Engineering Justification Paper: EJP09

Cost Beneficial Mains Replacement

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1 Summary Table

Name of Project	Safety & Cost Beneficial Mains Replacement		
Programme Reference	EJP09		
Primary Investment Driver	Asset Health/Environment		
Project Initiation Year	2026 (RIIO-3 element)		
Project Close Out Year	2031 (RIIO-3 element)		
Total Installed Cost Estimate (£m)	[Cost Information Redacted]		
Cost Estimate Accuracy (%)	+/-5%		
Project Spend to date (£m)	N/A		
Current Project Stage Gate	N/A (rolling programme of Asset Health investment)		
Reporting Table Ref	CV6.02, CV6.03, CV6.04, CV6.05, CV6.08, CV6.12		
Outputs included in RIIO-3 Business Plan	Yes		
Spend apportionment (£m)	RIIO-2	RIIO-3	RIIO-4
	[Cost Information Redacted]	[Cost Information Redacted]	[Cost Information Redacted]

Table 1: Summary Table

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Prices are pre-efficiency and are in 2023/24 price base.

This investment case does not satisfy the criteria for late competition or early competition and pursuing these activities would not be in the interests of the customer. We recognise the benefits that competition can bring to customers through efficiency and innovation. We continue to challenge ourselves as a business to ensure that we are harnessing competitive forces where they can provide these benefits. For specific detail on how we have assessed competition, please see Chapter 6 of the Workforce and Supply Chain Strategy (Appendix 17).

2 Executive Summary

This EJP details our plan to target repex investments to reduce leakage. An overall programme of repex work that includes EJP08-Mains IMRRP (Including Associated below=2" Steel) and the work envisaged in this paper will allow us to optimise planned work to maximise efficiency of delivery overall, clearly reflected in our cost benefits analysis.

Outside of our obligations on Tier 1 iron mains we also have a duty under the Pipeline Safety Regulations 1996 to ensure that all our pipelines are 'maintained in an efficient state, in efficient working order and in good repair'.

Pipeline leakage poses both a safety hazard and an environmental concern that we must address. Emissions from assets within the scope of this document account for 60% of mains emissions based on our 2021/22 baseline (or 66% against our 2025/26 baseline) and remain largely unaddressed.

Over the past two years, we've been collaborating with our global technology partners to introduce Advanced Leak Detection technology to the UK gas industry. This technology provides us with unprecedented insight into the actual leakage on our network, specifically for each individual pipe. We've utilised the empirical leakage data gathered through the new technologies deployed in RIIO-2 to calculate emissions at a granular level, enabling us to target cost-effective investments for maximum customer value. This has allowed us to re-evaluate our approach to managing the risk and environmental impact of these assets, confirming the significant benefits of a targeted intervention programme that will reduce leakage on our highest-risk and most environmentally impactful assets.

The programme is outlined in this EJP aligns with the Health & Safety Executive's (HSE) expectations to see the industry transition to observed leakage data to drive intervention decisions. It also meets our stakeholders' demands for managing our environmental impacts. We aspire to achieve net zero by 2050 and to significantly address methane emissions over the next decade. Further details on our environmental ambitions can be found in our Environmental Action Plan.

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Our Cost Benefit Assessment (CBA) approach for RIIO-3 is aligned with Ofgem's principles, ensuring that direct and indirect costs are captured; it is transparent in its calculations and follows cost-benefit best practice.

We have conducted extensive optioneering to assess the scale of programme we are proposing in our RIIO-3 plan, with a focus on balancing impact, feasibility and deliverability. The analysis was performed on our advanced modelling platform, allowing us to model each individual and the associated emissions from them. We reviewed these options with support from across the business, from our board and Sustainability Committee to our front-line operational colleagues. This paper focuses on four final options to test and demonstrate the value of this type of investment, and a 'do nothing' option which acts as a baseline.

Our chosen option utilises an unconstrained model that maximises the amount of mains replacement with a payback at 2040 as per the CBA templates in section 9.2. This option gives flexibility to the model to identify the most beneficial mains without forced constraints. [Commercially Sensitive Information Redacted]

For the small amount of tier 2 assets that do qualify for mandatory interventions through risk-based drivers, we are proposing to continue our approach to safety mains established in RIIO-2. This covers tier 2 iron mains which fall under the HSE's enforcement on iron mains and are not subject to a CBA criteria before replacement.

[Commercially Sensitive Information Redacted]

Table 2: Option 1 - Mains volume

[Commercially Sensitive Information Redacted]

Table 3: Option 1 - CISBOT volume

[Commercially Sensitive Information Redacted]

Table 4: Option 1 - Services volume

[Commercially Sensitive Information Redacted]

Table 5: Option 1 - Repex cost

3 Introduction

This paper focuses on safety-driven mains investment which are outside the Iron Mains Risk Reduction programme (IMRRP) as well as cost-beneficial mains renewal. The paper excludes any works driven by our IMRRP, see EJP08-Mains IMRRP (Including Associated below=2" Steel). [Commercially Sensitive Information Redacted]

Safety is a primary focus for our customers as well as a mandatory standard that we must deliver. The Pipeline Safety Regulations (1996) apply to all materials and diameters of distribution mains.

