed to P2 polyethylene mains equipment over the period 2006 to 2015. Kernel based on cell size of 50 and search radius of 500m.

Figure 4-10: First Generation Polyethylene (P2) Breaks and Leaks Density Maps



4.4.4. Scope

The polyethylene mains replacement program targets the replacement of the earliest 31 km of early generation high density medium pressure polyethylene, schedule for completion in 2021 and 2022. The program provides for a partial replacement of the existing earliest generation high density polyethylene network and is considered a longer term program beyond 2022. It covers proactive replacement of early generation high density medium pressure polyethylene mains and associated consumer service installations with high pressure assets.

The program may be extended both in relation to volume of replacement and targeted class of polyethylene (250 and 575) subject to the results of this initial replacement program and further investigations and research on failure of early generation polyethylene mains.

4.4.5. Business Drivers and Strategic Alignment

The primary drivers for this program are:

- To align with Multinet's Gas Network objectives to achieve safety and regulatory compliance;
- To maintain and improve safety by reducing the incidence of gas leaks, to the extent practicable, thereby mitigating the risk posed from squeeze–off failures, resulting from brittle cracking of polyethylene mains and resulting risk of incidents leading to loss of life or significant property damage;
- To maintain the integrity of customer service by eliminating supply losses arising from leak repairs; and
- To maintain compliance with the Gas Safety Case which requires Multinet Gas to minimise - as far as reasonably practicable - the hazards and risk to the safety of the public and customers of gas supply, including the risk of property damage.

4.4.6. Works Program

Multinet Gas is to target replacement of the earliest 31 km of early generation medium pressure/high density polyethylene.

The overall summary of the works program is shown in Table 4-9 and provides the expenditure and volumes associated with the two projects. It should be noted that two lengths are provided in Table 4-9; project length and P2 length. The project length results from the delivery of the works based around a high pressure block replacement methodology and will therefore include a proportion of steel mains dependant on the area. This length is used to help form the basis of the project estimate. The P2 length is the length of early generation polyethylene which will be replaced as result of the project.

Refer to Appendix 5.5.5 and 5.5.6 for details of each discrete early generation polyethylene project including high level scope, estimate and spatial map of the project.

Table 4-9: Forecast - Early Generation Polyethylene Mains Replacement Capital Program - Expenditure

Project	Project Length (m)	P2 Length (m)	Total	Scheduled
King Arthur Drive, Glen Waverley 3150	[redacted]	[redacted]	[redacted]	2021
Weeden Drive, Vermont 3133	[redacted]	[redacted]	[redacted]	2022
Total	**40,008**	**31,414**	**$15,877**	

4.5. Reactive Mains Replacement Program

4.5.1. Introduction

Reactive mains replacement provides for an allocation of capital expenditure to allow for the piecemeal renewal of minor sections of mains outside the planned mains replacement programs. These minor works result when reactive maintenance (i.e. repairing a mains leak) is deemed unsafe and inefficient; considering the deteriorated condition of the asset which limits the effectiveness to repair the fault.

The program typically covers the replacement of mains sections less than 60m in geographical areas of the gas distribution network, where the planned mains replacement program is not scheduled to take place within the immediate future.

This program excludes mains replacement associated with the planned mains replacement programs. It also excludes reactive service replacements which are covered in the Distribution Services Strategy (MG-SP-0010), third party damages and customer initiated works.

Historically this work has been RIN (Regulatory Information Notice) reported as part of the Mains Replacement program. From calendar year 2017 they will be specifically recorded and reported separately as ‘Reactive Mains Replacement’.

4.5.2. Scope

The reactive mains replacement program is considered ongoing in nature. It covers reactive failure of mains assets and their replacement resulting from the inability to effect a cost efficient maintenance repair using existing materials, equipment and work practice techniques.

4.5.3. Business Drivers and Strategic Alignment

The primary drivers for this program are listed below:

- To align with Multinet Gas Network objectives to achieve safety and regulatory compliance; and
- To ensure ongoing asset integrity by reactively replacing mains where a repair is assessed as being ineffective.

4.5.4. Works Program

Multinet Gas is to maintain the current reactive replacement methodology, with the forecast rate of replacement expected to be in line with current practices. The overall summary of the works program is shown in Table 4-10.

Given that this program is reactive in nature, the work volume and expenditure will naturally vary from year to year. However, to enable a forecast of future expenditure requirement, the historical average of close to $200k per annum (over the period 2013 to 2015) has been adopted.

Refer to Section 5.4.3 for details of previous reactive mains replacement capital expenditure.

Table 4-10: Reactive Mains Replacement Capital Expenditure

Program	2017	2018	2019	2020	2021	2022
Reactive Mains Replacement	$200	$200	$200	$200	$200	$200
Total Expenditure	**$200**	**$200**	**$200**	**$200**	**$200**	**$200**

5. APPENDIX

5.1. Glossary and Definitions

Term	Meaning
AER	Australian Energy Regulator
CI	Cast Iron
City Gate Regulator	A City Gate Regulator can supply gas at an outlet pressure greater than 7 kPa and is supplied from a Class 600 Pipeline.
District Regulator	A District Regulator can supply gas to a reticulation system at an outlet pressure of up to 7 kPa.
ESV	Energy Safe Victoria
Field Regulator	A Field Regulator can supply gas at an outlet pressure greater than 7 kPa and is not supplied from a Class 600 Pipeline.
FIR	Fracture Incident Rate. Typically expressed as the number of recorded fracture incidents per annum per kilometre for cast iron mains.
GDSC	Gas Distribution System Code Version 11
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
GIS	Geospatial Information System
GFC	Gas and Fuel Corporation
km	Kilometres
kPa	Kilopascals
LIR	Leak Incident Rate. Typically expressed as the number of recorded leak incidents per annum per kilometre for mains.
Main	A principle pipe typically carrying water or gas to buildings. The use of main(s) and pipe(s) are interchangeable in this document.
MAOP	Maximum Allowable Operating Pressure
MG	Multinet Gas
OH	Overhead
PTS	Principal Transmission System (PTS) consists of approximately 1,900 km of transmission pipelines covering Melbourne and central Victoria owned by APA Group and operated by AEMO. The majority of gas is supplied from the Longford facility in the Gippsland basin, with storage facilities that help meet demand during peak demand periods.
RIN	Regulatory Information Notice
SAP	Systems Applications and Products is an Enterprise Resource Planning tool which used at Multinet Gas for recording asset data and maintenance management.
SPR	Protected Steel - Refer to Material Classification Section 5.2
SUP	Unprotected Steel - Refer to Material Classification Section 5.2
TJ	Joule, 1 Giga Joule = 1,000,000 Joules, 1 Tera Joule = 1,000 Giga Joules

Term	Meaning
WBS	Work Break Down Structure is a cost object in SAP to capture project expenses. The WBS number provides a unique project identifier or reference.

5.2. Material Type Classification

5.2.1. 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 1800's with several independent utilities distributing coal gas, through the formation of the Gas and Fuel Corporation until the mid-1960's and introduction of natural gas in the late 1960's, to the current environment with 3 distribution companies by the dis-aggregation of the Gas and Fuel Corporation. The improvements in pipe technology and pipe materials are also reflected in the diverse range.

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

The cast iron mains originally laid by the pioneering companies were lead/hemp jointed. In the 1950's to 1960's 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, CI to PVC transition was via mechanical/O-ring compression fittings. Extension of the CI network was also mainly through PVC pipe.

The high pressure Mains laid since the 1950's 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 1960's. Coal tar enamels were superseded altogether by polyethylene coatings in the mid 1970's. Apart from coatings, a program for elimination of stray current instituted in the early 1970's and cathodic protection (CP), introduction in the mid 1970's, had a significant effect on arresting corrosion of steel mains. It is reported by Corrosion Protection Services that CP of all steel mains, medium and high pressure is now essentially complete.

Since the early 1970's polyethylene pipe has been used as mains for sizes 50mm 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 polyethylene 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 Multinet Gas has inherited much of the older parts of Melbourne, where most of the CI pipes and other pipes that have been in service for over 50 years, most of the older pipes are within the Multinet Gas boundary limits.

5.2.2. Classification of Mains

Pipe Type	Typical Service Pressure[30]	Approximate Period of Installation	Method of Jointing Pipe Lengths
Cast Iron-Lead joint	LP and MP[31]	1890 to 1950	Socket-Spigot + lead / hemp
Cast Iron-Mechanical Jointed	LP and MP[31]	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[32]
Polyethylene (pre 1980) CI.250/CI 500	LP/MP and HP	1975 to 1980	Fusion Welding

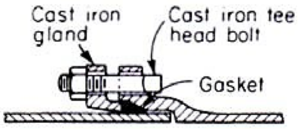
5.2.3. Cast Iron

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 CI 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 Figure 5-1

Figure 5-1: Cast Iron Joint Types



Typical Mechanical joint

Typical bell-and-spigot joint

5.2.4. Ductile Iron

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.

