ATTACHMENT 12.10
PVC MAINS REPLACEMENT STRATEGIC ANALYSIS AND MAINS REPLACEMENT PRIORITISATION TOOL OVERVIEW

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PVC MAINS REPLACEMENT STRATEGIC ANALYSIS AND MRP TOOL OVERVIEW

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Abbreviations

Abbreviation	Description
ATCO	ATCO Gas Australia
GDS	Gas Distribution System
GIS	Geographic Information System
km	Kilometre
kPa	Kilopascals
MAOP	Maximum Allowable Operating Pressure
MRP	Mains Replacement Prioritisation
OFGEM	of Gas and Electrical Markets
PA	Per Annum
PE	Polyethylene
RMAP	Risk Management Action Plan
uPVC	Un-plasticised Polyvinyl Chloride

Executive Summary

This document provides an overview of different asset management strategies considered by ATCO for the assessment and implementation of a PVC mains replacement program. The document consists of Part A, which provides a comparison of strategies and justification as to why a semi-quantitative risk assessment approach was selected, and Part B, which provides an overview of the application of the Mains Replacement Prioritisation Tool (**MRP**) Tool.

Part A

Various approaches were considered in order to ensure that the selected mains replacement strategy is such that would be undertaken by a prudent service provider acting efficiently, in accordance with good industry practice, to achieve the lowest sustainable cost of providing services.

Different approaches considered include:

- Condition based approach (Section 1.1);
- Comparable network qualitative risk assessment approach (Section 1.2):
- Age based approach (Section 1.3); and
- Semi-Quantitative Risk Assessment (**SQRA**) approach (Section 1.4).

ATCO considers that SQRA is the most suitable PVC mains replacement strategy. This approach was considered beneficial due its risk-based approach, reduced subjectivity, elimination of inconsistencies, and ability to provide a means of prioritisation.

When compared to other approaches, application of SQRA (utilising the MRP Tool) resulted in more conservative outcomes, or lower proposed quantities for replacement. The key advantages and disadvantages of each methodology are summarised below.

Table OV.1: Comparison of different approaches

	CONDITION BASED	COMPARABLE NETWORK QUALITATIVE ASSESSMENT	AGE BASED APPROACH	SQRA
Advantages	• Simply to apply as uses existing leak data only as an indicator of condition	• Simple to apply • Assumptions applied to large sections of the network	• Simple to apply • Considers 60 year life of asset as a basis for lifecycle strategy	• Minimises subjectivity • Location specific results • Consistent methodology • Consideration of numerous variables, industry data and subject manner expert input • Enables prioritisation • Enables monitoring of risk over time
Disadvantages	• Methodology aims to reduce or maintain current leak rates on the network without consideration of	• Subjective • Does not enable detailed prioritisation	• May result in replacement of acceptable quality mains	• Complex to apply • Requires detailed understanding of assessment methodology to

	CONDITION BASED	COMPARABLE NETWORK QUALITATIVE ASSESSMENT	AGE BASED APPROACH	SQRA
	current risk level and whether this is ALARP	• Results in higher risk levels and quantities selected for replacement		understand and interpret risk outcomes
Length of replacement (km)	320 km	1384 km	800 km	305 km

Part B

The MRP Tool was selected (as a SQRA approach) to prepare robust, cost effective and risk based mains replacement strategies on an annual basis by providing the following outputs and analysis options:

- Probability of a leak occurring for each segment of main (condition analysis);
- Individual risk of fatality for each segment of main;
- Grouping of multiple poor performing mains into single, cost effective projects to prevent multiple works programs in a suburb during consecutive years; and
- Prioritisation of mains replacement given financial or physical capability limitations.

The purpose of Part B of this document is to:

- Provide an overview of how the MRP Model uses ATCO data inputs to estimate condition and risk of mains;
- Provide an understanding of sensitivities and limitations of the MRP Tool;
- Provide an overview of the outputs of the MRP Tool and how to interpret results;
- Provide an overview of how results assist mains replacement program planning; and
- Stipulate review and update requirements of the MRP Tool.

PART A – PVC REPLACEMENT

1. STRATEGY REVIEW

Part A of this document provides an overview of different asset management strategies considered by ATCO for the assessment and implementation of a PVC mains replacement program.

1.1 Condition Based Assessment

A condition based strategy was assessed which aimed to identify a quantity of the poorest condition (highest leak rate) PVC for replacement in order to lower the average PVC leak rate to that of the average coastal network leak rate. The strategy utilises recorded leak rates on the network as the sole consideration to inform replacement quantities and locations.

Reducing the PVC leak rate to the overall coastal network leak rate as a benchmark was considered as an approach to assist in maintaining current level of leaks experienced on the network over the AA5 period. As PVC makes up approximately 80% of the network, the network average leak rate is heavily influenced by the PVC leak rate.