Under the regulatory framework, pipes can be put forward for remediation under cost-benefit principles. We consider safety and cost-benefit driven activity a critical element of our mains renewal plan, as it allows us to keep customers safe, reduce our impact on customers, minimise societal impacts and keep opex costs down, all whist being cost beneficial and attractive to our customers. Our CBA approach for RIIO-3 is aligned with Ofgem's principles, ensuring that direct and indirect costs are captured; it is transparent in its calculations and follows cost-benefit best practice. For further detail on the CBA approach, see section 5.4 of our Network Asset Management Strategy (NAMS).

A key part of our strategy for RIIO-3 relates to our environmental impact and the development of our network to enable a net zero future for the energy sector. We have an ambition to be net zero by 2050 and aim to achieve a material reduction in our Scope 1 and Scope 2 emissions by 2040/41. A key contributor to our carbon footprint is emissions from our low and medium pressure mains and service assets. See Figure 1 below which shows the makeup of our reported Scope 1 and 2 emissions.

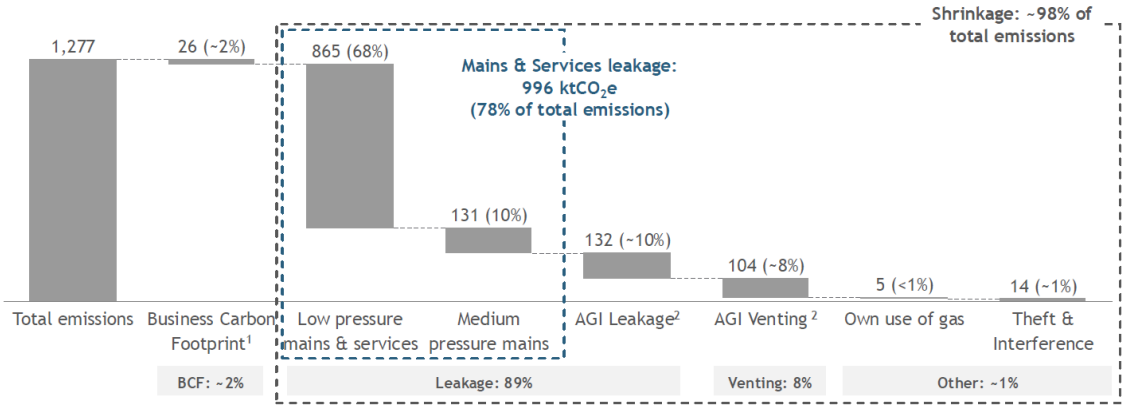

Figure 1: Cadent's Reported 2021/22 Scope 1 and 2 Emissions, ktCO2e

In RIIO-2 we have extensively piloted Advanced Leak Detection (ALD) technologies which have enabled us to create a robust Hybrid Leakage Model (HLM) to predict emissions, we have used this in the development of our RIIO-3 plans. The use of this HLM in setting our RIIO-3 approach presents an opportunity to precisely target investments to maximise benefits from our proposed programme. This aligns to the HSE proposed revisions to the iron mains enforcement policy (2026-2032) and the inclusion of Advance Leakage Detection approaches. We have used the HLM alongside the industry Standard Leakage Model (SLM) when comparing the CBA benefit of our investment options.

In RIIO-2, the volume of non-IMRRP mains replacement activity by network is as follows:

RIIO-2 Cost Beneficial Mains Replaced / Remediated over RIIO-2 (km)						
Region	**2021/22**	**2022/23**	**2023/24**	**2024/25**	**2025/26**	**Total**
EE	19	21	26	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]
NL	20	20	19	[Commercially Sensitive	[Commercially Sensitive	[Commercially Sensitive

RIIO-2 Cost Beneficial Mains Replaced / Remediated over RIIO-2 (km)						
Region	**2021/22**	**2022/23**	**2023/24**	**2024/25**	**2025/26**	**Total**
				Information Redacted]	Information Redacted]	Information Redacted]
NW	15	6	9	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]
WM	16	10	14	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]
Total	**69**	**58**	**67**	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]

Table 6: Cost Beneficial Mains Replaced / Remediated over RIIO-2[1]

The investments associated with these mains are set out below. In total, we will invest £265.7m over RIIO-2 on these assets.

Spend Profile over RIIO-2 (£m)						
Region	**2026/27**	**2027/28**	**2028/29**	**2024/25**	**2025/26**	**Total**
EE	5.48	8.61	12.32	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]
NL	14.31	9.77	13.02	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]
NW	3.81	3.40	3.49	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]
WM	3.96	2.69	5.11	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]
Total	**27.56**	**24.47**	**33.94**	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]	[Commercially Sensitive Information Redacted]

Table 7: Spend profile for Cost Beneficial Mains and Associated Services over RIIO-2, in 23/24 Price Base[2]

[1] Data taken from 2023/24 RRP and RIIO-2 BPDTs. Totals of Tier 2b, Tier 3, Other Mains and Robotic Intervention.
[2] Data taken from 2023/24 RRP and RIIO-2 BPDTs and uplifted to 23/24 price base. Totals of Tier 2b, Tier 3, Other Mains and Robotic Intervention.

