

Quantitative Risk Assessment for Bosworth Health Spa Development

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EXECUTIVE SUMMARY

Lakeside Lodges Limited is planning a new health spa development on Wellsborough Road, Market Bosworth, CV13 6PD, in close proximity to the Blaby to Alrewas section of the Feeder 4 pipeline (reference EM04BLAL). The pipeline section has a nominal diameter of 900 mm and is operated in accordance with IGEM/TD/1 (ref. [1]).

Lakeside Lodges has requested that ROSEN(UK) carry out a quantitative risk assessment (QRA) for the interaction between the pipeline and development, in order to establish the individual and societal risk at the location, taking into account the increase in population due to the new development.

This report reviews and assesses this new health spa development and presents the findings of the QRA.

Conclusions

- The maximum individual risk level for this assessment was determined to be 4.56×10^{-7} at the proposed site of one of the activity pods approximately 70m from the pipeline, which is below the 1.0×10^{-6} per year level that is considered to be 'broadly acceptable'
- The individual risk from explosion has been assessed and classified as "negligible".
- The FN curve for societal risk crosses the criterion line, therefore, a cost benefit analysis (CBA) has been performed. The PLL is calculated to be 1.65×10^{-4} , and the maximum number of casualties is 559.
- The optimised CPCA values obtained for both slabbing and thick-walled pipe are above the £47M criteria, therefore the costs are disproportionate to the benefits achieved and the risk are considered to be acceptable and ALARP.
- The optimised CPCA values obtained for both slabbing and thick walled pipe are above £127 Million which confirms that the standard methodology is appropriate and the acceptable result is valid for this low toughness pipeline.

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1 INTRODUCTION

Lakeside Lodges Limited is planning a new health spa development on Wellsborough Road, Market Bosworth, CV13 6PD, in close proximity to the Blaby to Alrewas section of the Feeder 4 pipeline (reference EM04BLAL). The pipeline section has a nominal diameter of 900 mm and is operated in accordance with IGEM/TD/1 (ref. [1]).

Lakeside Lodges has requested that ROSEN(UK) carry out a quantitative risk assessment (QRA) for the interaction between the pipeline and development, in order to establish the individual and societal risk at the location, taking into account the increase in population due to the new development.

This report reviews and assesses this new health spa development and presents the findings of the QRA.

2 METHODOLOGY

The methodology for reviewing and assessing the development is documented in NGT Hazard Assessment Methodology Manual, T/SP/HAZ/16 (ref. [2]).

The assessment has been completed using the following software:

- PIPESAFE Version 2.29.0 [3]

The risk from high pressure gas transmission lines is dominated by the rupture failure mode and this assessment analyses the risk from ruptures only. Historically, failures by rupture are mainly caused by external interference and ground movement, and these are the threats considered in this assessment

3 PIPELINE DETAILS

A summary of basic pipeline information is shown in Table 1 (ref. [4]). Where required, location specific data such as wall thickness or steel grade will be used in the assessment.

Data	Value
Pipeline Reference	EM04BLAL
Feeder Number	4
Pipeline Section Name	Blaby to Alrewas (Blaby to Twycross section)
Nominal Diameter (mm)	900
Nominal Wall Thickness (mm)	15.88
Steel Grade	X56*
Length (km)	50.75
MOP (bar)	70
Commissioning Date	September 1970
PSR Number	1188
Nominal depth of cover (m)	0.9
*Conflicting data sources report X60 and X56 at this location. X56 has been used for the QRA as this the lower grade and, therefore, conservative	

Table 1: Basic Pipeline Information

4 RISK ASSESSMENT

4.1 Failure Frequency Analysis

Historical data indicates that the most likely causes of full bore rupture are third party damage and ground movement, and these will dominate the risk, so analysis of further causes has not been conducted.

There is an existing 1050 mm diameter 14.27 mm wall thickness sleeve 74m in length at the Wellsborough Road crossing. Conflicting sources show a possible 1050 mm diameter 14.27 mm wall thickness sleeve across the unnamed road adjacent to Bosworth Water Park, however, details of this sleeve cannot be confirmed and therefore this QRA has been carried out without that protection to ensure conservatism. A depth of cover of 0.9 m has been used along the entire interaction length.

Conflicting data sources report pipeline material grades of X60 and X56 at this location. This QRA has been carried out using X56 as this is the lower grade and, therefore, the results will be conservative.

