Northern Gas Networks

A22.n – River Allen Major Project

Engineering Justification Paper

Contents

1. Summary table

Name of Project	*River Allen LTS diversion*		
Scheme Reference	*A22.n.NGN*		
Primary Investment Driver	*Asset Health*		
Project Initiation Year	*2023/24*		
Project Close Out Year	*2026/27*		
Total Installed Cost Estimate (£)	*£7.70m*		
Cost Estimate Accuracy (%)	*60%**		
Project Spend to date (£)	*£95,318.50*		
Current Project Stage Gate	*FEED*		
Reporting Table Ref	*5.01*		
Outputs included in GD3 Business Plan	*Yes – see section 8.4*		
Spend Apportionment (£m) (2023/24 prices)	**RIIO-GD2**	**RIIO-GD3**	**RIIO-GD4**
	£0.95m	*£7.70m*[i]	*No anticipated Capex costs – although the pipeline will have to continue to be internally inspected through standard practice.*

** Although we have undertaken comparable works recently and therefore have a solid understanding of the costs involved, the cost accuracy for this project remains relatively low. This is because the majority of the spending is associated with the procurement and construction activities, which need a defined route of the diversion and the method of installation. These elements will only be determined by the FEED study, the results of which will not be available until early to mid-2025.*

[i]*Excludes existing spend – inspections, emergency work and optioneering pre-FEED, including hydraulic modelling. This is included in "Project spend to date". £189,800 of the £7.7m utilised in RIIO-GD2 for FEED and detailed design.*

2. Executive summary

Catton to Cummersdale, an 18” steel pipeline operating at 19 bar, is exposed in the riverbed of a powerful watercourse – River Allen. Furthermore, the river's east bank is visibly eroding, which is putting the pipeline at further risk of being exposed and damaged, as the pipeline is currently only approximately four meters away from the bank's edge. Damage to this pipeline could lead to a catastrophic failure and the prolonged loss of supply to more than 100,000 customers, as well as causing significant environmental damage.

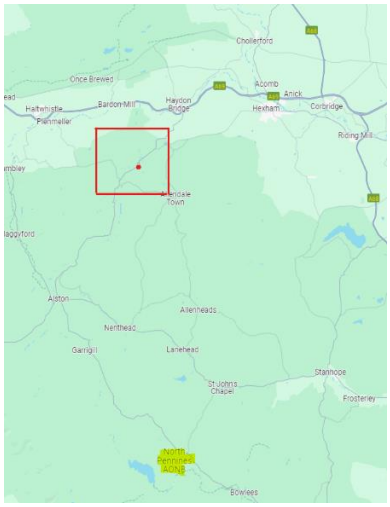

Figure 2 River crossing in the North Pennines Area of Outstanding

Following extensive investigation by expert consultants, it has been established that **the only plausible, effective long-term solution is for the pipeline to be diverted** at the estimated cost of £7.7m. The diversion would address the current exposure in the riverbed and the ongoing risk of exposure in the riverbank. Long-term resolution of these issues would also significantly benefit the local environment – North Pennines Area of Outstanding Natural Beauty (AONB). The immediate area surrounding the crossing falls within a Site of Specific Scientific Interest (SSSI) and is home to various wildlife. Any intervention in this area is subject to vigorous scrutiny by the Environment Agency and Natural England. Highly invasive or repeated interventions are challenged. Whilst diverting the pipeline is a highly invasive option, defining the diversion route provides NGN with an opportunity to place the most invasive tasks outside of the SSSI to protect it. Furthermore, the long-term nature of this solution eliminates the need for return construction visits and removes risks associated with interfering with the natural flow and change of the watercourse.

The section of the pipeline exposed in the riverbed is extremely vulnerable to being impacted by large natural materials within the watercourse. Every event where the river level increases above the normal range (0.53m for River West Allen) has the potential to lead to significant damage to the pipeline. This high-velocity watercourse can transport large boulders and wash away the temporary protection measures currently installed. We have already experienced this in 2019 when the concrete cobble mats we installed to protect the pipeline four years earlier were washed away. Therefore, to avoid damage that could lead to catastrophic consequences we must implement an effective and sustainable solution, which we can only achieve through the diversion of this pipeline.

