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MRP TOOL OVERVIEW

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MRP TOOL OVERVIEW

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ABBREVIATIONS

Term/Acronym	Definition
ATCO	ATCO Gas Australia
EOL	End of Life
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
PVC	Polyvinyl Chloride
RMAP	Risk Management Action Plan
SDR	Standard Dimensional Ratio
SQRA	Semi Quantitative Risk Assessment
uPVC	Un-plasticised Polyvinyl Chloride

EXECUTIVE SUMMARY

This document provides an overview of the Mains Replacement Prioritisation Tool (MRP) used by ATCO for the assessment and implementation of a Polyvinyl Chloride (PVC) mains replacement program.

Utilising a Semi-Quantitative Risk Assessment (SQRA) approach, the MRP Tool is used 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 the 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 this document is to:

- Provide an overview of how the MRP Model uses ATCO data inputs to estimate the condition and risk of mains;
- Provide an understanding of the 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.

1. MRP INTRODUCTION

ATCO utilises MRP software (herein referred to as the MRP Tool) to predict the risk and conditions 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 SQRA that enables the 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 the main (condition analysis)
- Individual risk of fatality for each segment of the 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.

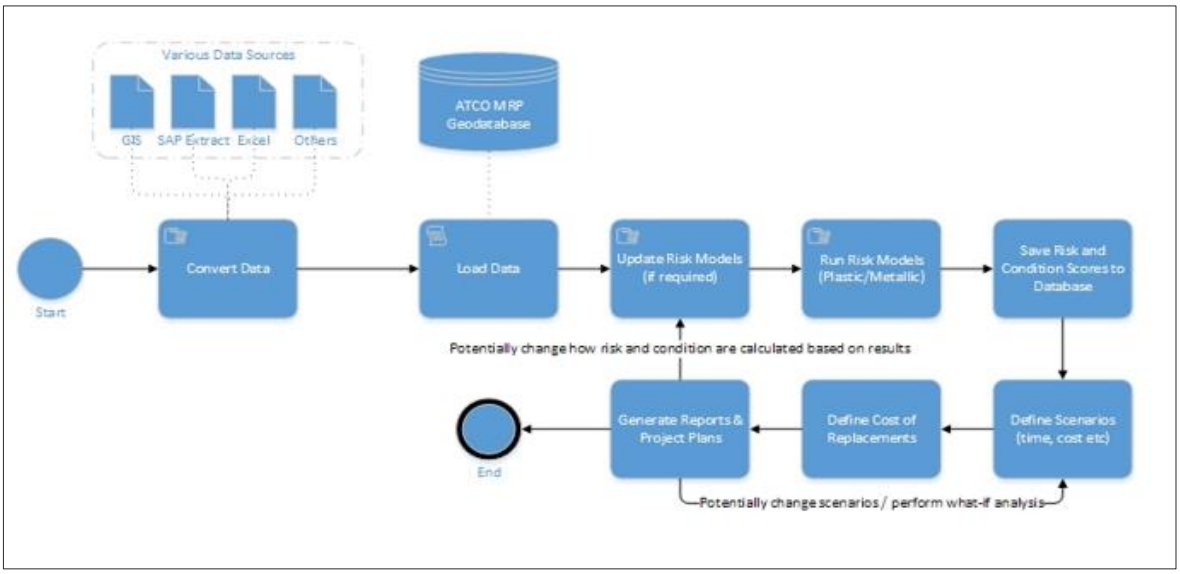
[1] DNV GL is an internationally accredited registrar and classification society, providing risk services within industries including oil and gas. DNV GL is one of the world's largest technical consultancies and develops services, rules, and standards for various industries, with innovations and findings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

2. 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 be applied to plastic mains up to a 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 2.1 presents an overview of the MRP Process.