The 2016 Igem/TD/1 Edition 4 Audit Report (ref [5]) reclassified this area Type R (Rural) from Type S (Suburban) and classed it as a population cluster instead. Due to the increase in population around the development, this QRA has been carried out using Type S parameters.

The failure frequencies used in this assessment are detailed in Table 2.

Failure Cause	Diameter (mm)	MOP (barg)	Wall Thickness (mm)	Grade	Area Type	Rupture frequency per million km years	Notes
Third Party	914.4	70	15.88	X56	S	1.4128	Standard Pipe
			15.88		S	0.0001	Standard pipe, sleeved
Ground Movement			15.88		S	0.0210	All
Total			15.88		S	1.4338	Standard Pipe
			15.88		S	0.0211	Standard pipe, sleeved

Table 2: Pipeline Failure Frequencies

4.2 Consequence Analysis

4.2.1 Hazard Distances

The boundary conditions used for the assessment are shown in Table 3. The principal hazard range criterion for people exposed to thermal radiation is taken as the distance from the fire from which there is a Significant Likelihood of Death (SLOD), equivalent to 1800 thermal dose units (TDU) [kW/m²] or 12.8 kW/m² exposure for 1 minute. All people receiving this dose or greater are assumed to become casualties, suffering life-threatening burn injuries with approximately 50% assumed to become fatalities in a normal population. In calculating the escape distance, a lower threshold of 1 kW/m² (320 Btu/ft²h) is used, to which it is assumed that a person can be exposed to an indefinite period of time without injury. It is further assumed that people who are not inside buildings are able to escape the effects of

the fire at a speed of 2.5 m/s. For 'sensitive' populations such as schools, hospitals etc., a more onerous 1% lethality criterion is used together with a reduced escape speed of 0.7 m/s. The reduced escape speed of 0.7 m/s is also used for adults at locations where sensitive populations are present, as they are assumed to assist the sensitive populations to escape.

Pipeline	U/S Boundary Condition	D/S Boundary Condition	Distance between (km)	D/S distance to location (km)
EM04BLAL	Pressure Maintained at Shangton	Pressure Maintained at Alrewas	67.47	36.81

Table 3: Pipeline Boundary Conditions

The resulting maximum hazard distances are given in Table 4.

Pipeline	Hazard Range	Distance (m)
EM04BLAL	Escape Distance (1800 TDU, 2.5 m/s)	338.9
	Escape Distance (1% lethality, 0.7 m/s)	682.8
	House Burning Distance (Piloted Ignition)	239.5

Table 4: Maximum Hazard Distances

4.2.2 Population Details

Currently, within the assessment area, the following buildings and population points are present:

- 68 holiday lodges, 58 caravan/camping pitches, and a lifeguard training facility, all associated with the Lakeside Lodges holiday park,
- 62 houses at the King Richards Wharf housing development to the East of the proposed development,
- Market Bosworth sports club,
- A Christmas tree farm.

It is noted that camping pitches previously visible in older satellite imagery to the North of the pipeline at 52.622629, -01.429579 (E438712 N302915) have been partially replaced by a lake in the most recent imagery and there are no plans for new accommodation in this area.

The new spa development will consist of 38 lodges, a main building, and 3 activity pods, all of which fall within the hazard zone of the pipeline. Aerial imagery from Google Earth of the proposed site is shown in Figure 1 and the proposed development plans for the Spa, existing lakeside lodges and King Richards Wharf housing development are shown in Figure 2, Figure 3 and Figure 4 respectively. The plan of the Spa and lodges are overlaid on the Google Earth Image in Figure 5. The King Richards Wharf Site plan has been consulted to accurately assign populations to the building site footprints visible in the aerial imagery.