5.2.5. Wrought Iron

Wrought iron has lower carbon content than that of cast iron. This 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.

[30] Refer to Table 2-2 for pressure ranges for each pressure tier.
[31] Used also at the lower end of the MP operating range.
[32] Also used in coils>100m, reducing the need for jointing.

Wrought Iron is classed similarly to that of Unprotected Steel.

5.2.6. Asbestos / Fibro Cement

According the information provided by the GIS, there are no longer any asbestos cement mains within Multinet Gas

5.2.7. 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 Multinet Gas 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 it's 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.

5.2.8. Polyethylene

Polyethylene mains since their introduction in the 1970's now accounts for a large proportion of the total distribution mains in the network. 63mm 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). Polyethylene is available in a large range of sizes with the largest size used in the distribution network being 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 Polyethylene)

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.

Life

Polyethylene mains are tested for a minimum life of 50 years. As with most mains the life is affected by the quality of construction during installation. With this in mind the majority of polyethylene mains should perform well. The exception to this will be the early generation polyethylene which are discussed in great detail in Section 4.4.

Maintenance Issues

The majority of 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 by the use of the squash-off jacks after a period of time. 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.

5.2.9. 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 considered to be 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.

5.2.10. Protected Steel

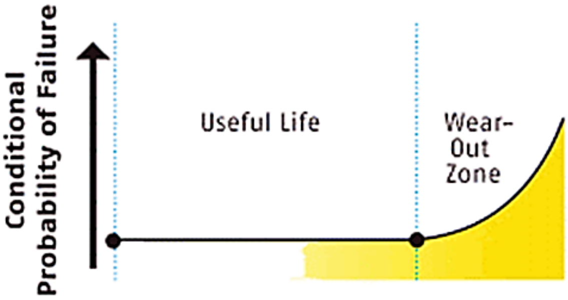
Coated steel in both screwed and welded are dependent on the corrosion protection coating. The coatings are regarded as having an effectively indefinite life. The main cause of degradation of the pipe coating is third party damage. The effective life of this piping system is determined by the faults 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.

5.3. Technical Life Model

The Technical Life Model assigns a life to all distribution mains segments that are currently live[33] 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 Figure 5-2. For the purposes of modelling a simplistic approach of a likely life is to be 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'. This data is provided in the Section 2.3.5 which provides Figure 2-3 showing the modelled failure profile of the gas distribution network and also the volume of 'early failures'. Additionally Figure 5-4 provides an overall spatial view of the distribution network depicting areas of early failures.

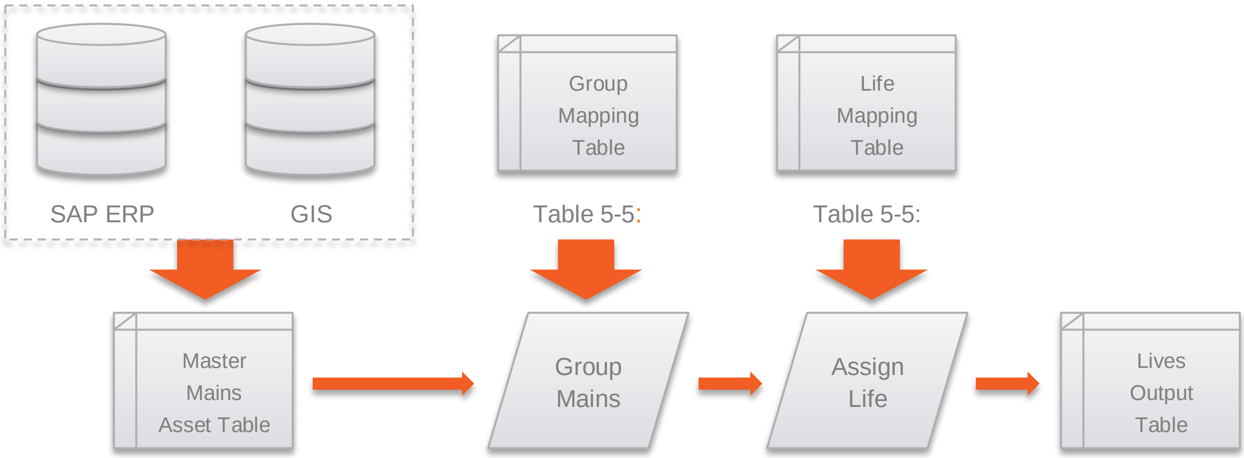
Figure 5-2: Conditional Probability of Failure



5.3.1. 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 Figure 5-3 and an example is provide in Section 5.3.2.

Figure 5-3: Technical Life Model Flow Chart



[33] Mains assets data extracted from SAP ERP and GIS systems for modelling purposes May 2016

5.3.2. Technical Life Model Example

Mains data is extract from SAP ERP and GIS. The follow is an example of such a mains record;

Table 5-1: Example Mains Record

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

In order 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 as provided in Table 5-5.

In the example provided in above the main would be grouped as Cast Iron Lead Jointed as the mains is C2 and installed prior to 1960.

Table 5-2: Example Mains Record Grouping

Equipment No.	Group	Pressure	Material Code	Diameter (mm)	Length (m)	Installation Year
26000001	**CI-LJ**	LP	C2	100	105	1953

The technical lives for the gas distribution network are based around a number of methodologies and reports which are provided in Table 5-4. The 'Failed Year' is determined by the addition of the 'Installation Year' and the assigned 'Technical Life'. In the example the technical life for a Cast Iron Lead Jointed of diameter 100mm is 75 years. This provides a failed year of 2028 (1953+75)

Table 5-3: 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**

5.3.3. Technical Life Spatial Map

Figure 5-4 provides an overview of the categorised failed mains based on technical life for the entire Multinet Gas distribution network. Mains have been categorised as failing prior to 2017 or 'Early Failures' which are shown in red and where they are forecast to fail within the period covered by this strategy (2017 to 2022) they are shown as a lighter shade of red. Table 2-6 has 1,033km of low pressure failing prior to 2017. This large proportion of failed low pressure is evident when Figure 5-4 is compared to the mains pressure map shown in Figure 5-5, where low, medium and high pressure are depicted respectively as grey, green and blue.

Figure 5-4: Mains Technical Life Spatial Map

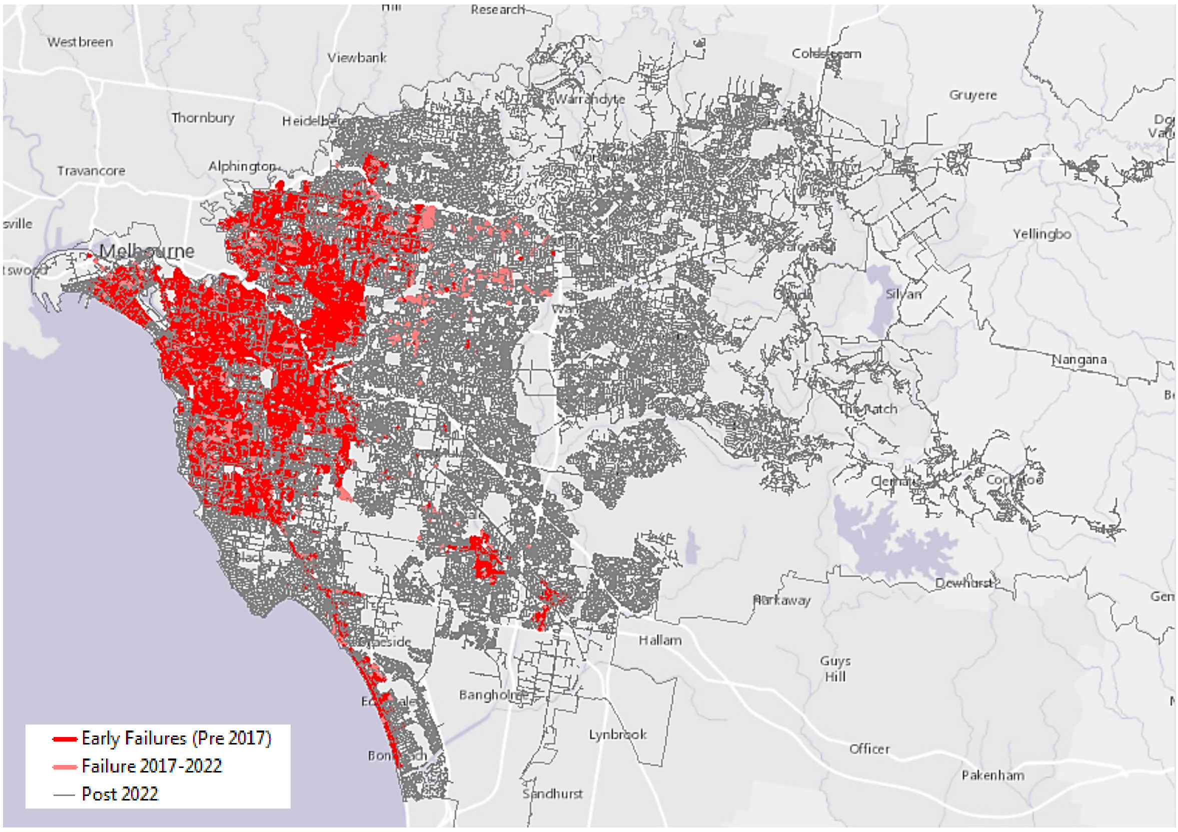
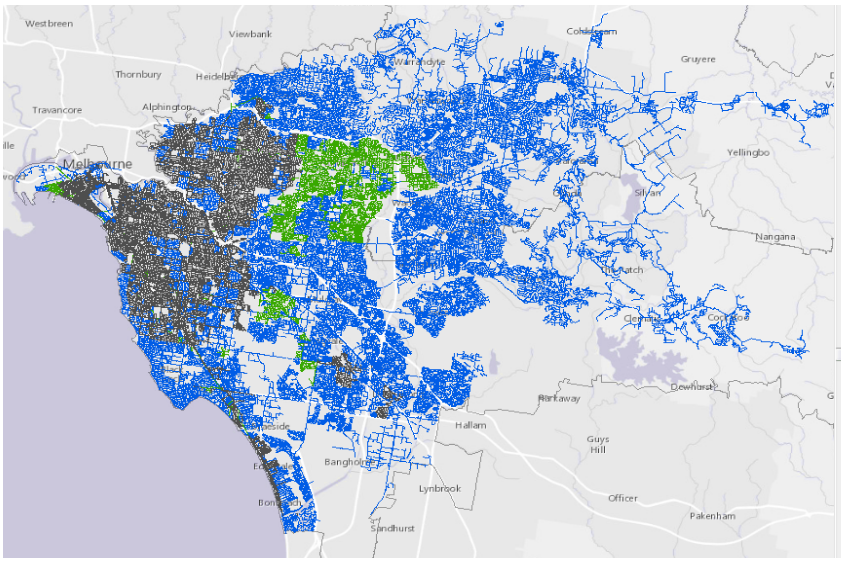