This strategy involved:

- Assessing the 5 yearly average PVC leak rate per suburb
- Weighting suburb averages against the proportion of the PVC network of which it makes up to achieve an overall PVC average leak rate. The average leak rate for all PVC on the network was calculated to be 0.04641 leaks per km per year
- The average leak rate experienced on the coastal network (all materials) is 0.03967 leaks per km per year
- In order to lower the average PVC leak rate to the benchmark average leak rate of the coastal network, this would require replacement of approximately 320 km of the poorest condition PVC.

While replacement of poorest condition PVC will result in lowering of the coastal network average leak rate, this assessment has not considered that leak rates of remaining PVC are likely to increase over the AA5 period as PVC continues to age and deteriorate.

Disadvantages of this methodology include:

- Suburb approach assumes characteristics and condition of all PVC pipe within a suburb is consistent, which may not be the case simply due to geographic proximity
- Risk based approach not implemented, therefore exposure risk and other environmental or asset specification risk influencers are not considered
- This strategy does not assess whether the risk associated with current levels of leaks is acceptable, and whether further reduction of leak rates over time should be undertaken to reduce risks to as low as reasonably practicable. This assessment cannot be achieved without qualitative or semi-quantitative risk assessment.

While a condition-based methodology was adopted during AA4 for the replacement of metallic mains, a similar application to PVC is not considered feasible. The quantity of metallic mains within the coastal network at the beginning of AA4 was significantly smaller (approximately 1.8%), with leak rates being significantly higher than that experienced by the rest of the network. The failure mode of metallic mains is predominantly corrosion, which occurs slowly over time. This allows for trending over time to accurately predict and identify highest risk locations for replacement. These characteristics of metallic mains enable a condition-based approach to be considered feasible for the metallic mains replacement program.

PVC fails predominantly through fitting or brittle failures, therefore timing of failure is difficult to predict. Failure is also influenced by ground disturbance, therefore poor condition PVC may be left unidentified for significant periods of time. Due to the quantity of PVC on the network and the multiple environmental and asset specification factors that influence risk, this strategy is not considered feasible for application to PVC assets.

1.2 Comparable Network Approach

Australian Gas Networks and APA, Final Plan Attachment 8.2 Distribution Mains and Services Integrity Plan December 2016 provides an overview of AGN's risk assessment methodology and outcomes applicable to PVC mains within their Victorian natural gas network.

ATCO has undertaken a benchmarking exercise in order to ascertain the PVC risk outcomes should a similar risk management approach be applied the ATCO GDS.

Note: While the networks are comparable in age and operational controls, the quantity of PVC on the AGN network is only 1.3% of the quantity on ATCO's network.

AGN's approach to PVC assessment considered:

- PVC in high-density inner suburbs was considered High risk. The consequence of PVC failure was assessed as major, with frequency assessed as unlikely. The frequency determination considered that PVC experiences a lower failure rate than cast iron mains, which were assessed as occasional. ATCO have assumed that AGN's "high density inner suburb" is comparable to "high risk locations" on ATCO's network. Applying a similar methodology to ATCO's network would result in 787 km of PVC mains assessed as High risk.
- PVC within the Central Business District (CBD) was assessed by AGN as Intermediate risk rather than High risk. This lower risk ranking is because PVC at this location is impact modified. Impact modified PVC is of a higher density, more robust and less susceptible to impact failure than PVC used elsewhere. ATCO does not have impact modified PVC on the network, nor is there PVC located within the Perth CBD. As such, this risk is not comparable between the two networks.
- PVC within low-density suburbs was assessed as Intermediate risk. The consequence of PVC failure was assessed as major, with frequency assessed as remote (lower frequency than high-density suburbs due to lower rate of failures and proximity to buildings). It is assumed that all remaining PVC on the ATCO network (not assessed as High risk) would fall within this category of assessment. Therefore, 8,813 km of PVC would be assessed as Intermediate risk.
- Intermediate risk PVC mains on AGN's network were installed as part of piecemeal replacement in cast iron and unprotected steel networks during the 1980's, and are planned for replacement as part of the cast iron and unprotected steel replacement programs. NPV analysis considered that it was inefficient not to replace these mains and, as such, the mains could not be demonstrated to be ALARP and must be reduced to low.

- No PVC was assessed as Low risk.

Application of a similar approach to that of AGN would result in ATCO assessing 787 km as High risk. As High risk cannot be accepted, it is assumed that 787 km of PVC would require replacement during the AA5 period.

AGN assessed that remaining PVC located in low-density suburbs was Intermediate and “not ALARP” on the basis that replacement could efficiently be achieved as part of existing replacement programs. While application of this approach would result in ATCO assessing 8813 km as Intermediate risk, it is not reasonable to assume that NPV analysis would result in this full quantity being deemed “not ALARP”.