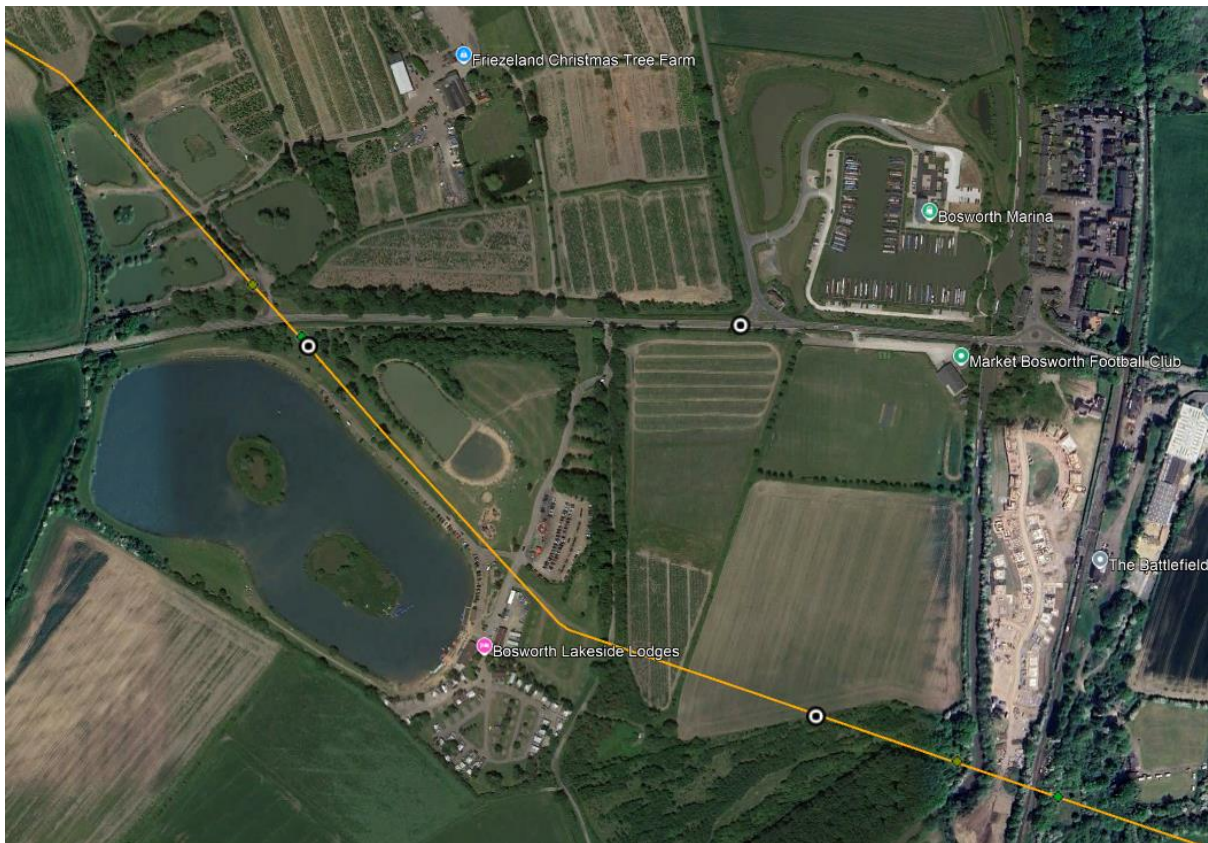


Figure 1: Aerial Imagery of Proposed Site



Figure 2: Plan of Spa Site (ref. [6])





Figure 5: Development Overlaid on Google Earth Imagery

The houses and farm have been assigned the generic population and residency values from TP-HAZ-16 (ref. [2]). The camp pitches have been assumed to have seasonal variation in line with TP-HAZ-16. Seasonal variation has been applied to the lodges using assumptions from the client (ref. [9]). Non-generic populations have been determined by information available online (ref. [10] [11] [12]) details have been provided in Table 5. There are numerous team training sessions and fixtures held during evenings and weekends at the football club, so a conservative population of 100 has been assigned for the entirety of the non-working day.

Description	Hours population present	Population (Normal / Sensitive)	Proportion outdoors (%)
Market Bosworth FC	Non-working day	100	100
Houses	Working Day	1	10
	Non-working Day	3	10
	Night	3	1
Christmas Tree Farm	Working Day	4	60
	Non-working Day	6	10
	Night	6	1