Figure 5-5: Mains Pressure Spatial Map



5.3.4. Technical Life Material Group Mapping

Table 5-4 provides the technical lives for each material group including an asset group description, wall thickness range, coating type, diameter .range and reference.

Table 5-4: Forecast Technical Life Mapping Table

Group	Asset Group	Wall Thickness/Coating Type	Diameter Range	Technical Life	Reference[34]
CI-LJ	Cast Iron Main Lead Joint	Thin	0-225mm	75[35]	GHD
		Medium	250 -300mm	100	GHD
		Thick	375-900mm	120	GHD
CI-M	Cast Iron Main Mechanical Joint	Thin	0-225mm	50	GHD
		Medium	250-300mm	70	GHD
		Thick	375-900mm	80	GHD
SUP	Unprotected Steel	-	-	60	GHD
SPR	Protected Steel – Pre 1930	Pre' 1930 Aspb/Bit	-	100	D. J. Bartlett
SPR	Protected Steel – 1930 to 1949	Coal Tar	-	110	
SPR	Protected Steel – 1950 to 1969	Coal Tar Enamel	-	110	
SPR	Protected Steel – 1970 to 1979	Coal Tar Enamel	-	120	
SPR	Protected Steel – 1980	Extr. PE	-	140	
PVC	Poly Vinyl Chloride	-	-	60	GHD
PE	Polyethylene	-	-	60	GHD

[34] GHD: Sinclair Knight Merz was engaged jointly by the Office of the Regulatory General and the Australian Competition and Consumer Commission on 9th January 1998 to review the Asset Valuations of 20 June 1997 for the gas transmission and distribution entities which include Multinet. This report is known as the 'ODRC Asset Valuation Review 1998'. The technical lives detailed in the Table 5.8 of the 'ODRC Asset Valuation Review 1998' are based on detailed methodologies that were specified by Gascor and GTC but were modified by GHD based on assessments of pipeline economic life by the National Institute of Economic and Industry Research (NIEIR). D.J.Bartlett: Report development by D.J.Bartlett, Scientific Services Laboratory, Gascor. This report is the reference for the methodologies and lives adopted by Gascor for Cast Iron and Steel pipes. It aligns with those lives reported in Table 5.8 of the 'ODRC Asset Valuation Review 1998 for Cast Iron pipes. Lives for steel mains are expanded on in this report based on age, coating type and cathodic protection status. Lives stated align well with those reported by GHD.

[35] Life for Cast Iron Lead Joint 0-225mm of 75 years taken as median of the live for 18-50mm of 70 years and 100mm to 225mm of 80 year. Lives taken from Table 5.8 of the 'ODRC Asset Valuation Review 1998'.

5.3.5. Technical Life Material Type Classification and Group Mapping

Table 5-5 provides the mapping association between the Multinet Gas internally assigned pipe material and grouping code. It also provides a description of the material including coating and jointing type where applicable.

Table 5-5: Material Type Mapping Table

Material Code	Description	Code[36]	Group	Length (m)	Length (%)
C2	Cast Iron (Type of Joint Unknown)	M	Pre. 1960, CI-LJ, else CI-M	898,538	9.29%
C3	Cast Iron Mechanical Joint	M,U	CI-M	170,758	1.77%
C4	Cast Iron Southern	M,U		2,387	0.02%
C5	Cast Iron A.I.S	M,U		1,590	0.02%
C6	Cast Iron Metters Clow	M,U		451	0.00%
C7	Cast Iron Staveley	M,U		863	0.01%
C8	Cast Iron Stanton	M,U		3,374	0.03%
C9	Cast Iron Stanton-Staveley	M,U		113	0.00%
C10	Cast Iron Lead Jointed	L,U	CI-LJ	119,833	1.24%
D2	Ductile Iron - Uncoated	M,U	CI-M	410	0.00%
D3	Ductile Iron - Plastic Coated	-		-	-
F2	Fibro Cement	-	Pre. 1960, CI-LJ, else CI-M	-	-
P2	Plastic Polyethylene (P.E.)	B	PE	2,014,988	20.84%
P3	Plastic Poly Vinyl Chloride (P.V.C.)	S	PVC	600,721	6.21%
P4	Plastic Pipe Other- Low Pressure Only	-		-	-
P5	Plastic Impact Modified Poly Vinyl Chloride (P.V.C.)	S		4	0.00%
P6	Plastic Polyethylene (P.E.) CL 500 Medium Density	B,E	PE	1,396,321	14.44%
P7	Plastic Polyethylene (P.E.) CL 250 Medium Density	B,E		2,586	0.03%
P8	Plastic Polyethylene (P.E.) PE80B Metric	B,E		820,322	8.48%
P10	Plastic Polyethylene (P.E.) PE100 Metric	B,E		150,579	1.56%
S2	Steel (Coating or Joint Unknown)[37]	S	HP Is SPR, rest SUP	318,058	3.29%
S3	Steel Coated and Screwed[38]	S		56,920	0.59%
S4	Steel Coated and Welded	W	SPR	1,812,049	18.74%
S5	Steel Galvanised	W	SUP	43,957	0.45%
S6	Steel Coated Gibault Joint			1,269	0.01%
S7	Steel Plastic Coated and Welded (Internally Linked)	W	SPR	1,248,562	12.91%
S8	Steel Plastic Coated and Screwed	S		173	0.00%
S9	Steel Interpon F.B.E. (Fusion Bond Epoxy)	W		95	0.00%
S10	Steel Napgard F.B.E. (Fusion Bond Epoxy)	W		583	0.01%
W2	Wrought Iron Galvanised	S	SUP	4,860	0.05%

[36] M – Mechanical Joint, W – Welded Joint, S – Screwed Joint, U – Uncoated, C - Coated

[37] All high pressure (HP) protected, unprotected for rest (CP or coating applied not known)

[38] All HP protected, unprotected for cathodic protection(CP) but has enamel (1950-69) rather than PE coating

5.4. Forecast Unit Rates

5.4.1. Introduction

In determining the unit rates to apply to our forecast mains replacement capex we have used four main methods. In order of preference the methods are as follows:

- to undertake a two party tender using our competitively sourced service providers. We can only 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;
- where two party tender is not practical, we rely on actual historical rates where we have previously undertaken work in the postcode;
- where we have not previously undertaken works we engage our independent estimator; or
- we undertake postcode density correlation to establish unit rates in similar postcodes based on actual historical rates.

In relation to forecasting our capital expenditure for supply regulators within this strategy we have adopted an internal estimate bottom up build methodology and where available performed a comparison with historical projects similar in type.

We note that our 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 aforementioned methodologies.