4 Equipment Summary

4.1 Overview of the assets

Our distribution mains form a network 127,155km in length, connecting our Local Transmission System (LTS) to homes and businesses. They run underneath every street where we supply gas to a property. The makeup of the networks is the result of over a century of investment, policy and regulation in the transportation of gas. This investment has led to an extremely safe and reliable infrastructure performance, with a standard of services of 99.999% with regards to interruptions.

Over time, there have been various approved materials to carry gas, sanctioned replacement techniques and maintenance regimes to manage the assets. A summary of the asset stock for each region is shown in Table 8 below. The network is split into diameter tiers; Tier 1: 8 inches and below, Tier 2: above 8 inches and below 18 inches, Tier 3: 18 inches and above.

Material	Tier	EE (km)	NL (km)	NW (km)	WM (km)	Total (km)
Iron	1	4,644	2,728	3,148	2,542	**13,062**
	2	1,375	927	1,186	1,308	**4,796**
	3	302	511	405	205	**1,423**
Steel	1	1,886	544	842	1,024	**4,296**
	2	644	103	280	343	**1,370**
	3	376	237	152	121	**886**
Polyethylene (PE)	1	37,569	13,891	24,966	16,284	**92,710**
	2	2,905	1,381	2,200	1,703	**8,189**
	3	88	124	132	30	**374**
Other (mainly Asbestos Cement)	1	2	0	44	0	**46**
	2	0	0	5	0	**5**
	3	0	0	1	0	**1**
Total		**49,791**	**20,446**	**33,361**	**22,253**	**127,158**

Table 8: Asset Base as per 2023/24 RRP

This paper deals specifically with:

- Tier 2 and Tier 3 iron mains within 30 meters of a building[3]
- all iron mains greater than 30 meters from a building
- steel mains over 2”
- Tier 2 and Tier 3 asbestos cement[3]
- non-metallic mains i.e. PE that needs replacement

Table 9 shows the population of mains in scope for this investment paper.

[3] Tier 1 iron mains within 30m of a building and asbestos Tier 1 are included in EJP08

	EE (km)	NL (km)	NW (km)	WM (km)	Total (Km)
Steel	2,906	884	1,274	1,488	**6,552**
Tier 2 Iron below 30m from a building	1,227	905	1,131	1,220	**4,483**
Tier 3 Iron below 30m from a building	261	501	380	197	**1,339**
Iron below 30m from a building	354	51	142	239	**786**
Polyethylene (PE)	40,562	15,395	27,298	18,016	**101,271**
Asbestos Cement	0	0	6	0	**6**
TOTAL	**45,310**	**17,736**	**30,231**	**21,160**	**114,437**

Table 9: Population of mains in-scope for this investment paper

5 Problem/Opportunity Statement

We have a critical role to play in decarbonising the gas system. We have an ambition to be net zero by 2050 and aim to materially reduce methane leakage from our network over the next decade.

Leakage from our mains and services account for 78% of our Scope 1 and 2 emissions. Our replacement programme during RIIO-2 is primarily focused on safety but will allow us to achieve (20%[4]) reduction vs 2021/22 baseline.

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Targeting proactive interventions has been historically challenging as we did not have the data and modelling capabilities available to identify our leakiest pipes at an individual asset level. SLM, the standard industry-wide methodology for calculating emissions, operates at the 'cohort' level. Building on the data we have collected in RIIO-2 and the ongoing ALD programme that the HSE will be mandating, we will have the tools in RIIO-3 to be targeted with our interventions.

For the mains assets covered within this EJP and our wider low and medium pressure asset population we have created a 'hybrid SLM' that uses available observed emissions data from our industry-leading North London programme, where we have surveyed 10,000km of mains. This has been incorporated into our modelling platform (for more detail see EJP09-SE-Cost Beneficial Mains Replacement, Annex E), where we already hold advanced deterioration modelling capabilities and our core systems data to identify critical characteristics of the leakiest pipes and apply these across all of our networks to target the highest emitting assets for intervention.

With the hybrid model applied, we have utilised the CBA principles provided by Ofgem to optioneer different intervention programmes with the goal of proactively driving emissions down whilst also reducing the risk from the assets that our analysis tells us leak the most.

This approach aligns with IMRRP, which sets out several requirements for mains that are not tier 1 iron within 30m. It stipulates that network operators must ensure we have an adequate maintenance regime in place and are actively managing the risk. The HSE have recently notified all GDNs that ALD will be mandated from 2026, and as a result we must have an intervention programme to address any issues we find via ALD in an appropriate way. The Hybrid SLM model built on the empirical data we have collected in our North London network allows us to meet these requirements in a targeted and cost-effective manner.