Description	Hours population present		Population (Normal / Sensitive)	Proportion outdoors (%)
Playground in Market Bosworth	Summer	Working Day	0 / 10	100
		Non-working Day	0 / 20	100
	Autumn/Spring	Working Day	0 / 10	100
		Non-working Day	0 / 15	100
	Winter	Working Day	0 / 5	100
		Non-working Day	0 / 5	100
Leicestershire Lifeguards	Non-working Day		20	60
	Working Day		20	60
Camping and Caravan Pitches	Summer	Working Day	58	100
		Other Times	174	100
	Autumn/Spring	Working Day	29	100
		Other Times	87	100
	Winter	Working Day	6	100
		Other Times	18	100
Playground at Lakeside and surrounding recreational area	Summer	Working Day	45 / 10	100
		Non-working Day	75 / 20	100
	Autumn/Spring	Working Day	15 / 5	100
		Non-working Day	30 / 15	100
	Winter	Working Day	6 / 3	100
		Non-working Day	15 / 5	100
Existing Lodges	Summer	Working Day	68	100
		Other Times	204	100
	Autumn/Spring	Working Day	51	100
		Other Times	153	100
	Winter	Working Day	34	100
		Other Times	102	100

Description	Hours population present		Population (Normal / Sensitive)	Proportion outdoors (%)
Spa Lodges	Summer	Working Day	38	100
		Other Times	114	100
	Autumn/Spring	Working Day	29	100
		Other Times	87	100
	Winter	Working Day	19	100
		Other Times	57	100
Main Spa Building	Once a Week (Wedding/Event)	8am – 12am	150	10
	All other days	8am – 12am	100	10
Activity Pods	All days	8am – 9pm	20	10

Table 5: Population details

There are two roads within the hazard distance of the assessed interaction length (Wellsborough Road and Unnamed Road). The car flow rate for Wellsborough Road was estimated from manual count point data (ref. [13]). The car flow rate for the Unnamed Road was estimated from manual count point data (ref. [14]) of a nearby similar sized road. All vehicles are assumed to have two occupants and vehicles are assumed to provide no long-term protection from thermal radiation. Therefore, occupants are assumed to be outdoors at all times, although they can benefit from surrounding shelter, if available.

Table 6 and Table 7 include the data used for these road crossings. Road populations seen in Table 7, were produced using the methodology laid out in the HAMM Pipelines Review (ref. [15])

Parameter	Wellsborough Road	Unnamed Road
Road Type	B	C
Speed (miles per hour)	30	30
Area type	R	S
Traffic flow (vehicles per day)	5119	130

Table 6: Road Details

Residency Period	Number of People within Hazard Range	
	Wellsborough Road	Unnamed Road
00:00 – 07:00	1	0
07:00 – 09:00	12	0
09:00 – 15:00	8	0
15:00 – 19:00	10	0
19:00 – 00:00	3	0

Table 7: Road populations

A railway (The Battlefield Line Heritage Railway) crosses the hazard distance. The rail input parameters and population estimations are given in Table 8 and Table 9 (ref. [16] [17]). The estimated number of fatalities from a derailment is 76.

Residency Period	Number of trains passing within period
00:00 – 07:00	0
07:00 – 09:00	0
09:00 – 15:00	6
15:00 – 17:00	2
17:00 – 19:00	0
19:00 – 00:00	0

Table 8: Rail Details

Parameter	Shackerstone to Shenton
Number of Trains	8
Fatality probability in Derailment	0.5
Pipeline within spontaneous house burning distance of the track (m)	475
Spontaneous house burning distance (m)	239.3
Number of tracks	1
Train speed (mph)	15
Thinking time (secs)	5
Braking distance (m)	916

Table 9: Rail Populations

Figure 6 shows the population in close proximity to the pipe assessed as part of this risk assessment.