For each of the four expenditure programs, we have adopted one or more of the above methods in establishing the expenditure of the program. These are summarised below and detailed further in this section:

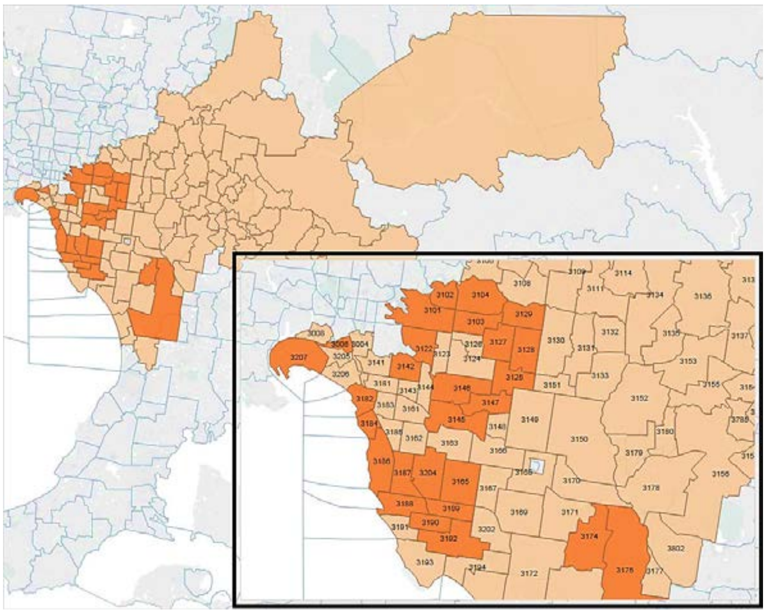
- Low Pressure replacement program has been estimated based on a mix of the unit rate methods and is detailed further in Section 5.4.2.;
- Medium Pressure Cast Iron replacement program has been estimated by our Independent Estimator for the main replacement components and internal estimate for the supply regulator estimates. Details for each project estimate are provided in Section 5.5.;
- Early Generation High Density Polyethylene replacement program has been estimated by our Independent Estimator. Details for each project estimate are provided in Section 5.5.; and
- Reactive replacement is unplanned and is therefore forecast based on historical expenditure. This detailed further in Section 5.4.3.

5.4.2. Unit Rate Low Pressure Mains Replacement Projects

Postcodes and Lengths

The targeted low pressure replacement projects for the 2018 to 2022 period are resigned to 27 postcodes as geographically shown in Figure 5-6. Their volumes, as detailed in Table 4-4, collectively make up the 625 km of low pressure replacement for the 5 year period.

Figure 5-6: Low Pressure Target Postcode Map



Unit Rate based on Tender and Historical Rates

As stated in Section 5.4.1 above, forecasting preference is given to two party tender using our competitively sourced service providers or actual historical rates where we have previously undertaken work in the postcode. Of the 27 postcodes in the 2018 to 2022 period, 10 have related works where we are able to forecast using these methods. These 10 postcodes are shown spatially in Figure 5-7.

Figure 5-7: Postcode where work previously undertaken - Map

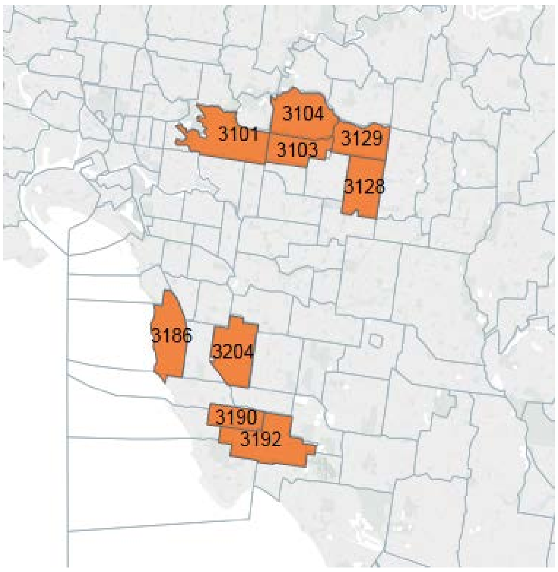


Table 5-6 provides the unit rate for each of the 10 postcodes where works have been undertaken previously and are to take place in the period 2018 to 2022.

Table 5-6: Postcode Unit Rate based on Tender and Historical

Post Code	Suburb	Unit/Rate ($/m)	Tender	Historical	Source
3101	Cotham, Kew	[redacted]	X	X	#16-003 Kew East LP to HP Upgrading. Historical #16-060 Kew East to Kew. Historical #16-094 Kew Part 1. Two Party Tender. #16-103 Kew Part 2 (Item 4B). Two Party Tender Average of unit rates of above projects
3103	Balwyn, Balwyn East	[redacted]	X		#15-025 Canterbury-Balwyn. Two Party Tender
3104	Balwyn North, Greythorn	[redacted]	X		#16-104 Balwyn North Cleanup. Two Party Tender
3128	Box Hill, Box Hill Central, Box Hill South, Houston, Wattle Park	[redacted]	X		#16-122 Balwyn North-Mont Albert Pt 1. Two Party Tender. Works took place in Box Hill, Box Hill South
3129	Box Hill North, Kerrimuir, Mont Albert North	[redacted]	X		#16-122 Balwyn North-Mont Albert Pt 1. Two Party Tender. Works took place in Box Hill, Box Hill South
3186	Brighton, Brighton North, Dendy	[redacted]		X	#15-078 Warleigh Gr, Brighton. Historical
3190	Highett	[redacted]		X	#13-026 Sandringham to Highett LP to HP. Historical
3192	Cheltenham, Cheltenham East, Cheltenham North, Southland Centre	[redacted]		X	#15-024 Mentone to Mordialloc #14-028 Highett to Cheltenham Average of above 2 unit rates
3204	Bentleigh, McKinnon, Ormond, Patterson	[redacted]	X		#16-099 McKinnon Upgrade. Two Party Tender

Unit Rate based on Independent Estimator

The unit rates for the following 5 postcodes, as detailed in Table 5-7, were estimated via consultation with an independent estimator. Reasons for this being are that there were no historical works in the following areas to analyse and determine unit rates. Furthermore, based on the density factor scale, a number of the areas were significantly higher and outside the normal density factor range of historical projects. As a result a suitable reference unit rate was not applicable. Density factor is detailed in the next section.