[4] Using the standard leakage model

5.1 What happens if we do nothing?

If we do nothing, the assets will deteriorate and will pose the following service risks:

- Safety: Assets within 30 metres of a building have the potential to cause a major incident, leading to serious injury or loss of life.
- Environmental: Any release of gas from our mains will result in additional carbon emissions.
- Regulatory compliance: As outlined in section 5, we must comply with PSR (1996).
- Interruptions to supply: A supply interruption could be caused by the need to isolate the failed pipe or by a major pipe failure.
- Financial: Every escape from our network carries a cost of attending and repairing the pipe, as well as restoring any supplies turned off, or lost during the leak.
- Other: Continued failure of the same main will cause high levels of customer disturbance, and in turn dissatisfaction e.g. repeated road closures and excavations in the same location.

5.2 Key outcomes and understanding success

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5.3 Alignment with overall RIIO-3 investment strategy

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5.4 Narrative real-life example of problem

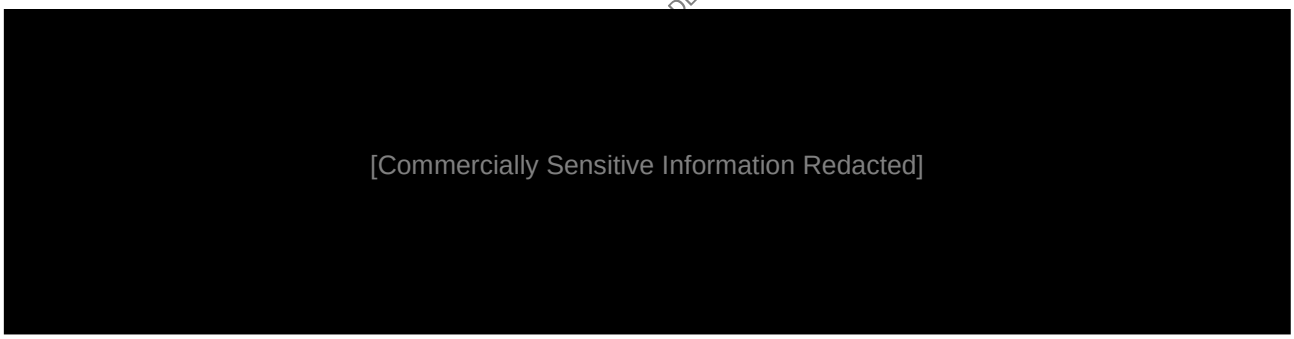

Figure 2: Cadent maps 01/01/24 prior to delivery of scheme with highlighted asset and associated leakage points

5.5 Project Boundaries

[Commercially Sensitive Information Redacted]

6 Probability of Failure

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[Commercially Sensitive Information Redacted]

Table 10: Deterioration Rates Assumed in the RIIO-3 Mains Modelling

6.1 Probability of Failure Data Assurance

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7 Consequence of Failure

[Commercially Sensitive Information Redacted]

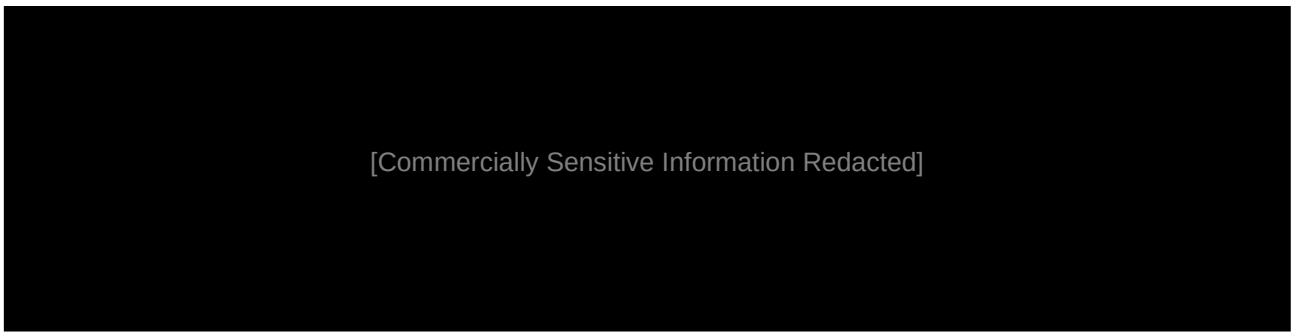

Figure 3: Indicative MRPS Incident Rate for IMRRP and Non-IMRRP Assets

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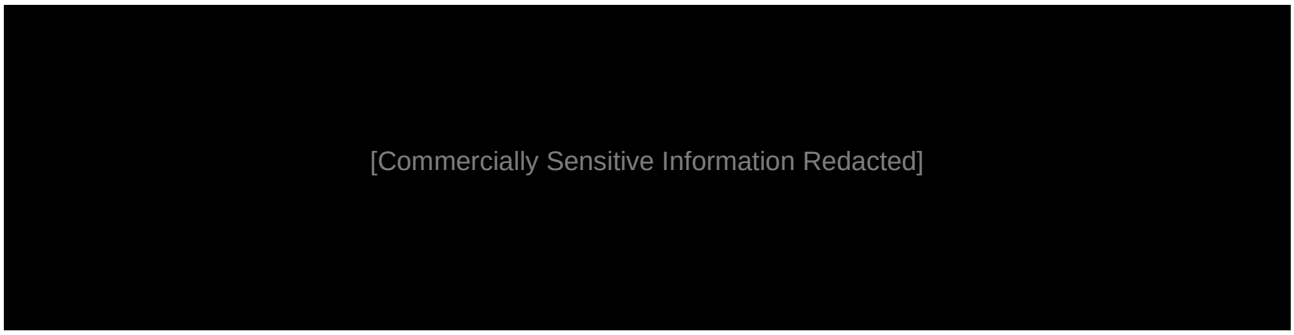