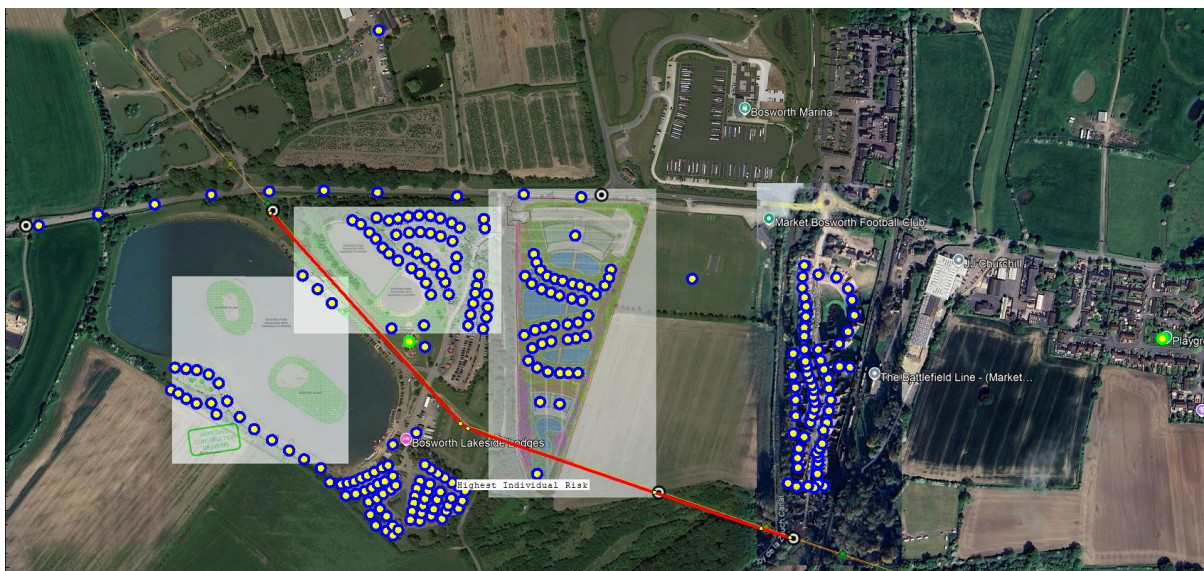


Figure 6: PIPESAFE Site Map

4.3 Risk Assessment Results

4.3.1 Individual Risk

The maximum individual risk was determined to be 4.56×10^{-7} at the proposed site of one of the activity pods approximately 70m from the pipeline.

This is below the 1.0×10^{-6} per year level that is considered to be 'broadly acceptable'.

4.3.2 Explosion Risk

For pipelines where buildings are identified within 30 m, a high-level calculation is undertaken to estimate the Individual Risk at the building arising from explosions. The failure frequency of a pinhole leak for the appropriate wall thickness of pipe is determined from IGEM/TD/2 [18] for corrosion and material and construction defects. Previous work [19] is used to determine the explosion probability at the distance of the building from the pipeline, for the given pipeline parameters. Taking account of the length of pipeline within 30 m of the building, the probability that the leak does not initially ignite and cause a fire, and the estimated vulnerability of occupants, the individual risk is calculated and reported in Table 10.

Location	Failure frequency of pinhole leaks (per 1000 km per year)	Distance from Pipeline	Explosion Probability	Individual risk (per year)
Existing lodges between lake and pipeline	Negligible	10	1.37×10^{-4}	Negligible

Table 10: Explosion Risk Results

4.3.3 Societal Risk

Societal risk is expressed as the relationship between frequency (F) of an event and the expected number of fatalities (N) in the form of a FN curve, the results are adjusted by a scaling factor, equal to 1.6 km divided by the pipeline interaction distance so that they can be compared against the acceptance criterion for broadly acceptable risk given in IGEM/TD/2 (ref. [18]) which applies to an assessment length of 1.6 km.

The FN curve is shown plotted against the National Gas risk criterion in Figure 7. The PLL is calculated to be 1.65×10^{-4} , and the maximum number of casualties is 559.

The FN curve crosses the criterion line, therefore, a cost benefit analysis (CBA) has been performed.