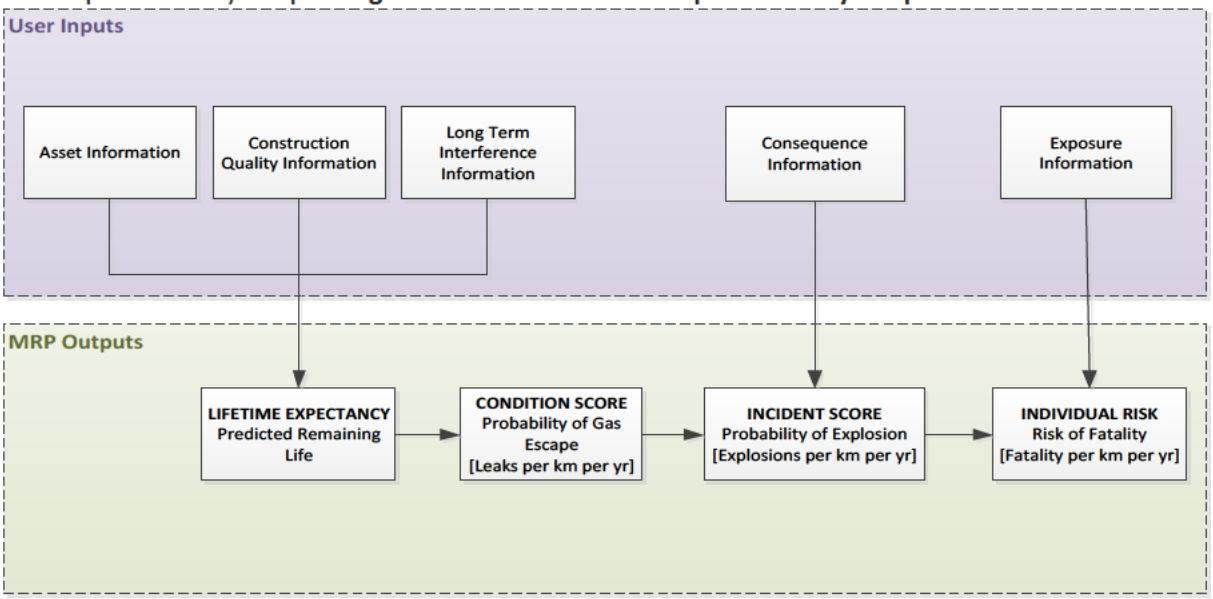
Figure 2.1: MRP Process Overview



2.1 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 2.2: MRP Tool User Inputs and Key Outputs **Figure 2.2: MRP Tool User Inputs and Key Outputs**



Data is inputted into the MRP Tool primarily from SAP and GIS, and is updated on an annual basis (please refer to Section **Error! Reference source not found.** 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) that 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).

2.2 Benefits

The benefits of using the MRP tool to inform the End of Life (EOL) Mains Replacement program 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 the 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 inform prioritisation based on risk (within a risk bracket). For example, if 100 km of PVC were assessed as High risk, a 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 estimating 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 DNV's 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.

3. 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 2016*".

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 Table 3.1 below.

Table 3.1 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

Input Factor	Input Source
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

4. 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 the automatic output of reports to document analysis.

5. 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.

5.1 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 the 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 assesses 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 assesses these as a “Low” risk.

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

5.2 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 are 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 the 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, and
- Segments with an equally poor condition as the sections prioritised by risk in the same area.

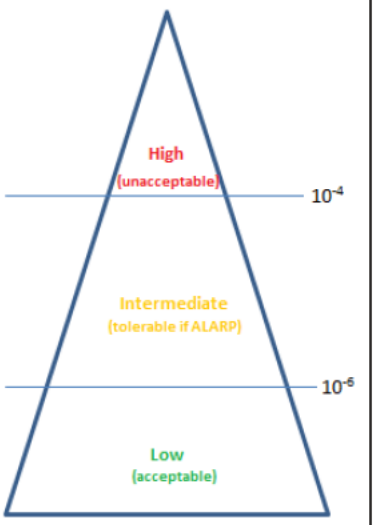
6. CONDITION AND RISK OUTCOME INTERPRETATION

6.1 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 a quantitative risk (i.e. probability of a fatality event per km per year), tolerability criteria have 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 6.1.

Table 6.1: 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 6.2.

Table 6.2: Qualitative to Semi-Quantitative Risk Correlation

[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

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)

6.2 Condition Outcomes

The MRP Tool predicts the condition of each pipeline segment in terms of leaks per km per year. As discussed in Section 5.2, the 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.

7. 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 an unacceptable risk and are prioritised for replacement against any previously identified high risks to ensure the highest-risk placement and efficiencies are realised.
2. Any Intermediate risk mains within the 10^{-4} to 10^{-6} probability of fatality per km per year bracket are identified for prioritisation where practicable.
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 the 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 the 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 the 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.

7.1 7.2 Long Term Replacement Strategy

The EOL PVC Mains Replacement Business Case further details the long term PVC Mains Replacement Strategy, and how the MRP Tool informs the ongoing replacement program. Whilst risk and condition is a key consideration in the development of the replacement program, additional factors are considered in determination of what constitutes “reasonably practicable” risk reduction.

8. 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 GL has 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.

9. REPORTING

Outcomes of the annual run will be documented in the annual update of the *Asset Condition Report – Distribution 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 risks 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.

10. REFERENCES

Table 10.1: 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

11. DOCUMENT APPROVAL

	Title	Name	Signature	Date
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]		[redacted]
[redacted]	[redacted]	[redacted]		[redacted]
[redacted]	[redacted]	[redacted]		[redacted]

12. DOCUMENT HISTORY

Rev	Date	Amended By	Reason for Change
A	20/08/2018	Marnie Foreman	New Document Created
1	25/08/2018	Colette Murray	Formatted and prepared for AA5 Submission
2	7/7/2023	Tony Trifunoski	Part A removed as strategy options analysis documented within EOL PVC Mains Replacement Business Case. Minor updates to reflect current practices.
	2/8/2023	Kate Cave	Document updated to ATCO template