The occurrence of PVC as piecemeal replacement within cast iron areas is found on ATCO’s network within the old Fremantle Low Pressure network. The application of an approach similar to AGN would result in 579 km of Intermediate risk as being deemed “not ALARP” and requiring replacement during the AA5 period.

Table 1.1: Methodology Outcome Comparison

	High Risk	Intermediate Risk (not ALARP)	Intermediate Risk (ALARP)	Low Risk
AGN	85 km	25 km	12 km (impact modified)	0 km
ATCO	787 km	597 km	8300 km	0 km

1.3 Age Based Approach

The network currently has approximately 9,600 km of PVC with varying age, some of which is approaching, or exceeds, 60 years of age. The current average age of PVC in the network is 34 years. To replace 9,600 km of PVC by its 60 year design life would require replacement of on average 160 km per year (to achieve a steady quantity of replacement over time).

Implementing a life-cycle strategy on age alone is not considered prudent. Depending on various influences, it is possible for the useful life of PVC to exceed or occur before 60 years. There is evidence within the water industry that the useful life of PVC may extend up to 100 years. In ATCO’s experience however, failures on PVC mains predominantly occur from fittings such as tapping bands, and service tees, which may fail significantly earlier than the PVC 60-year design life, to an extent where replacement of PVC mains is the optimal cost solution over reactive or proactive repair of fittings.

In order to achieve a robust and prudent mains replacement program, ATCO must assess PVC approaching its end of life by considering a variety of risk and condition factors, not just age. While the age of the network will influence these factors and must be kept in mind for long-term asset management planning, it is not considered prudent to replace mains based on age if they are monitored and determined to be in acceptable condition.

1.4 Semi-Quantitative Risk Assessment

Semi-Quantitative Risk Assessment (SQRA) may be utilised to support qualitative assessment and inform location specific risk estimation when suitable frequency and consequence data is available. The output of SQRA provides a consequence probability in terms of events per year, which can then be mapped to ATCO’s qualitative risk matrix, which dictates risk tolerance.

The benefits of SQRA over typical qualitative assessment include:

- Minimises subjectivity of the assessment and prevents risk categories from being applied too broadly
- Methodologies for assessing risk levels based on applicable industry data and subject matter expert assessments, further reducing subjectivity of the assessment
- Ability to use location specific relevant data (i.e. from SAP or GNIS), including leak, incident and environmental data to inform risk outcomes
- Quantified results enable detailed prioritisation based on risk (within a risk bracket). For example, if 100 km of PVC were assessed as High risk, semi-quantitative assessment would enable prioritisation from highest to lowest risk within this bracket
- Numerous variables and influences can be considered in conjunction to estimate overall risk in a consistent manner
- Risk trends can be monitored over time to inform long term asset management strategies.

As SQRA adopts a more detailed, refined and structured approach to estimate risk, outcomes are considered to provide a more accurate representation of risk when compared to qualitative approaches. ATCO retains information (namely within GNIS and SAP) on leak rates, incidents, asset data and environmental factors, which can be considered collectively to inform location specific risk levels. As such, with the use of a suitable SQRA tool (such as DVNs MRP Tool), this methodology can be applied by ATCO to provide a robust and prudent assessment of risk associated with PVC mains on the network.

1.5 Recommended Approach

ATCO considers that SQRA is the most suitable approach for assessing risk associated with PVC mains on the network. This approach ensures that all available location specific information which may influence risk is considered and applied consistently across the entire network. The methodology also reduces subjectivity, eliminates inconsistencies, and provides a means of prioritisation.

When compared to other potential methodologies, application of the MRP Tool resulted in more conservative (lower) risk outcomes, or lower proposed quantities for replacement. The key advantages and disadvantages of each methodology are summarised in **Table 1.2**.

Table 1.2: Comparison of different approaches

	CONDITION BASED	COMPARABLE NETWORK QUALITATIVE ASSESSMENT	AGE BASED APPROACH	SQRA
Length of replacement (km)	320 km	1384 km	800 km	305 km
Advantages	• Simply to apply as uses existing leak data only as an indicator of condition	• Simple to apply; • Assumptions applied to large sections of the network.	• Simple to apply; • Considers 60 year life of asset as a basis for lifecycle strategy	• Minimises subjectivity; • Location specific results; • Consistent methodology; • Consideration of numerous variables, industry data and subject manner expert input; • Enables prioritisation; • Enables monitoring of risk over time

	CONDITION BASED	COMPARABLE NETWORK QUALITATIVE ASSESSMENT	AGE BASED APPROACH	SQRA
Disadvantages	• Methodology aims to reduce or maintain current leak rates on the network without consideration of current risk level and whether this is ALARP.	• Subjective; • Does not enable detailed prioritisation; • Results in higher risk levels and quantities selected for replacement; •	• May result in replacement of acceptable quality mains; •	• Complex to apply; • Requires detailed understanding of assessment methodology to understand and interpret risk outcomes

PART B – MRP IMPLEMENTATION OVERVIEW

2. MRP Introduction

ATCO implements Mains Replacement Prioritisation (**MRP**) software (herein referred to as the MRP Tool) to predict the risk and condition associated with plastic mains on the Gas Distribution System (**GDS**).