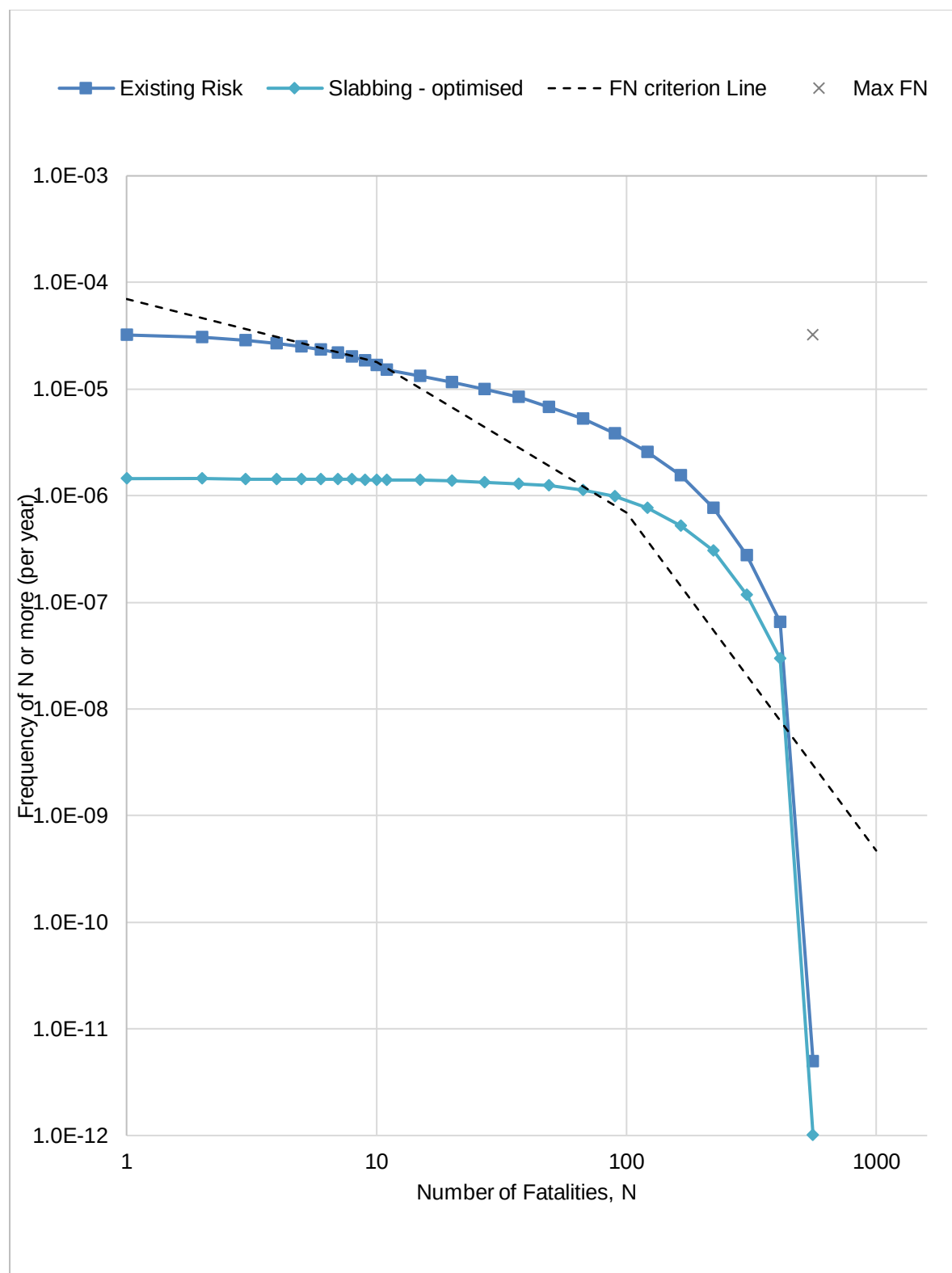


Figure 7: Societal Risk fN Curve for EM04BLAL

4.3.4 Cost Benefit Analysis

Cost benefit analysis evaluates the ratio of the cost of a particular measure against the risk benefit expressed in terms of the difference in the Potential Loss of Life (PLL) to determine if the risk is As Low As Reasonably Practicable (ALARP). In the case of societal risk, the PLL is based on the sum of the calculated FN pairs.

The cost benefit analysis calculation is undertaken in the form of a Cost Per Casualty Averted (CPCA), based on the following:

$$\text{CPCA} = \text{Cost of mitigation measure} / \text{RL} \times (\text{PLL}_1 - \text{PLL}_2)$$

Where PLL_1 and PLL_2 are the values before and after mitigation. The Remaining Life, RL (of the asset) in the above equation, is taken as 40 years for the assessment (ref. [2]).

The mitigation measures considered in the assessment are installing impact protection slabs along the length of the development or re-laying the pipeline section with increased wall thickness. The costs associated with implementation of these mitigation measures are as follows (ref. [20])

- Impact Protection slabs - £1500/m + £20,000 set-up cost
- Increased wall thickness line pipe - £6000/m + £50,000 set-up cost

The reduction factors from IGEM/TD/2 are applied to update the rupture frequency estimated to calculate PLL_2 .