Table 11: Service risk Consequences

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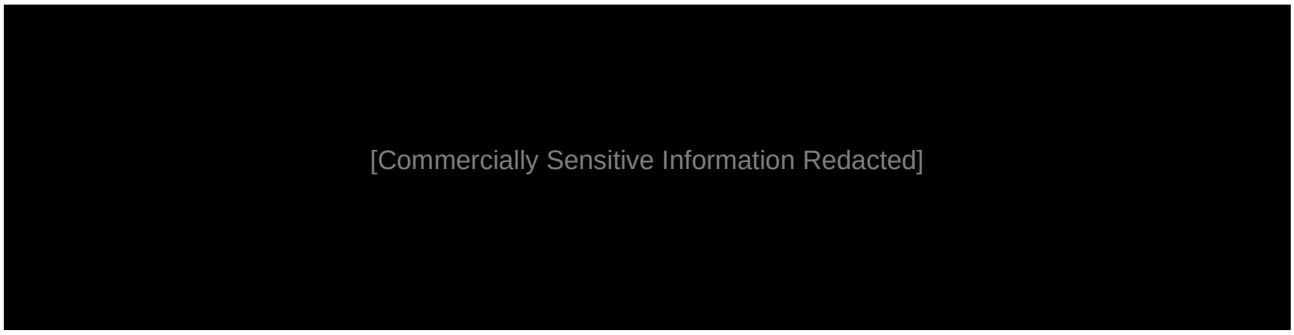

Figure 4: Monetised Risk if no Investment

8 Options Considered

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8.1 How we have structured this section

[Commercially Sensitive Information Redacted]

8.2 Modes of Intervention

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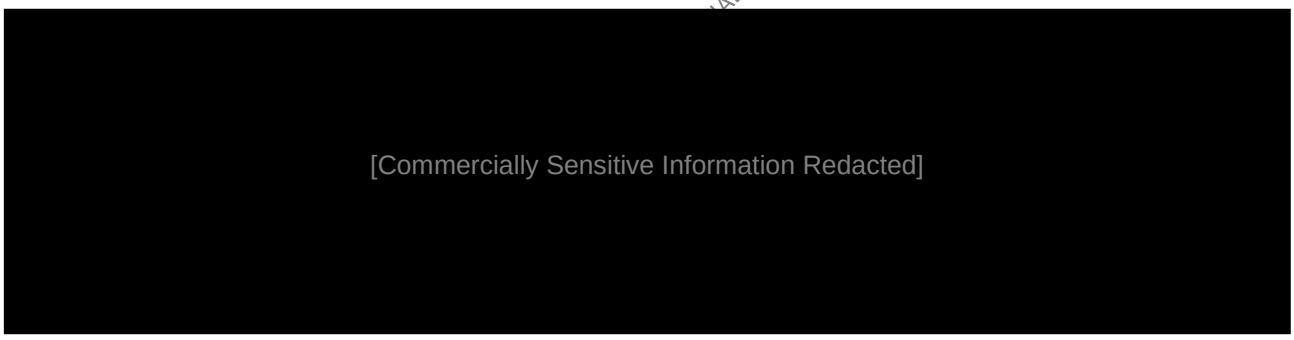

Table 12: Intervention Modes

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8.2.1 Intervention Mode 1: Repair pipe with robotic intervention (CISBOT)

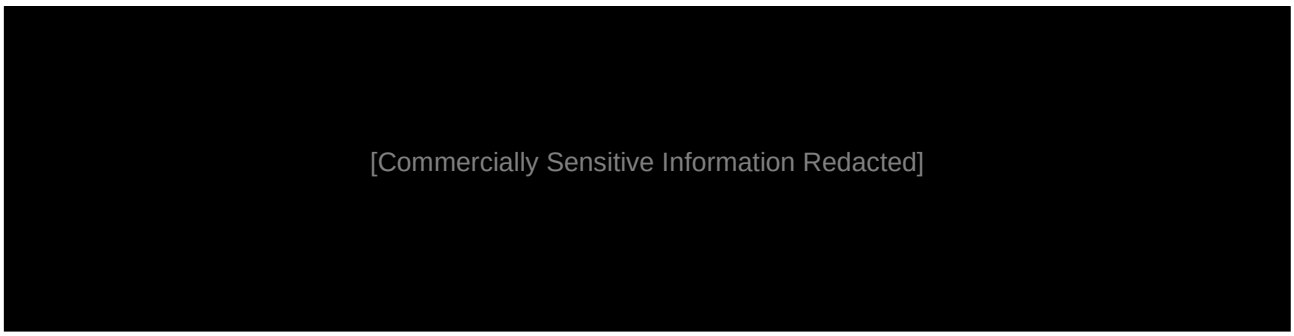

Table 13: Remediation via CISBOT

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8.2.2 Intervention Mode 2: Replace the main via open-cut