The MRP Tool was developed by DNV GL[1] and is built on the ESRI ArcGIS Desktop platform, utilising the power of Geographic Information System (**GIS**) and its spatial capabilities. The Tool provides ATCO with a semi-quantitative risk based decision support that enables assessment of replacement scenarios and project planning for plastic mains with a Maximum Allowable Operating Pressure (**MAOP**) of up to 700 kilopascals (**kPa**). The MRP Tool assists ATCO to prepare robust, cost effective and risk-based mains replacement strategies on an annual basis by providing the following outputs and analysis options:

- Probability of a leak occurring for each segment of main (condition analysis)
- Individual risk of fatality for each segment of main
- Repair cost versus replacement cost analysis
- Grouping of multiple poor performing mains into single, cost effective projects to prevent multiple works programs in a suburb during consecutive years
- Prioritisation of mains replacement given financial or physical capability limitations.

2.1 Purpose

The purpose of Part B is to:

- Provide an overview of how the MRP Model uses ATCO data inputs to estimate condition and risk of mains
- Provide an understanding of sensitivities and limitations of the MRP Tool
- Provide an overview of the outputs of the MRP Tool and how to interpret results
- Provide an overview of how results assist mains replacement program planning
- Stipulate review and update requirements of the MRP Tool.

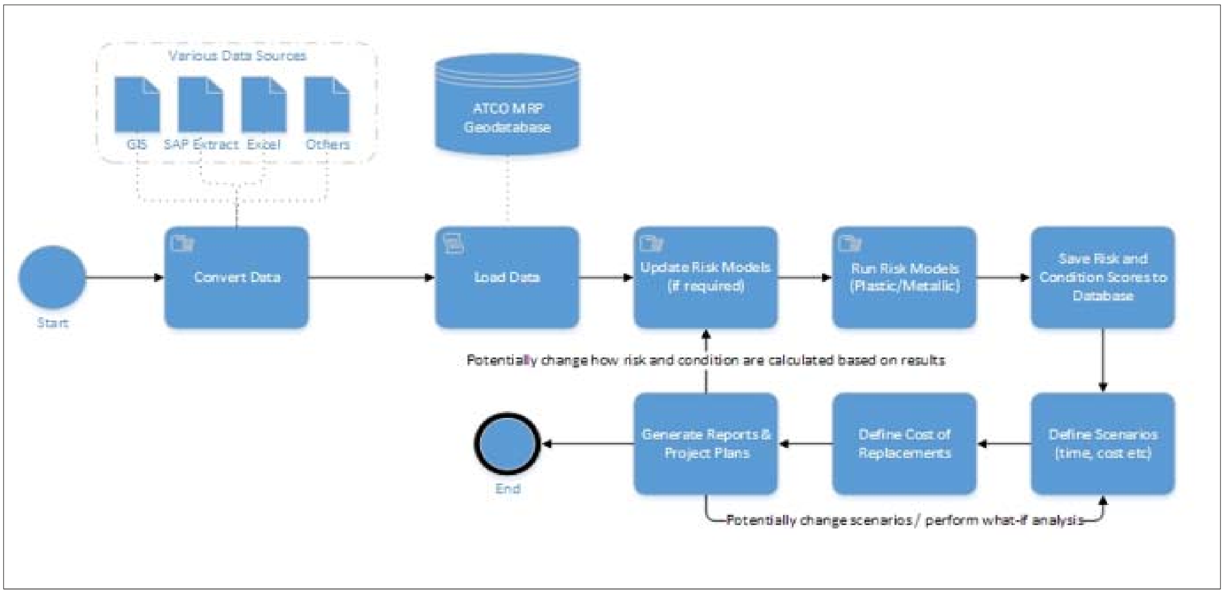
[1] DNV GL is an internationally accredited registrar and classification society, providing risk services within industries including oil and gas. DNV GL is one of the world's largest technical consultancies and develops services, rules and standards for various industries, with innovations and findings from research and development projects often used as the basis for international standards.

3. MRP Tool Overview

The MRP Tool has been created using a similar concept to a model previously created for the Office of Gas and Electrical Markets (**OFGEM**) in Great Britain, and can been applied to plastic mains up to a Maximum Allowable Operating Pressure (MAOP) of 700 kPa. The model has been developed using subject matter expert views of the effect of circumstantial factors on the expected lifetime of a pipeline. Associated risk calculations are then attributed to the remaining life of the pipeline using standardised risk curves and historical incident data.

Figure 3.1 presents an overview of the MRP Process.