Figure 5-8: Postcode by independent estimator

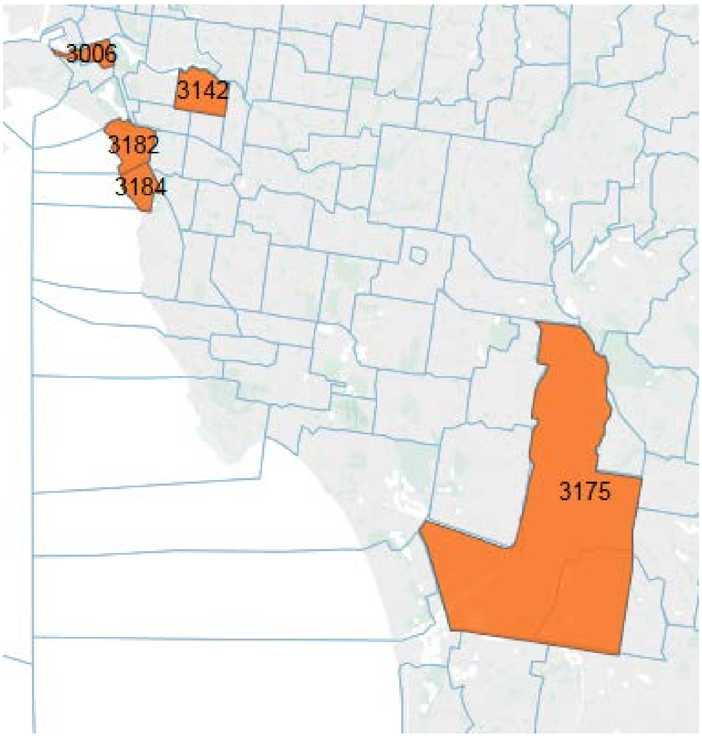


Table 5-7: Postcode Unit Rate based on Independent Estimator

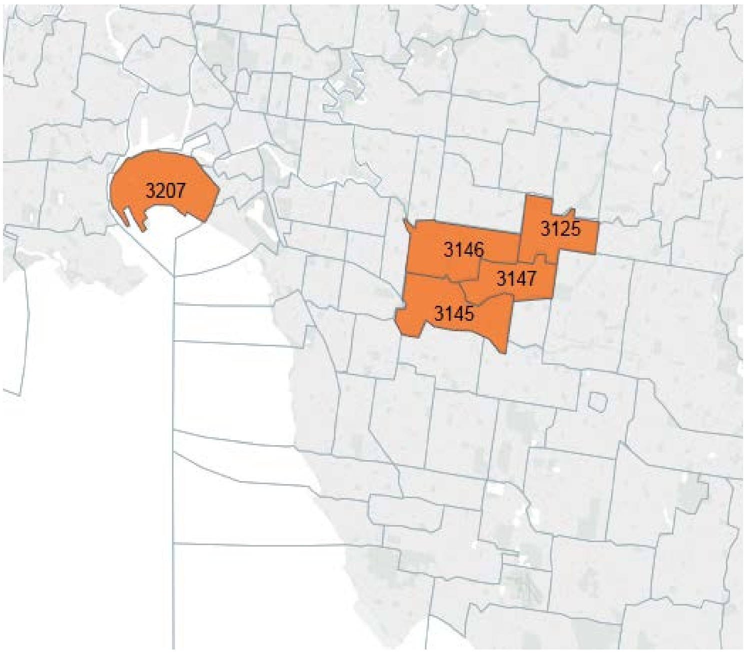
Post Code	Suburb	Unit/Rate ($/m)	Advisian Estimate Reference #
3006	Southbank	[redacted]	MG-2016-03
3142	Hawksburn, Toorak	[redacted]	MG-2016-04
3175	Bangholme, Dandenong, Dandenong East, Dandenong North, Dandenong South, Dunearn	[redacted]	MG-2016-01
3182	St Kilda, St Kilda West	[redacted]	MG-2016-02
3184	Brighton Road, Elwood	[redacted]	MG-2016-05

Unit Rate based on Density Factor

The unit rates for the following 5 postcodes, as spatially shown in Figure 5-9 and detailed in Table 5-8, were estimated using a density factor applied to an established unit rate from historical, tender or combination unit rates. The density factor was only applied to postcodes with similar dwelling densities[39] except where it was deemed that higher unit rates were acceptable.

[39] Dwelling density data sourced from ABS 2011 Census data

Figure 5-9: Postcode by Density Factors - Map



Density factors are based on ABS 2011 Census data which is used in conjunction with postcode data to derive a density factor for each relevant postcode:

$$Dwelling\ density = \frac{Number\ of\ dwellings}{Kilometer^2}$$

$$Density\ factor = \frac{Dwelling\ density\ (Target\ postcode)}{Dwelling\ density\ (Reference\ postcode)}$$

$$Target\ Unit\ Rate = Density\ factor\ x\ Reference\ Unit\ rate$$

Table 5-8: Postcode Unit Rate based on Density Factor

Post Code	Suburb	Unit/Rate ($/m)	Reference Postcode
3125	Bennettswood, Burwood, Surrey Hills South	[redacted]	3101, 3107, 3165
3145	Caulfield East, Central Park, Darling, Malvern East	[redacted]	3103, 3165, 3107, 3101
3146	Glen Iris	[redacted]	3103, 3165, 3107, 3101
3147	Ashburton, Ashwood	[redacted]	3103, 3165, 3107, 3101
3207	Garden City, Port Melbourne	[redacted] [40]	3101, 3165

[40] Density factors for 3207 were revised due to the nature of the dwellings in the postcode being concentrated in the works area.

Unit Rate based on Postcode Similarity

The unit rates for the following 7 postcodes, as spatially shown in Figure 5-10 and detailed in Table 5-9, were estimated based on similarity from field experience. Postcodes that have similar profiles from field experience would have identical unit rates and the corresponding methodology.

Figure 5-10: Postcode Similarity - Map

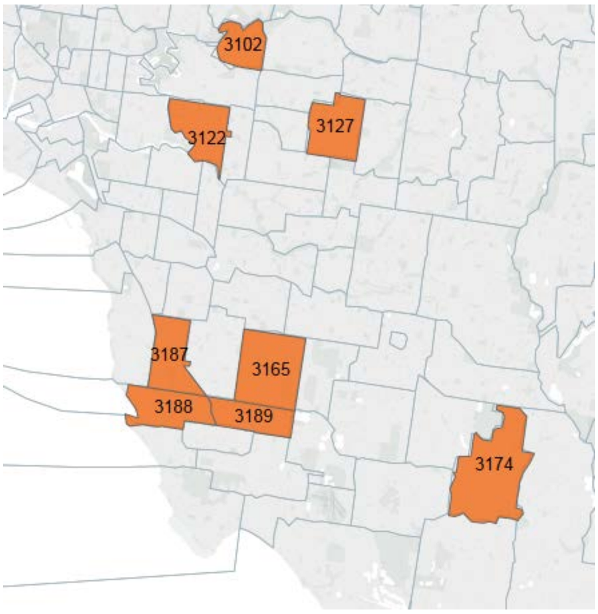


Table 5-9: Unit Rate based on Postcode Similarity

Post Code	Suburb	Unit/Rate ($/m)	Reference Postcode	Methodology
3102	Kew East	[redacted]	3101	#16-003 Kew East LP to HP Upgrading. Historical #16-060 Kew East to Kew. Historical #16-094 Kew Part 1. Two Party Tender. #16-103 Kew Part 2 (Item 4B). Two Party Tender Average of unit rates of above projects
3122	Auburn South, Hawthorn, Hawthorn North, Hawthorn West	[redacted]	3142	Advisian Independent Estimate #MG-2016-04
3127	Mont Albert, Surrey Hills, Surrey Hills North	[redacted]	3128,3129	#16-122 Balwyn North-Mont Albert Pt 1. Two Party Tender. Works took place in Box Hill, Box Hill South.
3165	Bentleigh East, Coatesville	[redacted]	3204	#16-099 McKinnon Upgrade Two Party Tender
3174	Noble Park, Noble Park East, Noble Park North	[redacted]	3175	Advisian Independent Estimate #MG-2016-01
3187	Brighton East, North Road	[redacted]	3204	#16-099 McKinnon Upgrade Two Party Tender
3188	Hampton East, Hampton North	[redacted]	3204	#16-099 McKinnon Upgrade Two Party Tender
3189	Moorabbin, Wishart	[redacted]	3204	#16-099 McKinnon Upgrade Two Party Tender

5.4.3. Unit Rate Reactive Mains Replacement Projects

The reactive mains replacement program is considered ongoing in nature. It covers reactive failure of mains assets and their replacement resulting from the inability to effect a maintenance repair using existing materials, equipment and work practice techniques.

The program typically covers the replacement of mains sections less than 60m in geographical areas of the gas distribution network where the planned mains replacement is not scheduled to take place within the immediate future.

Table 5-10 below provides the list of projects that have been carried out in calendar years inclusive from 2013-2015.

The total expenditure over the historical period in real $2017 was $564k which over the three year period averages to $188k per annum.

Table 5-10: Historical Reactive Mains Replacement Projects

Project Name	WBS	Length (m)	2013	2014	2015	Total ($2017)	Unit rate ($/m)
Harrow St, Box Hill	MG-COS-002895, MNG-002895	130.5	[redacted]			[redacted]	[redacted]
Cameron Ct, Kew	MG-COS-05099, MNG-05099	44	[redacted]			[redacted]	[redacted]
Guest St, Hawthorn	MG-COM-000019	162.9		[redacted]		[redacted]	[redacted]
Paget Street, Oakleigh	MG-COM-000048	485		[redacted]		[redacted]	[redacted]
Clarendon St, South Melbourne	MG-COM-000050	51.5		[redacted]		[redacted]	[redacted]
Virginia Cr, Caulfield South	MG-COM-000181	504			[redacted]	[redacted]	[redacted]
Yarra St, South Yarra	MG-COM-000096	503			[redacted]	[redacted]	[redacted]
Total (Real $2017)		**1,881**	**$62,680**	**$205,173**	**$272,323**	**$563,813**	

5.5. Discrete Project Scopes

5.5.1. Clayton South Medium Pressure Cast Iron Block Renewal, 3169 (M17)

This discrete project provides for the permanent abandonment of 3.2 km medium pressure cast iron mains in the Clayton South area and aligns with Multinet Gas's program to decommission all medium pressure cast iron by end 2021. Table 5-11 provides a breakdown of the diameter and length of cast iron main to be decommissioned.