4.3.4.1 ALARP Criteria

The criteria that are applied for pipeline risk assessments are as follows (ref. [20]):

1. Where $\text{CPCA} < £15\text{M}$, ALARP is not demonstrated without further detailed cost benefit analysis;
2. Where $£15\text{M} < \text{CPCA} < £75\text{M}$, further consideration should be given by National Gas management to the need for mitigation measures;
3. Where $\text{CPCA} > £75\text{M}$, risks are considered ALARP.

Therefore, when cost benefit analysis is undertaken, the CPCA value is initially compared with a criterion value of £75M. If the CPCA value is below this criterion value, then a more detailed analysis is undertaken and consideration is given to the maximum number of casualties predicted as follows [A.14]:

- If the maximum number of casualties predicted is 10 to 100, a Gross Disproportion Factor (GDF) of 10 is used to give a revised CPCA criterion value of £24M;
- If the maximum number of casualties predicted is 101 to 1000, a GDF of 20 is used to give a revised CPCA criterion value of £47M;
- If the maximum number of casualties predicted is over 1000, a GDF of 30 is used to give a revised CPCA criterion value of £71M

4.3.4.2 Pipeline Details

The cost benefits of two risk reduction measures have been considered, installation of concrete slabbing and relaying the pipeline with thick-walled pipe.

There are no sections of heavy wall pipe on this pipeline. The cost benefit analysis (CBA) will use a heavy wall pipe wall thickness of 19.05 mm and a material grade of X56, resulting in a design factor of 0.46.

The CBA has been undertaken by applying concrete slabbing or increased wall thickness (for the unprotected pipe sections only). Table 11 shows the revised failure frequencies that have been calculated for the pipeline.

Failure Cause	Diameter (mm)	MOP (barg)	Wall thickness (mm)	Grade	Area Type	Rupture frequency per million km years	Notes
Third Party	914.4	70	15.88	X56	S	1.4128	Standard pipe
			15.88			0.2666	Standard pipe, slabbed
			15.88			0.0001	Standard pipe, sleeved
			19.05			0.1188	HWP
Ground Movement			15.88 / 19.05			0.0210	-
Total			15.88			1.4338	Standard pipe
			15.88			0.2876	Standard pipe, slabbed
			15.88			0.0211	Standard pipe, sleeved
			19.05			0.1398	HWP

Table 11: Pipeline Failure Frequencies

4.3.4.3 Protection over entire interaction length

The CBA has been undertaken by applying concrete slabbing or increased wall thickness along the entire interaction length.

The results of this CBA for applying protection along the entire interaction length are summarised in Table 12.

Parameter	Concrete Slabbing	Thick-Walled Pipe
Location of protection	Unprotected Sections only	
Length of protection (m)	894	851
Total cost (£)	1,361,000	5,156,000
EV before risk reduction (per year)	1.645×10^{-4}	
EV after risk reduction (per year)	3.301×10^{-5}	1.607×10^{-5}
CPCA (£million)	259	869

Table 12: Summary of CBA for Applying Protection Along Entire Interaction Length

4.3.4.4 Optimised protection at a specific location

The pipeline is known to have low toughness. Previous work has shown that a standard risk assessment methodology is acceptable for low toughness pipelines as long as the CPCA is above £127Million [21].

The pipeline optimisation method has been used to determine the minimum CPCA value that is achievable. The results of this optimised CBA for applying slabbing protection at a specific location are summarised in Table 13. The result for thick-walled pipe was over £500 million so no further details have been reported.

Parameter	Concrete Slabbing
Location of protection	From the playpark towards the new development
Length of protection (m)	174
Total cost (£)	281,574
EV before risk reduction (per year)	1.645×10^{-4}
EV after risk reduction (per year)	1.203×10^{-4}
CPCA (£million)	160

Table 13: Summary of optimised CBA for applying protection at a specific location

The maximum number of casualties is between 100 and 1000, therefore a gross disproportion factor of 20 is used giving a revised CPCA criterion value of £47M.

The optimised CPCA values obtained for both slabbing and thick-walled pipe are above the £47M criteria, therefore the costs are disproportionate to the benefits achieved and the risks are considered to be acceptable and ALARP.