Figure 3.1: MRP Process Overview



3.1 Plastic Model

The plastic model considers the differences in breaking behaviour between Polyethylene (**PE**) pipe and Unplasticised Polyvinyl Chloride (**uPVC**) pipe. The greater potential for brittleness of uPVC normally leads to breaking rather than the formation of gradually increasing leaks, while PE is considered to produce leaks that develop over time when there is impact by stones or roots.

A high-level overview of the inputs and outputs of this process is provided in Figure 3.2: MRP Tool User Inputs and Key Outputs

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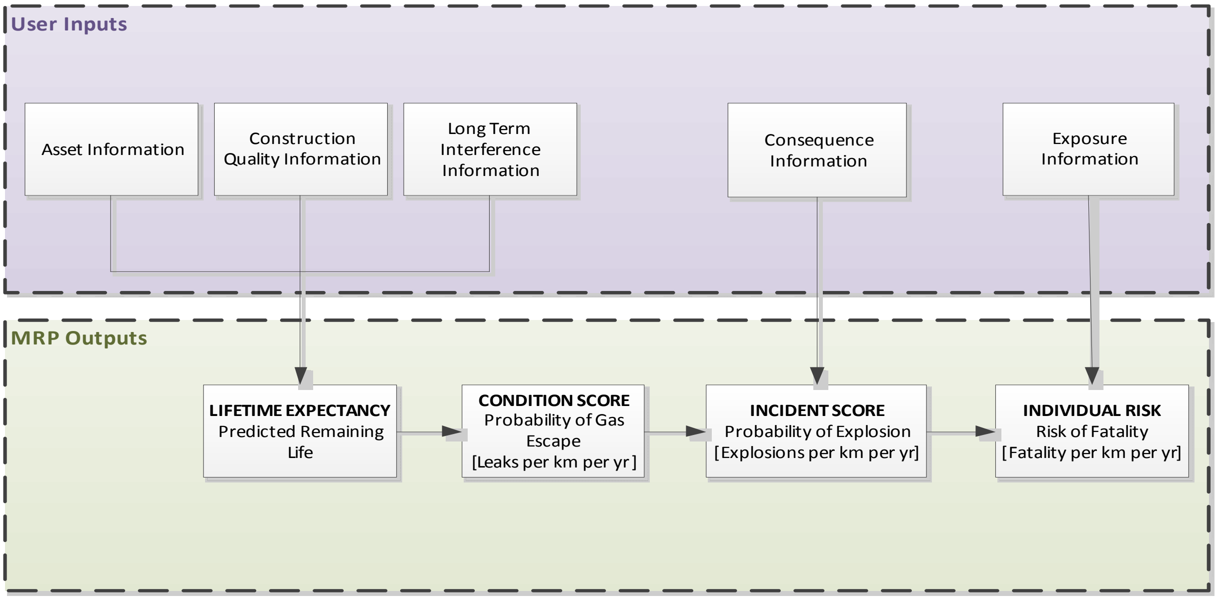
Figure 3.2: MRP Tool User Inputs and Key Outputs



Data is inputted into the MRP Tool primarily from SAP and GNIS, and is updated on an annual basis (please refer to Section 4 for a list of user input data, sources and assumptions).

The model identifies factors that have been proven to influence the degradation of PVC and PE pipes, including asset, construction and long term interference information, and cumulates them in a scoring system to give an estimated lifetime, which is then used to calculate the probability of failure (a conditions score, in terms of leaks per kilometre (**km**) per year).

The risk associated with each pipeline segment is not only influenced by the propensity to leak (condition score), but the likelihood of a leak tracking and entering a property, accumulating to within explosive limits, and finding an ignition source such that an explosion occurs.

The model takes into consideration factors (consequence information) which influence this likelihood, such as proximity to buildings, ground cover type, pipeline diameter and operating pressure, and gas ingress history within the area, to provide a probability of an explosion incident (incident score, in terms of explosions per km per year).

The risk of a fatality occurring as a result of an explosion within a building is influenced by the population density of the surrounding area. There is a greater chance of a fatality occurring in more population-dense areas, so population density is assessed by the model to influence the risk of fatality (individual risk, in terms of fatalities per km per year).

4. MRP Plastic Model User Inputs

An overview of the plastic model input factors and their associated abbreviations, units of measurement, derivation or assumptions, output values and sensitives is provided within "*DNV GL, Mains Replacement Prioritisation Specification (ATCO Gas Australia), Revision 1.2, 5th December 2015*"[1].

ATCO inputs data into the MRP Tool from various sources, including ArcGIS and SAP. An overview of the data sources that ATCO uses for input into the model is provided in **Error! Reference source not found.**below.