Table 5-11: Clayton South Block Renewal - Length Decommissioned Cast Iron

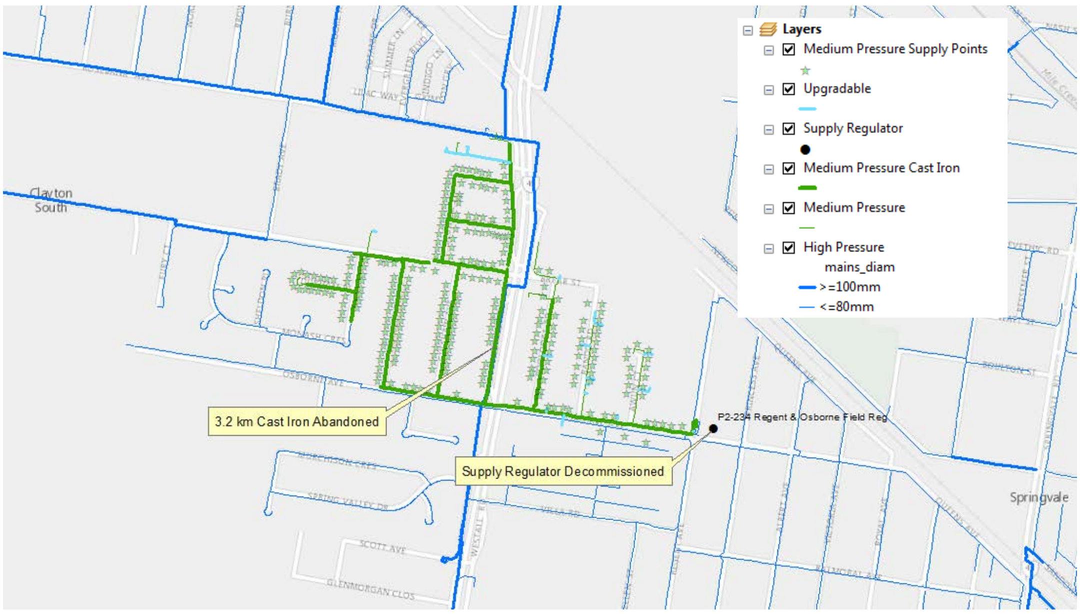
Diameter (mm)	Length (m) [41]
100	2,123
150	1,078
Total Length (m)	**3,201**

The project as shown in Figure 5-11 has been designed around a 'block' replacement methodology whereby a discrete section of approximately 4.1 km of medium pressure is replaced/upgraded with the resulting mains operated at high pressure. The project will result in the following:

- Abandonment of 3.2 km of aging medium pressure cast iron mains which constitute approximately 78% of the overall 4.1 km of main proposed for replacement;
- Decommissioning of the single area supplied field regulator known as P2-254 (Regent and Osborne); and
- Introduction of high pressure to meet current and future supply requirements in the area.

[redacted]

Figure 5-11: Clayton South– Project Plan Overview



[41] Length based on GE Smallworld 'computed length'

5.5.2. Like for Like Medium Pressure Cast Iron Project

This project provides for the permanent abandonment of 8 km medium pressure cast iron main and aligns with Multinet Gas's program to decommission all medium pressure cast iron by end 2021. Table 5-12 provides a breakdown of the diameter and length of cast iron main to be decommissioned.

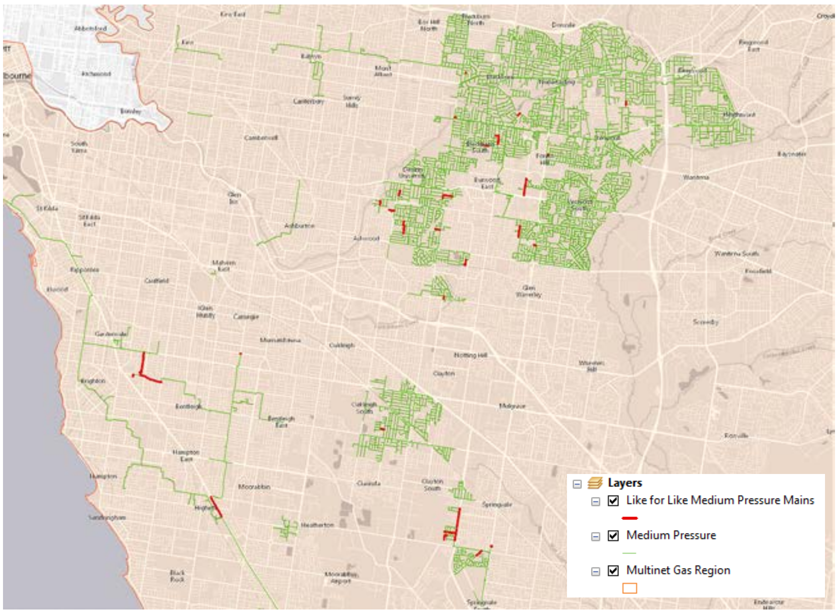
Table 5-12: Like for Like Medium Pressure - Length Decommissioned Cast Iron

Diameter (mm)	Length (m) [42]
Less 100	1,018
100	2,480
150	3,807
300	777
Total Length (m)	**8,082**

The 8 km is made up of minor sections of cast iron dispersed within the medium pressure networks as displayed in red in Figure 5-12. Given the geographic dissemination of the 8 km of cast iron, the most cost efficient delivery methodology of replacement is 'like for like'. This provides for direct replacement at the same operating pressure, in this case medium pressure, with an equivalent sized main. This has resulted in the development of 30 minor projects ranging from 9 to 1,667 metres in length. Table 5-13 provides a breakdown of the diameter and length of the existing cast iron main to be decommissioned along with the equivalent main size and material selected as replacement.

[redacted]

Figure 5-12: Like for Like Medium Pressure Cast Iron Project Map



[42] Length based on GE Smallworld 'computed length'

Table 5-13: Like for Like Medium Pressure Cast Iron Project List

Project	Cast Iron Diameter	63 PE	125 PE	180 PE	150 ST	300 ST	Length (m)
Blue Hills Avenue #3	50 mm	226					226
Cochrane Street #4	50 mm	88					88
Constance St and Gissing St #5	100 mm		375				375
Davison St and Midway St #6	100 mm		412				412
Elizabeths St, Francis St, Noel St and Union St#8	150 mm				1,667		1,667
Florence St #9	50 mm	190					190
Gyton Av #11	150 mm				380		380
Halley St #12	50 mm	96					96
Ireland Rd #14	100 mm	14					14
Leila Rd #15	300 mm					36	36
Mahoneys Rd #16	150 mm				557		557
Malabar Rd #17	50 mm	17					17
Middleborough Rd #18	25 mm	47					47
Middleborough #19	100 mm		87				87
Monomeith Cr #20	100 mm		138				138
Montpellier Rd #21	50 mm	107					107
Morrison St #22	50 mm	110					110
Mount Okeasant Rd #23	50 mm	75					75
Nepean Hwy #24	300 mm					742	742
Nettelbeck Rd #25	100 mm		405				405
Parkmore #26	50 mm	62					62
Peacock St #27	100 mm	160					160
Sandgate Rd #28	100 mm		230				230
Spring Rd #29	100 mm		232				232
Springvale Rd #30	150 mm			45			45
Tadstan Rd #31	100 mm		145				145
Taylor Av #32	100 mm		283				283
The Boulevard #33	150 mm				111		111
Vickery St #34	150 mm			9			9
Westall Rd #35	150 mm				1,037		1,037
Total Length (m)		**1,192**	**2,307**	**54**	**3,752**	**777**	**8,082**

5.5.3. Graham Street, Port Melbourne 3207 (M12)

This discrete project provides for the permanent abandonment of 7 km medium pressure cast iron mains in the Port Melbourne area and aligns with Multinet Gas's program to decommission all medium pressure cast iron by end 2021. Table 5-14 provides a breakdown of the diameter and length of cast iron main to be decommissioned.

Table 5-14: Graham Street, Port Melbourne - Length Decommissioned Cast Iron

Diameter (mm)	Length (m)[43]
100	716
150	3,648
225	42
300	2,597
Total Length (m)	**7,003**

The project as shown in Figure 5-13 has been designed to minimise the direct replacement of the medium pressure cast iron, requiring only 3.1 km of grid mains. These grid mains have been designed to be operated at high pressure in order to;

- Minimise the direct size for size replacement of the existing 300mm and 225 medium pressure cast iron mains to that of 180mm polyethylene;
- Meet high pressure supply requirements for the schedule 2018-2022 low pressure to high pressure mains replacement of Port Melbourne; and
- Meet future high pressure supply requirements for low pressure to high pressure mains replacement programs in Port Melbourne, South Melbourne and Albert Park scheduled for post 2022.

In order to upgrade the area to high pressure and realise the construction efficiencies and supply benefits, a new high pressure feed is required. This high pressure feed will be in the form of a new field regulator sized at 25,000 standard cubic metres per hour to be constructed at Multinet Gas' South Melbourne Depot and will eventually replace the existing field (P2-010) and district (P1-163) regulators. Independent Estimated pricing provided excludes the field regulator cost which has been developed based on an internal bottom up build estimate. The project scope overview is provided in Table 5-15 with costs summarised in Table 5-16.