5 CONCLUSIONS

- The maximum individual risk level for this assessment was determined to be 4.56×10^{-7} at the proposed site of one of the activity pods approximately 70m from the pipeline, which is below the 1.0×10^{-6} per year level that is considered to be 'broadly acceptable'
- The individual risk from explosion has been assessed and classified as "negligible".
- The FN curve for societal risk crosses the criterion line, therefore, a cost benefit analysis (CBA) has been performed. The PLL is calculated to be 1.65×10^{-4} , and the maximum number of casualties is 559.
- The optimised CPCA values obtained for both slabbing and thick-walled pipe are above the £47M criteria, therefore the costs are disproportionate to the benefits achieved and the risk are considered to be acceptable and ALARP.
- The optimised CPCA values obtained for both slabbing and thick walled pipe are above £127 Million which confirms that the standard methodology is appropriate and the acceptable result is valid for this low toughness pipeline.

6 REFERENCES

- [1] IGEM/TD/1 Edition 6. Steel Pipelines for High Pressure Gas Transmission. IGEM Communication 1789., 2021.
- [2] T/SP/HAZ/16. Specification for Hazard Assessment Methodology Manual Part 1 High Pressure Pipelines. National Gas Transmission July 2018.
- [3] DNV. PIPESAFE Version 2.29.0. July 2023.
- [4] NGT, Pipeline Data Book, Issue 40, June 2023.
- [5] National Gas, *IGEM/TD/1 Edition 4 Audit Report Blaby to Alrewas Feeder 4*, National Gas, 2016.
- [6] *Bosworth Family Health and Wellness Spa - Development Proposal Plan Drawing No. GL2223 02C*, 09/08/2024.
- [7] SR Construction Limited, *Bosworth Water Trust Water Construction Plan Drawing No. MU2481-W01 Rev 04*, Brierly Hill, 09/11/2021.
- [8] Owl Homes, "New Homes in Market Bosworth," Property HQ, [Online]. Available: <https://owlhomes.co.uk/development/king-richards-wharf-market-bosworth>. [Accessed 19th March 2025].
- [9] J. Golby, *Correspondence between Jon Golby (Golby and Luck) and Elizabeth Kennedy (ROSEN UK) cc: Toby Ryley (Lakeside Lodges)*, 18th March 2025.
- [10] "Leicestershire Lifeguards," 2018. [Online]. Available: <http://leicestershirelifeguards.org.uk/>. [Accessed 19 March 2025].
- [11] "Market Bosworth Football Club," 2025. [Online]. Available: <https://marketbosworthfc.co.uk/teams/>. [Accessed 19 March 2025].
- [12] "Market Bosworth Cricket Club," Active Together, 2025. [Online]. Available: <https://www.active-together.org/directory/market-bosworth-cricket-club>. [Accessed 19 March 2025].
- [13] Department for Transport, "Road Traffic Statistics," 2019. [Online]. Available: <https://roadtraffic.dft.gov.uk/manualcountpoints/806395>. [Accessed 21st March 2025].
- [14] Department for Transport, "Road Traffic Statistics," [Online]. Available: <https://roadtraffic.dft.gov.uk/manualcountpoints/802147>. [Accessed 02 04 2025].
- [15] DNV, "Risk Assessment Methodologies for Pipelines and AGIs 2020/2021, HAMM Pipelines 2020/2021 Review, National Grid & Cadent Gas," 2022.
- [16] "Battlefield Line Railway - Wikipedia," Wikimedia, [Online]. Available: https://en.wikipedia.org/wiki/Battlefield_Line_Railway. [Accessed 19 March 2025].
- [17] T. S. R. Society, "Timetable - The Battelfield Line," Wix.com, 2025. [Online]. Available: <https://www.battlefieldline.co.uk/timetable>. [Accessed 19 March 2025].
- [18] Institution of Gas Engineers and Managers, "IGEM/TD/2 Edition 2 (with amendments July 2015), 'Assessing the Risks from High Pressure Natural Gas Pipelines'.".
- [19] A. Phillips, "Investigation of Explosion Risk due to Natural Gas Transmission Pipelines', Advantica Report 7859," 2005.
- [20] National Gas, ROSEN UK, "Email correspondence between Jody Harrison (NG) and Justin Sheppard (ROSEN UK)," 24/05/2024.
- [21] M. Robinson and D. Adams, "Summary of Integrity and Risk Assessment Studies on Low Toughness Pipelines Operated by National Grid UKT," GL Noble Denton, Loughborough, August 2012.

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