Table 4.1: Plastic Model Input Data Sources, Assumptions and Sensitivities

INPUT FACTOR	INPUT SOURCE
Material	ArcGIS Layer = Material
Nominal Diameter	ArcGIS Layer = Nominal Diameter
Length	ArcGIS Layer = Shape Length
Age of Pipe	ArcGIS Layer = Installation date
Pressure	ArcGIS Layer = MAOP Layer = Distribution Level
PE Generation	ArcGIS data for Diameter
Joints	ArcGIS Layer = Installation date
SDR Class	ArcGIS layer = SDR
Tube Material Quality	ArcGIS field = Material
Construction Quality	ArcGIS Layer = Installation date
Soil Preparation Quality	ArcGIS Layer = Common Trench
Depth of Cover	ArcGIS Layer = Suburb Polygons
Connection Density	Meter count per main, manually calculated
Connection Quality	ArcGIS Layer = Installation date
Branching Quality	ArcGIS Layer = Installation date
Repair Quality	ArcGIS Layer = Installation date
Soil Type	ArcGIS Layer = Geology Type
Pollution	ArcGIS Layer for Contaminated or remediated land
Sharp Stones	ArcGIS Layer = Common Trench
Soil Stability	ArcGIS Layer = Wetlands dataset
Root Presence	SAP Code = Damaged from tree root
Ground Water	ArcGIS Layer = Groundwater
Traffic Intensity	ArcGIS Layer = Traffic points and road type
Gas Quality Condensate	Arc GIS Layers = Pressure, Material and constant input
Proximity to Electrical Cables	ArcGIS Layer = Western Power assets
Proportion Open Ground	ArcGIS Layers = sleeves, CCAs
Proximity of Property to Pipe	ArcGIS Layers
No. Previous Gas In Building Events in last 5 Years.	SAP Incident codes

Population Density	ArcGIS Layer = Australian population grid 2011

5. MRP Outputs and Capabilities

The MRP Tool allows outputs to be visualised within ArcFM, however it also allows outputs to be exported to Excel to enable detailed analysis of pipeline segments on the network.

Key outputs against each pipeline segment provided by the model include:

- Condition score: Probability of a leak occurring (leaks per km per year)
- Incident score: Probability of explosion incidents (explosion incidents per km per year)
- Individual Risk score: Probability of a fatality event (fatalities per km per year)
- Estimated remaining life of the pipeline segment.

Exporting this data to Excel enables detailed analysis to be undertaken and allows ATCO to sort data by material type or risk level.

Within the tool itself, outputs can be visualised at a suburb level. The average risk or condition score can be calculated at a suburb level, and allocated an associated colour on the map depending on risk.

Once the tool has executed its analysis, additional tool capabilities are available to assist ATCO to use this information in developing mains replacement programs:

- Scenario Analysis: Evaluate multiple replacement scenarios to determine the most effective balance between risk versus investment
- Project Analysis: Automatically group recommended replacement mains together to create projects.

Additional capabilities include a flexible report manager, which enables automatic output of reports to document analysis.

6. MRP Tool Limitations

The MRP Tool has some limitations that users must be aware of to fully understand and analyse outputs. In particular, there are instances where the incident score and individual risk score will default to zero; it is important to understand why and how this may happen.

6.1 Low Risk Pipelines

The MRP Tool will only provide a risk score for pipeline segments when a certain ratio between expected life and age is satisfied. Where pipe segments are relatively new, and there is little or no historical incident or accident data within the vicinity, the risk score will default to zero. This is case for a large quantity of newer PE pipe segments on the network.

Although the MRP Tool defaults these very low risk segments to zero, ATCO still assess these segments against the ATCO risk matrix. A leak on a new pipeline resulting in a fatality event is still theoretically possible, although it is considered to be a hypothetical (less than one in a million events per year) event. As such, ATCO assess these as a “Low” risk.

Note: These pipeline segments are still allocated a non-zero condition score (indicating possibility of leaks occurring on these pipeline segments).

6.2 Leak Tracking Potential

Where it is deemed possible for a gas leak to track and accumulate within a building, leading to a fatality event, an incident and individual risk score is provided. The MRP Tool assesses the distance between the pipeline segment and a building (estimated based on GIS data). If the pipeline segment is within 30 m proximity of a building, it is deemed feasible for a leak to track, and an incident and individual risk score is calculated.

If the pipeline segment is considered too far for a leak to track (greater than 30m), a risk score of zero is outputted, regardless of whether the segment is within a high population density area. This assessment of risk is independent of condition. As a result, pipeline segments with high leak rates may have a zero risk score if the tool does not assess that a building is within proximity.

As such, in areas of the network which share equally poor condition and leak rates, there will be interconnecting pipeline segments which result in 0 incident or individual risk scores due to having no building within close proximity (for example, road crossing, vacant block of land, suburban park). When undertaking project planning, this needs to be recognised to ensure poor condition segments are considered regardless of proximity to buildings.