Table 5-15: Graham Street, Port Melbourne – Project Scope Overview

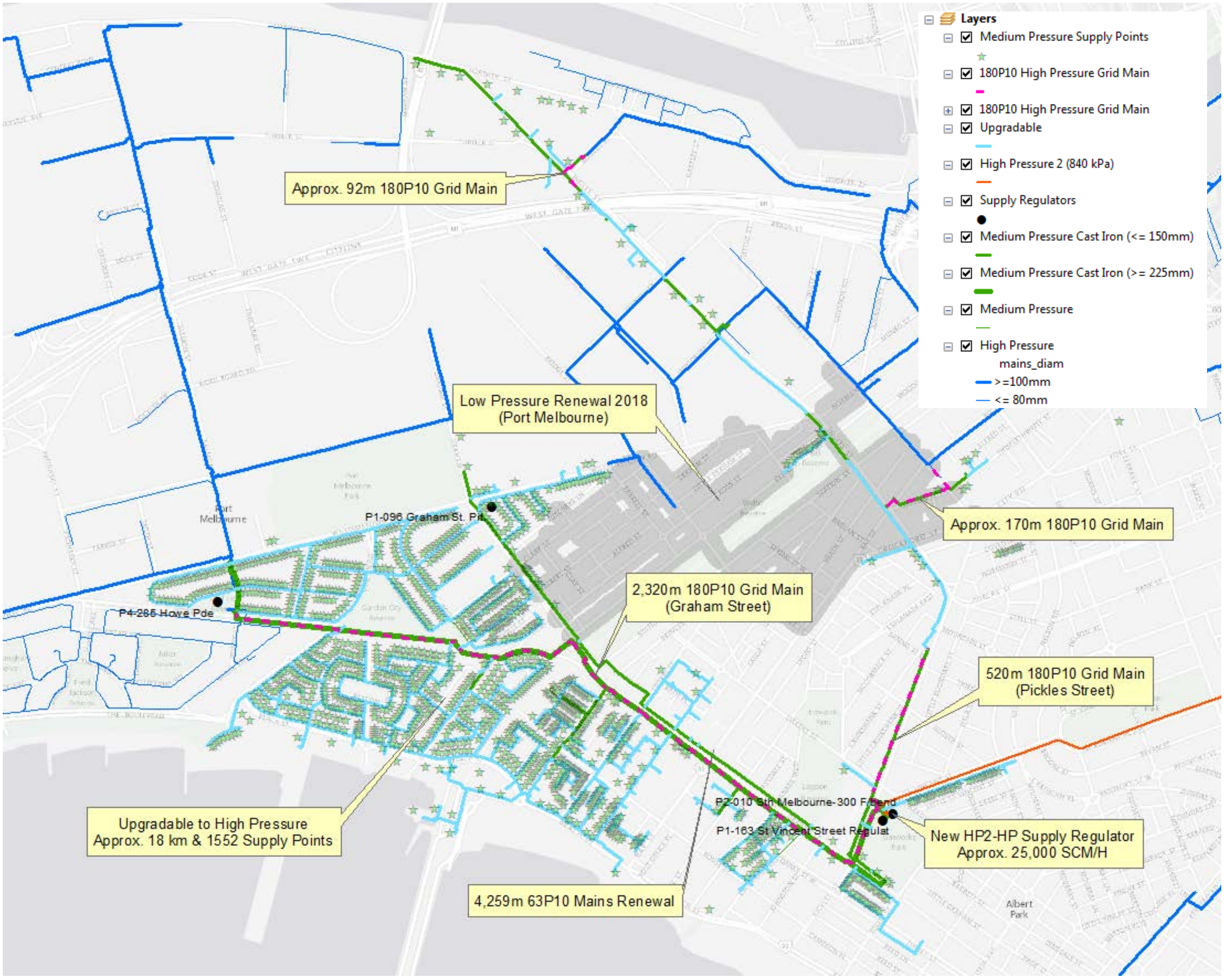
Item	Description	Length (m)
1	180P10 Grid Main (Graham Street, Pickles)	3,102
2	63P10 Main Renewal	4,259
3	Upgradable Mains (Medium Pressure to High Pressure)	17,789
4	Upgrade 1,552 Supply Points	
5	New HP2-HP Supply Regulator (≈ 25,000 SCM/H)	

[43] Length based on GE Smallworld 'computed length'

Table 5-16: Graham Street, Port Melbourne – Forecast Overview

Description	Total ($2016)	Total ($2017)
Items 1-4 (Mains and Services Works)	[redacted][44]	[redacted]
Item 5 (Supply Regulator)	[redacted][45]	[redacted]
Total		[redacted]

Figure 5-13: Graham Street, Port Melbourne – Project Plan Overview



[44] Pricing based on Advisian Estimate for Port Melbourne Renewal - Graham St, Reference MG-2016-06
[45] Pricing based on Supply Regulator Pit Estimate “GrahamSt_PortMelb_HP2-HP_PitEstimate”

5.5.4. Aughtie Drive, St Kilda 3128 (M13)

This discrete project provides for the permanent abandonment of 5.5 km medium pressure cast iron mains in the St Kilda, Balaclava and Elsternwick area and aligns with Multinet Gas's program to decommission all medium pressure cast iron by end 2021. Table 5-17 provides a breakdown of the diameter and length of cast iron main to be decommissioned.

Table 5-17: Aughtie Drive, St Kilda – Length Decommissioned Cast Iron

Diameter (mm)	Length (m)[43]
150	477
225	26
450	3,647
600	1,321
Total Length (m)	**5,471**

The project as shown in Figure 5-14 has been designed to minimise the direct replacement of the medium pressure cast iron, requiring only two sections of grid main, totalling 4 km in length. These grid mains have been designed to be operated at high pressure in order to;

- Minimise the direct size for size replacement of the existing 600mm and 450mm medium pressure cast iron mains to that of 300mm steel and 180mm polyethylene;
- Meet high pressure supply requirements for the schedule 2018-2022 low pressure to high pressure mains replacement of Elwood and St Kilda; and
- Meet future high pressure supply requirements for low pressure to high pressure mains replacement programs in Middle Park, Balaclava, Ripponlea and Elsternwick scheduled for post 2022.

The grid mains will initially replace the supply for existing four medium to low pressure district regulators that support the suburbs of Middle Park, Balaclava, Ripponlea and Elsternwick. This will require modifications to the existing district regulators, P1-156, P1-340, P1-188 and P1-874 that include but are not limited to inlet pipework, inlet valves and regulator replacement in order to meet the required inlet pressure increase from medium to high pressure. Additionally as part of the project the two existing medium pressure regulators, P2-110 and P2-007, will require significant modifications in order to meet supply requirements both current and future along with meeting proposed high pressure equipment and piping ratings.

Upon detailed assessment, where the existing pits are found not to be suitable due to internal volume constraints limiting the installation of larger regulators a new regulator station(s) will need to be constructed. Estimated pricing provided currently excludes this cost and has been developed based on the lowest technical cost which provides for the redesign and modification to the existing medium pressure supply points. These are summarised in Table 5-18.

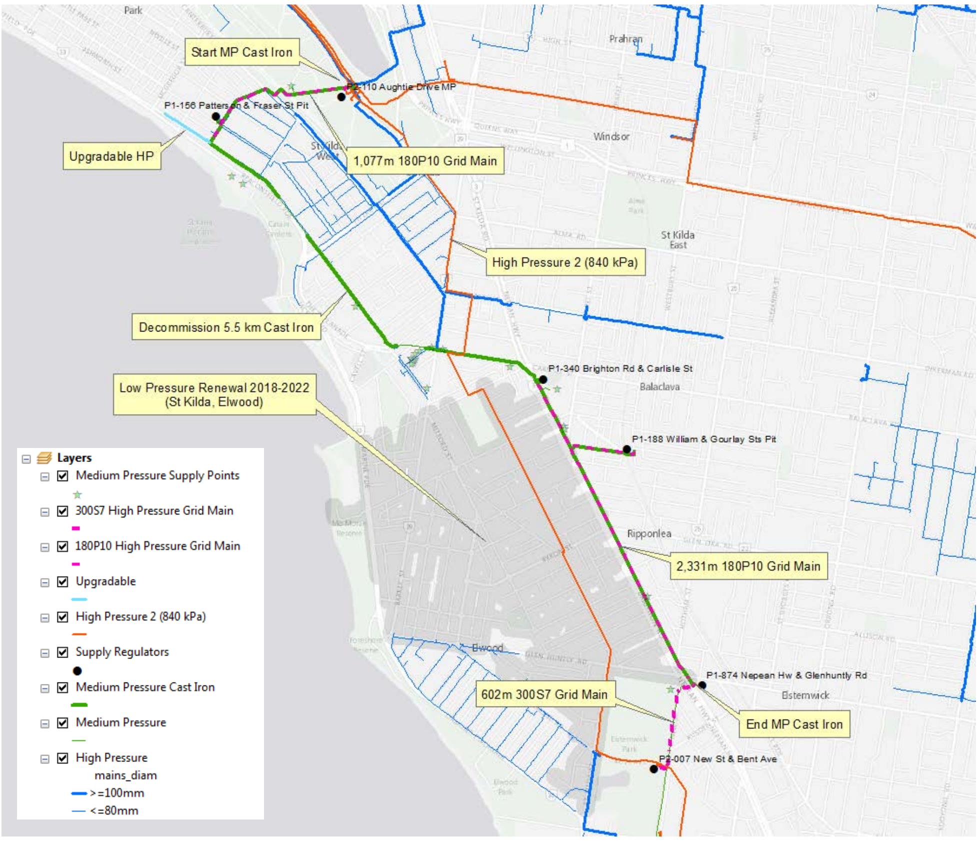
Table 5-18: Aughtie Drive, St Kilda – Project Scope and Forecast Overview