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Table 14: Replacement via open-cut

8.2.3 Intervention Mode 3: Replace the main via insertion

[Commercially Sensitive Information Redacted]

Table 15: Replacement via insertion

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8.3 Timing choices

[Commercially Sensitive Information Redacted]

8.4 Options

[Commercially Sensitive Information Redacted]

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Figure 5: Cadent's Vehicle Mounted Emissions Detection Technology

[Commercially Sensitive Information Redacted]

[Commercially Sensitive Information Redacted]

Table 16: Programme scenarios considered

[Commercially Sensitive Information Redacted]

8.4.1 Programme Option 0: No Additional CBA

[Commercially Sensitive Information Redacted]

[Commercially Sensitive Information Redacted]

Table 17: Option 0 - Mains volumes

[Commercially Sensitive Information Redacted]

Table 18: Option 0 - Services volume

[Commercially Sensitive Information Redacted]

Table 19: Option 0 - Repex cost

8.4.2 Programme Option 1: 2040 Payback + CISBOT

[Commercially Sensitive Information Redacted]

[Commercially Sensitive Information Redacted]

Table 20: Option 1 - Mains volume

[Commercially Sensitive Information Redacted]

Table 21: Option 1 - CISBOT volume

[Commercially Sensitive Information Redacted]

Table 22: Option 1 - Services volume

[Commercially Sensitive Information Redacted]

Table 23: Option 1 - Repex cost

8.4.3 Programme Option 2: RIIO-2 Approach

[Commercially Sensitive Information Redacted]

[Commercially Sensitive Information Redacted]

Table 24: Option 2 - Mains volume

[Commercially Sensitive Information Redacted]

Table 25: Option 2 - Services volume

[Commercially Sensitive Information Redacted]

Table 26: Option 2 - Repex cost

8.4.4 Programme Option 3: Double RIIO-2 Approach + CISBOT

[Commercially Sensitive Information Redacted]

[Commercially Sensitive Information Redacted]

[Commercially Sensitive Information Redacted]

Table 27: Option 3 - Mains volume

[Commercially Sensitive Information Redacted]

Table 28: Option 3 - CISBOT volume

[Commercially Sensitive Information Redacted]

Table 29: Option 3 - Services volume

[Commercially Sensitive Information Redacted]

Table 30: Option 3 - Repex cost

8.4.5 Programme Option 4: 2050 Payback + CISBOT

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[Commercially Sensitive Information Redacted]

Table 31: Option 4 - Mains volume

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[Commercially Sensitive Information Redacted]

Table 32: Option 4 - CISBOT volume

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Table 33: Option 4 - Services volume

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Table 34: Option 4 - Repex cost

8.5 Technical Summary Table: Programme Options

[Commercially Sensitive Information Redacted]

Table 35: Summary of Programme Options

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9 Business Case Outline and Discussion

9.1 Key Business Case Drivers Description

[Commercially Sensitive Information Redacted]

9.2 Business Case Summary

[Commercially Sensitive Information Redacted]

9.2.1 Summary of results

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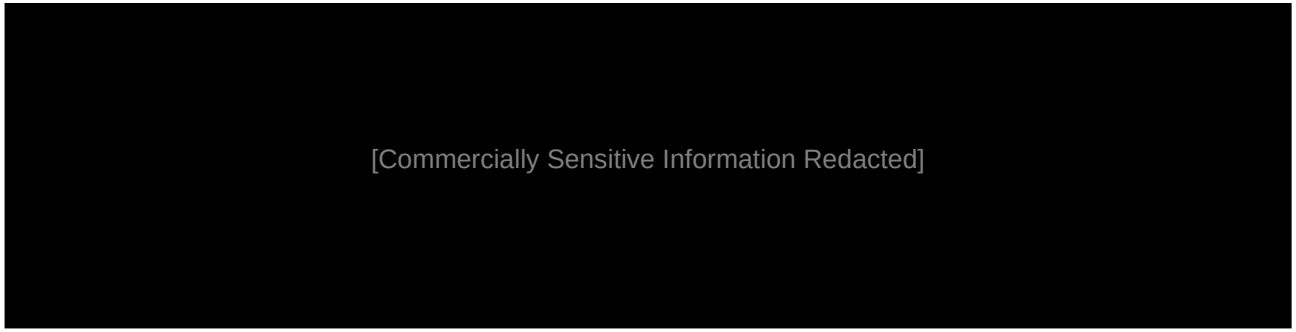