ATCO’s approach to prioritise mains replacement must therefore consider:

- Highest risk segments and areas followed by
- Segments with equally poor condition as the sections prioritised by risk in the same area.

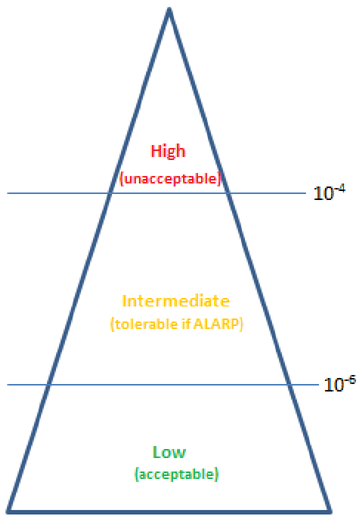
7. Condition and Risk Outcome Interpretation

7.1 Individual Risk Outcomes

ATCO's mains replacement strategy is developed taking into consideration the outputs of the MRP model and analysing results against risk tolerability criteria. As the output of the MRP tool is quantitative risk (i.e. probability of a fatality event per km per year), tolerability criteria has been applied to allow for correlation to ATCO's qualitative risk matrix.

The qualitative to quantitative correlation has been developed in line with good industry practice[2]; for tolerance of Individual Risk (risk of one fatality resulting from an event), against ATCO's risk tolerance criteria. One fatality was taken as a baseline, which aligns with the ATCO consequence category of "major". This correlation based on risk tolerance is shown in Table 7.1.

Table 7.1: Risk Tolerance Correlation

FREQUENCY	MAJOR CATEGORY	ATCO TOLERANCE TO RISK	INDUSTRY GOOD PRACTICE INDIVIDUAL RISK TOLERANCE CRITERIA (QUANTITATIVE)	
Frequency	Extreme*	Not tolerable in accordance with risk matrix	Individual risk > 10^{-4} per year not tolerable	
Occasional	High			
Unlikely				
Remote	Intermediate	Tolerable if ALARP in accordance with risk matrix	Individual risk between 10^{-4} to 10^{-6} per year tolerable if ALARP	
Hypothetical	Low	Acceptable in accordance with risk matrix	Individual risk less than 10^{-6} per year acceptable	
**Note: No "Extreme" risk for fatality consequence anticipated to be identified on the network.*				

This frequency correlation criteria has been documented more broadly and accepted within the GDS Safety Case[4], as outlined in Table 7.2.

[2] References include:

BSI Standards Publication. *"PD 8010-3:2009+A1:2013 Pipeline Systems - Part 3: Steel Pipelines on Land - Guide to the Application of Pipeline Risk Assessment to Proposed Developments in the Vicinity of Major Accident Hazard Pipelines Containing Flammables."* BSI Standards Limited 2013, 2013.

State of New South Wales through the Department of Planning "Hazardous Industry Planning Advisory Paper No 4 (HIPAP 4): Risk Criteria for Land Use Safety Planning", 2011

Table 7.2: Qualitative to Semi-Quantitative Risk Correlation

FREQUENCY	QUALITATIVE DESCRIPTOR	QUANTITATIVE PROBABILITY DESCRIPTOR
Frequent	Event expected to occur once per year or more	One or more Per Annum (**PA**)
Occasional	Event may occur occasionally in the life of the asset	Less than One to one in a hundred PA (<1 to 10^{-2} PA)
Unlikely	Event is unlikely to occur within the life of the asset, but is possible	One in a hundred to one in ten thousand PA (10^{-2} to 10^{-4} PA)
Remote	Event not anticipated to occur for the asset at this location	One in ten thousand to one in a million PA (10^{-4} to 10^{-6} PA)
Hypothetical	Event is theoretically possible, but has never occurred on a similar asset	Less than one in a million PA (<10^{-6} PA)

7.2 Condition Outcomes

The MRP Tool predicts condition of each pipeline segment in terms of leaks per km per year. As discussed in Section 5.2, poor condition will only correlate to risk should leak tracking into a building be deemed feasible for the given pipeline segment.

As such, condition scores must be assessed in isolation to risk scores to properly inform replacement programs.

8. Replacement Program Planning

The following initial steps are undertaken during annual mains replacement program planning:

1. High risk mains as identified by the MRP Tool are considered unacceptable risk and are prioritised for replacement against any previously identified high risks to ensure highest risk placement and efficiencies are realised.
2. Any Intermediate risk mains within the "upper intermediate" (10^{-4} to 10^{-5} probability of fatality per km per year) bracket are identified for prioritisation where practicable. These mains are considered to have the potential to become High risk over the planning period.
3. Mains with zero risk score, however with equally poor or worse condition score (predicted leaks per km per year) than the average Intermediate risk main are identified. These segments are allocated a default 0 risk score due to exceeding 30m from a property. Typically these segments interconnect the highest individual risk score pipelines and therefore need to be considered as part of the replacement program.