Description	Length (m)	Unit Rate ($2016)	Unit Rate ($2017)	Total ($2017)
180P10 Grid Main, Fed via P2-110, Supplying P1-156 (Northern Grid)	1,077	[redacted][46]	[redacted]	[redacted]
300S7 Grid Main, Fed via P2-007, Supplying P1-874 (Southern Grid)	602	[redacted][47]	[redacted]	[redacted]

[46] Pricing based on Advisian Estimate for Lorimer Street, Docklands, Reference MG-2016-21
[47] Pricing from Advisian Estimate for Darling Road, Docklands, Reference MG-2016-14

Description	Length (m)	Unit Rate ($2016)	Unit Rate ($2017)	Total ($2017)
180P10 Grid Main, Fed via 300S7, Supplying P1-188 and P1-340 (Southern Grid)	2,331	[redacted][46]	[redacted]	[redacted]
Medium Pressure Services Transfer, MP to LP and MP to HP, Approx. 21 based on GIS MP supply point data.			[redacted]	[redacted]
Regulator Modifications to P2-110, P2-007, P1-156, P1-340, P1-188 and P1-874				[redacted][48]
Total	**4,010**			**XXXXX**

Figure 5-14: Aughtie Drive, St Kilda – Project Plan Overview



[48] Pricing based on Supply Regulator Pit Estimate "Aughtie Dr_Regulators_Modification_Estimate"

5.5.5. King Arthur Drive, Glen Waverley 3150 (M43)

This discrete project provides for the permanent abandonment of 20.4 km medium pressure early generation polyethylene mains in the Glen Waverley area and aligns with Multinet Gas's program to target the highest risk earliest generation polyethylene mains by end 2022. Table 5-19 provides a breakdown of the year laid (decade) and length of early generation polyethylene main to be decommissioned.

Table 5-19: King Arthur Drive, Glen Waverley – Project Lengths

Material	Year Laid (Decade)	Length (m)
P2 Polyethylene	1970	20,401
P2 Polyethylene	1980	17
P2 Polyethylene	1990	40
Total		**20,458**

The project as shown in Figure 5-15 has been designed around a 'block' replacement methodology whereby a discrete section of approximately 20.4 km of medium pressure is replaced/upgraded with the resulting mains operated at high pressure. The project will result in the following:

- abandonment of 20.4 km of early generation polyethylene; and
- introduction of high pressure to meet current and future supply requirements in the area.

[redacted]

Figure 5-15: King Arthur Drive, Glen Waverley – Project Plan Overview

5.5.6. Weeden Drive, Vermont 3133 (M43)

This discrete project provides for the permanent abandonment of 11 km medium pressure early generation polyethylene mains in the Vermont area and aligns with Multinet Gas's program to target the highest risk earliest generation polyethylene mains by end 2022. Table 5-20 provides a breakdown of the year laid (decade) and length of early generation polyethylene main to be decommissioned.

Table 5-20: Weeden Drive, Vermont – Project Lengths

Material	Year Laid (Decade)	Length (m)
P2 Polyethylene	1970	11,013
P6 Polyethylene	2000	168
S2 Steel		1,586
S4 Steel		1,206
S7 Steel		3,686
Total Length (m)		**17,659**

The project as shown in Figure 5-16 has been designed around a 'block' replacement methodology whereby a discrete section of approximately 17.7 km of medium pressure is replaced/upgraded with the resulting mains operated at high pressure. The project will result in the following:

- abandonment of 11 km of early generation polyethylene; and
- introduction of high pressure to meet current and future supply requirements in the area.

[redacted]

Figure 5-16: Weeden Drive, Vermont – Project Plan Overview

5.6. Low Pressure Prioritisation List

The following table provide the list of low pressure post codes ordered by aggregate facture and leak incident rates.

Table 5-21: Low Pressure Post Code Prioritisation List

Post Code	Suburb	FIR	LIR	Length (km)
3105	Bulleen	0.71	0.80	6.36
3108	Doncaster	0.47	0.54	9.52
3104	Balwyn North, Greythorn	0.32	0.59	50.93
3129	Box Hill North, Kerrimuir, Mont Albert North	0.21	0.37	45.74
3189	Moorabbin, Wishart	0.17	0.28	55.61
3174	Noble Park, Noble Park East, Noble Park North	0.17	0.38	35.63
3175	Bangholme, Dandenong, Dandenong East, Dandenong North, Dandenong South, Dunearn	0.16	0.60	22.18
3165	Bentleigh East, Coatesville	0.16	0.27	28.69
3103	Balwyn, Balwyn East	0.14	0.54	44.60
3188	Hampton East, Hampton North	0.14	0.34	29.67
3006	Southbank	0.12	0.65	9.09
3186	Brighton, Brighton North, Dendy	0.11	0.45	73.24
3122	Auburn South, Hawthorn, Hawthorn North, Hawthorn West	0.11	0.67	67.24
3184	Brighton Road, Elwood	0.11	0.86	27.77
3190	Highett	0.10	0.43	17.87
3204	Bentleigh, McKinnon, Ormond, Patterson	0.10	0.29	62.90
3125	Bennettswood, Burwood, Surrey Hills South	0.09	0.62	43.65
3128	Box Hill, Box Hill Central, Box Hill South, Houston, Wattle Park	0.09	0.45	48.75
3102	Kew East	0.08	0.46	30.25
3142	Hawksburn, Toorak	0.08	0.66	50.93
3147	Ashburton, Ashwood	0.08	0.52	24.62
3187	Brighton East, North Road	0.08	0.29	71.27
3205	South Melbourne	0.08	0.41	43.21
3167	Oakleigh South	0.07	0.18	38.19
3123	Auburn, Hawthorn East	0.06	0.46	43.49
3181	Prahran, Prahran East, Windsor	0.06	0.51	65.21
3182	St Kilda, St Kilda West	0.06	0.71	41.87
3146	Glen Iris	0.06	0.47	70.35
3183	Balaclava, St Kilda East	0.06	0.51	45.97
3185	Elsternwick, Gardenvale, Ripponlea	0.06	0.47	45.29
3126	Camberwell East, Canterbury	0.06	0.25	44.22
3101	Cotham, Kew	0.05	0.35	74.54
3127	Mont Albert, Surrey Hills, Surrey Hills North	0.05	0.17	84.69
3143	Armadale, Armadale North	0.05	0.49	33.68
3163	Carnegie, Glen Huntly, Murrumbeena	0.05	0.38	107.97
3144	Kooyong, Malvern, Malvern North	0.05	0.65	39.02
3206	Albert Park, Middle Park	0.05	0.25	51.51
3192	Cheltenham, Cheltenham East, Cheltenham North, Southland Centre	0.05	0.38	9.63
3166	Hughesdale, Huntingdale, Oakleigh, Oakleigh East	0.04	0.43	39.36
3141	Chapel Street North, South Yarra	0.04	0.66	54.96
3162	Caulfield, Caulfield South, Hopetoun Gardens	0.04	0.48	31.79
3161	Caulfield Junction, Caulfield North	0.04	0.30	40.38
3124	Camberwell, Camberwell North, Camberwell South, Camberwell West, Hartwell, Middle Camberwell	0.03	0.59	65.68
3145	Caulfield East, Central Park, Darling, Malvern East	0.03	0.34	73.24
3195	Aspendale, Aspendale Gardens, Braeside, Mordialloc, Parkdale, Waterways	0.03	0.25	38.58
3207	Garden City, Port Melbourne	0.03	0.36	29.19
3004	Melbourne	0.02	0.65	13.09
3194	Mentone, Mentone East, Moorabbin Airport	0.00	0.41	7.50
3196	Bonbeach, Chelsea, Chelsea Heights, Edithvale	0.00	0.24	25.73
3197	Carrum, Patterson Lakes	0.00	0.22	2.28
3133	Vermont, Vermont South	0.00	0.00	0.07
3168	Clayton, Notting Hill	0.00	0.00	1.16
3171	Sandown Village, Springvale	0.00	0.00	1.91
3172	Dingley Village, Springvale South	0.00	0.00	0.19
3193	Beaumaris, Black Rock, Black Rock North, Cromer	0.00	0.00	0.46
3202	Heatherton	0.00	0.00	0.03

5.7. List of Tables

5.8. List of Figures