Table 36: CBA Outputs for all scenarios Hybrid Leakage Model

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9.2.2 Discussion of results

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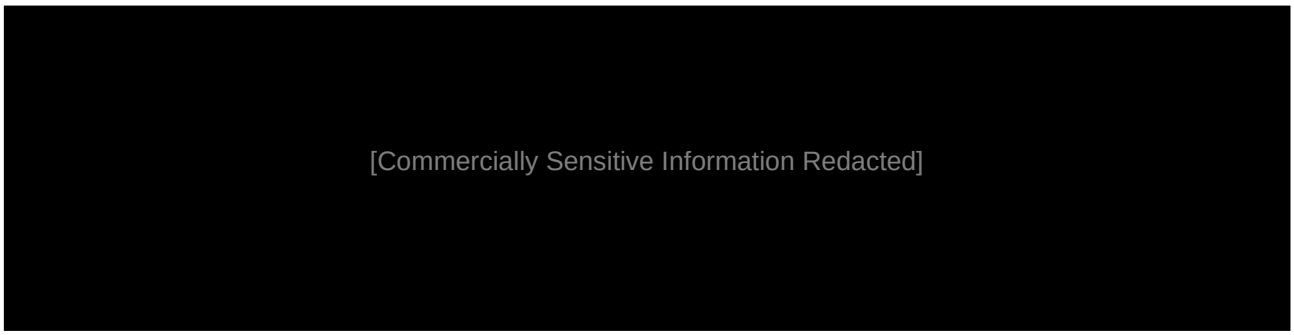

Figure 6: Projected OPEX Costs

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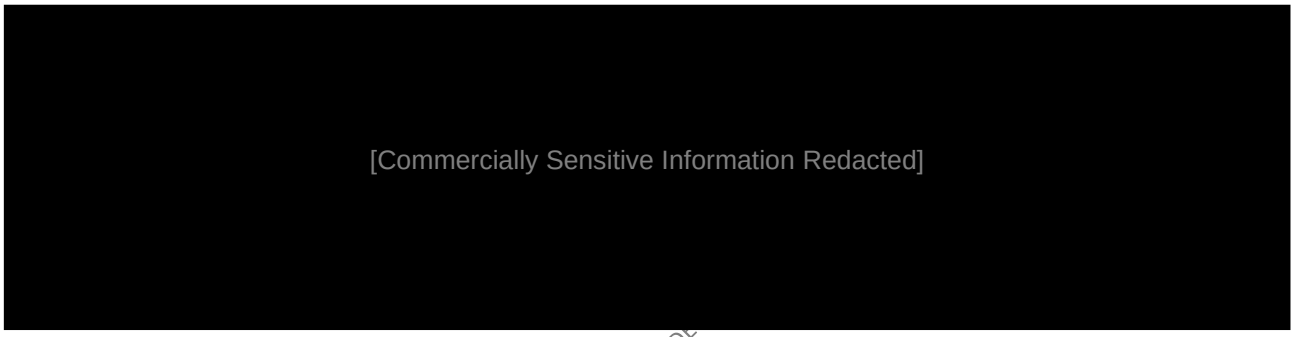

Figure 7: Comparison of Environmental Impact of Programme Options (mains carbon benefit only)

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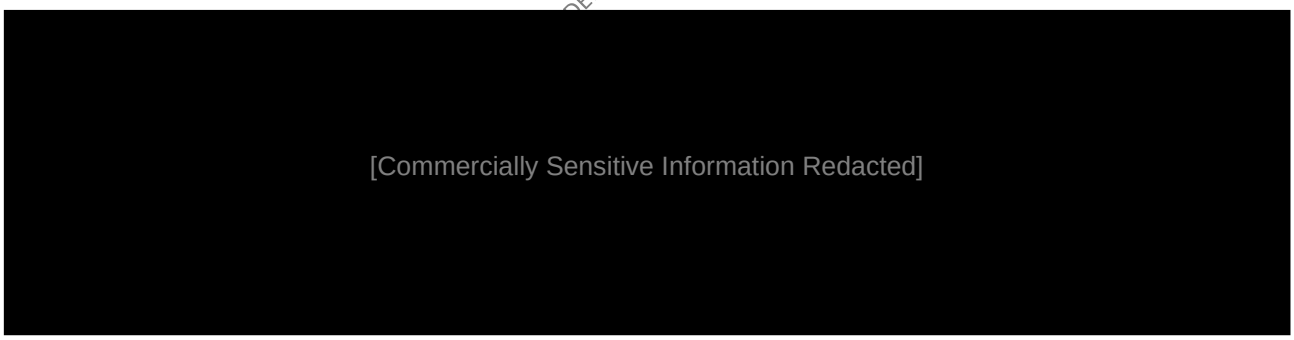

Figure 8: Comparison of Gas Escapes (Failure Rate Proxy) of Programme Options

9.2.3 Sensitivity Testing

[Commercially Sensitive Information Redacted]

[Commercially Sensitive Information Redacted]

Table 37: Business Sensitivity Tests Applied

9.2.4 Conclusions

[Commercially Sensitive Information Redacted]

10 Preferred Option Scope and Project Plan

10.1 Preferred Option

[Commercially Sensitive Information Redacted]

[Commercially Sensitive Information Redacted]

Table 38: Option 1 - Mains volume (inclusive of CISBOT)

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Table 39: Option 1 - CISBOT only volume