Once highest risk and poorest condition segments have been identified, this supports the selection of a minimum quantity for replacement based on maintaining network integrity and managing risk to ALARP.

These identified mains are selected as a starting point, however final selection of mains for replacement balances the following considerations:

- **Practicality** – Where the tool identifies short segments of Intermediate risk mains in a location surrounded by lower risk mains, this may not be selected for replacement, and rather monitored on an annual basis to ensure it does not become a High risk.
- **Project bundling** – where combining works with other replacement projects enables a greater overall level of risk reduction to be achieved for a lower cost (on a risk-adjusted basis).
- **Program efficiencies** – where replacing lower risk segments connecting identified higher risk mains makes financial sense (for example, if a PVC insertion technique is deemed suitable, it may be more financially feasible to replace an entire street regardless of any lower risk segments in that street, than it is to replace individual segments (via excavation or drilling) and return at a later date).
- **Smarter Planning Projects –** Where works can be delayed or brought forward to align with other utility works to significantly reduce disruption to the public and significantly reduce expenditure associated with reinstatement.

The ultimate goal during annual planning of locations will be to reduce the highest risk pipelines while also considering the most prudent approaches to gain the greatest level of overall risk reduction at the lowest cost possible.

8.1 Long Term Replacement Strategy

Outputs from the MRP Tool will assist ATCO in long-term replacement strategy development once risk trending is undertaken. It is anticipated that within 5 years, ATCO will have adequate outputs from the Tool to enable risk trending. Understanding how the risk profile of mains will change on the network over time will ensure long-term replacement quantities are sustainable and as steady as possible in order to reduce impact to customers while maintaining the safety and integrity of the network.

MRP Output trending will be undertaken initially via two methods:

1. Suburb risk and condition averages will be compared and assessed (on a material basis) in order to determine rate of increasing risk and condition degradation. This will be undertaken for the whole network.
2. Selected mains (not anticipated for replacement in the immediate future) of various materials, sizes and age will be identified for tracking of risk and condition scores.

9. Revision and Review

The MRP Tool will be updated with current data and executed on an annual basis during planning periods. Fault data associated with the mains are extracted from SAP and loaded into the MRP Tool. To capture changes to the network over time, distribution mains are loaded into the MRP Tool as geodatabase files (gdb file).

DNV have provided ATCO with a training package providing detailed instruction on how to update data and run models. These training slides are stored within EIM.

As inputs (i.e. leak survey and response data) will change over time, it is expected that risk outcomes will change annually. As such, locations selected for replacement will be reviewed and updated on an annual basis. An annual program review will be prepared to provide an overview of locations that have been selected for prioritisation as outlined in Section 7.

Should high leak rates (greater than 0.1 per km per year) at a given location on the network be identified during a non-planning period, ATCO may reprioritise this location based on actual network leak rates to ensure the safety of the public.

10. Continual Improvement

ATCO have continual improvement initiatives in place to refine the MRP Tool over time. Current areas of focus for improvement of the MRP Tool and its implementation include:

- Further refine and document how project planning capabilities within the MRP Tool can assist in replacement program planning
- Investigate and document best available technique for forecasting based on risk and condition trending. Forecasting is not currently a capability of the MRP Tool, therefore forecasts need to be extrapolated from risk and condition trends
- Review how valuable information obtained from ongoing PVC studies may enable refinement of the MRP Tool to provide results with a higher degree of accuracy. For example, if it is identified that a particular batch or year of PVC has increased potential for failure due to manufacturing defects, the increased probability associated with the age can be refined within the MRP Tool.

11. Reporting

Outcomes of the annual run will be documented in the annual update of the *Asset Lifecycle Strategy – Pipelines, Mains and Services*.

Asset Services are to provide risk outcomes annually to Technical Compliance to ensure the *Natural Gas Formal Safety Assessment* is updated to reflect the current level of various risk of mains on the network. In the event that any High-risk pipeline segments are identified, a Risk Management Action Plan (**RMAP**) will be implemented to ensure this risk is treated to an acceptable level in a timely manner.

12. References

Table 12.1: References

NO.	REFERENCE
1	DNV GL, Mains Replacement Prioritisation Specification (ATCO Gas Australia), Revision 1.2, 5th December 2015.
2	BSI Standards Publication. “PD 8010-3:2009+A1:2013 Pipeline Systems - Part 3: Steel Pipelines on Land - Guide to the Application of Pipeline Risk Assessment to Proposed Developments in the Vicinity of Major Accident Hazard Pipelines Containing Flammables.” BSI Standards Limited 2013, 2013.
3	State of New South Wales through the Department of Planning “Hazardous Industry Planning Advisory Paper No 4 (HIPAP 4): Risk Criteria for Land Use Safety Planning”, 2011
4	Gas Distribution System (GDS) Safety Case (TCO PL00005) Rev 6, 2017