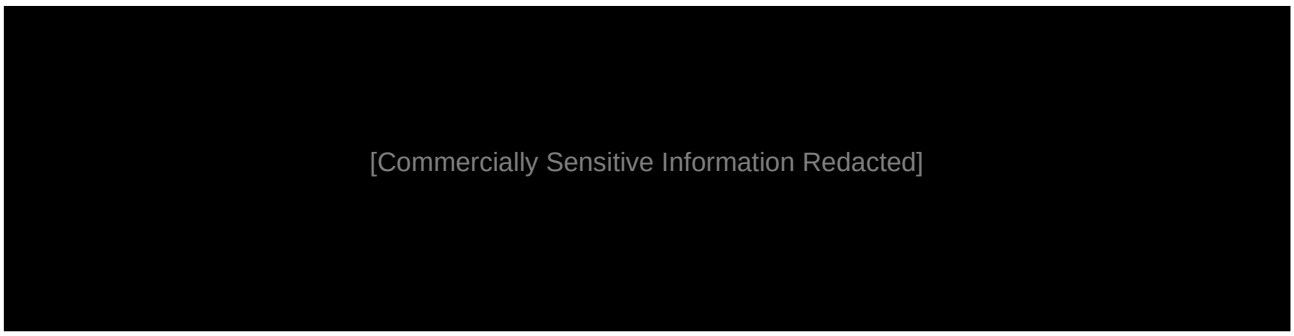

Table 40: Option 1 - Services volume

10.2 Asset Health Spend Profile

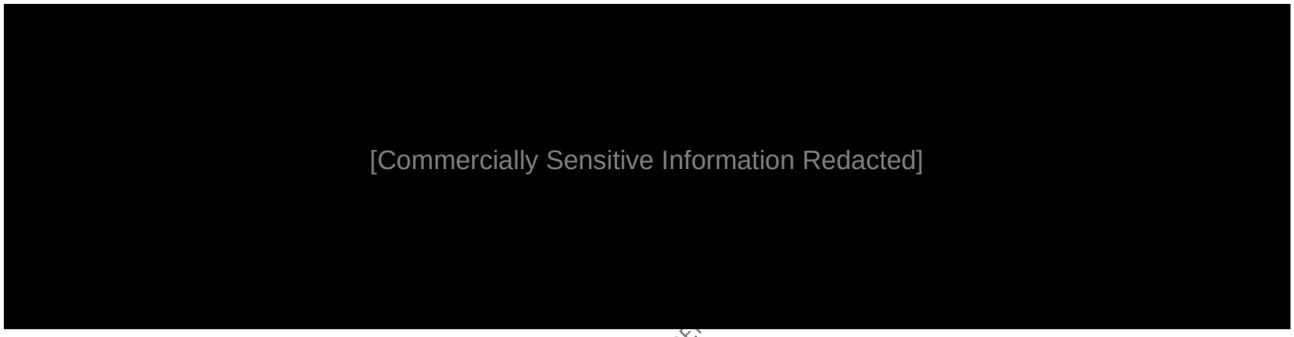

Table 41: Option 1 - Repex cost

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10.3 Investment Risk Discussion

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10.4 Project Plan

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10.5 Key Business Risks and Opportunities

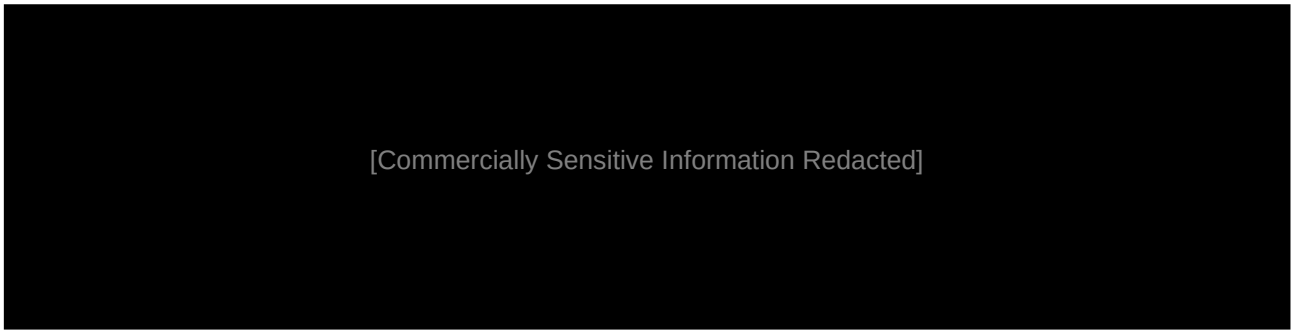

Table 42: Key Risks

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10.6 Outputs included in RIIO-2 Plans

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11 Regulatory Treatment

[Commercially Sensitive Information Redacted]

12 Glossary

Abbreviation/term	Meaning
HSE	Health & Safety Executive
IMRRP	Iron Mains Risk Reduction Programme
MRPS	Mains Replacement Prioritisation System
MOBs	Multiple Occupancy Buildings
RRP	Regulatory Reporting Process
GiB	Gas in Building(s)
PSR	Pipeline Safety Regulations
GSMR	Gas Safety (management) Regulations
NPV	Net Present Value
CBA	Cost Benefit Analysis

Table 43: Glossary

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[Commercially Sensitive Information Redacted]