3. Project status and request summary

The status of the project is currently in FEED delivery, before going out to detailed design. Delivery of this diversion is initially planned in Year 1 of RIIO-GD3 and we are forecasting that the entire project will cost around £7.7m (the total amount being requested). This is based on a similar type of work carried out in the past (see section 4.1) but is also subject to the FEED study which will determine the new pipeline route, depth and construction method.

This section of the Catton to Cummersdale pipeline falls within a highly volatile watercourse. During RIIO-GD1 this pipeline was protected with a specialist concrete mattress, however, a flooding event in 2015 led to the mattress being washed away. We have conducted regular inspections at this location and witnessed that the pipeline exposure level has varied throughout. We proposed to remedy the exposure during RIIO-GD2, expecting to design an in-channel solution, based on the optioneering piece completed in 2019. We started the design process with our specialist consultant, however, a routine inspection in 2023 revealed that the pipeline exposure has progressed beyond previous levels.

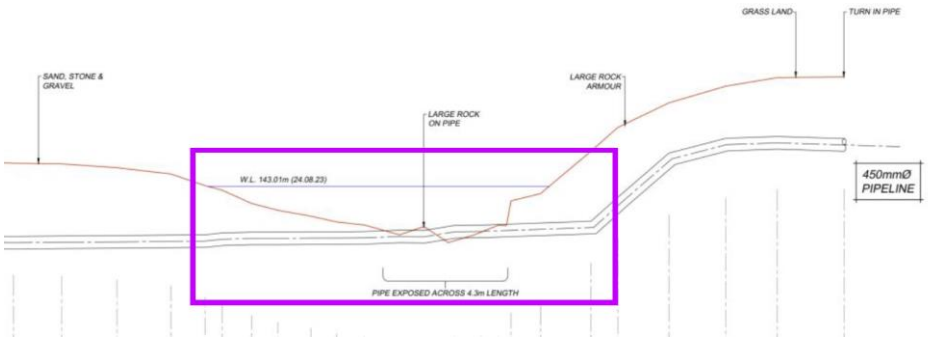

Figure 3 Inspection report 2023

Working with our specialist contractors, we promptly safeguarded the pipeline in its current position by using temporary rock bags. This measure allowed us to continue with the detailed design for the originally planned in-channel solution. However, after consultations with the Environment Agency and Natural England concerning the temporary emergency works, the design strategy shifted. The consensus between NGN and these agencies advocated for a long-term solution, and, based on the analysis from our specialist consultants as well as our previous experiences at this location, a diversion emerged as the only viable option. The detailed analysis supporting this option is contained in section 7.1 below.

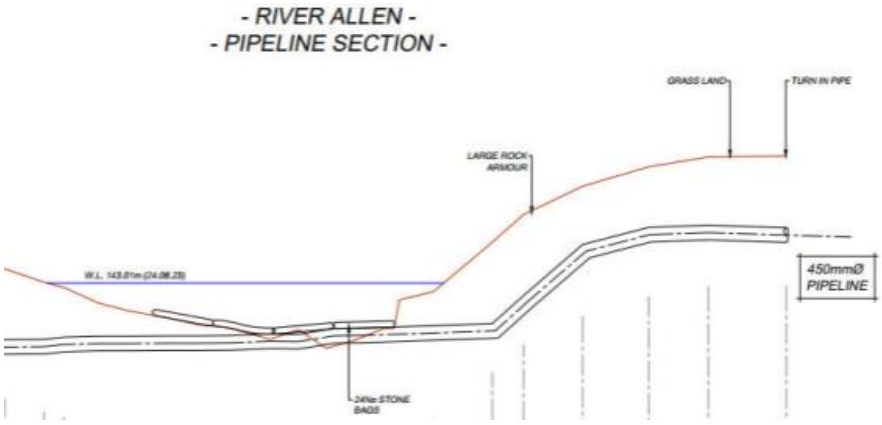

Figure 4 Emergency temporary protection works carried out in 2023 – cross-section view

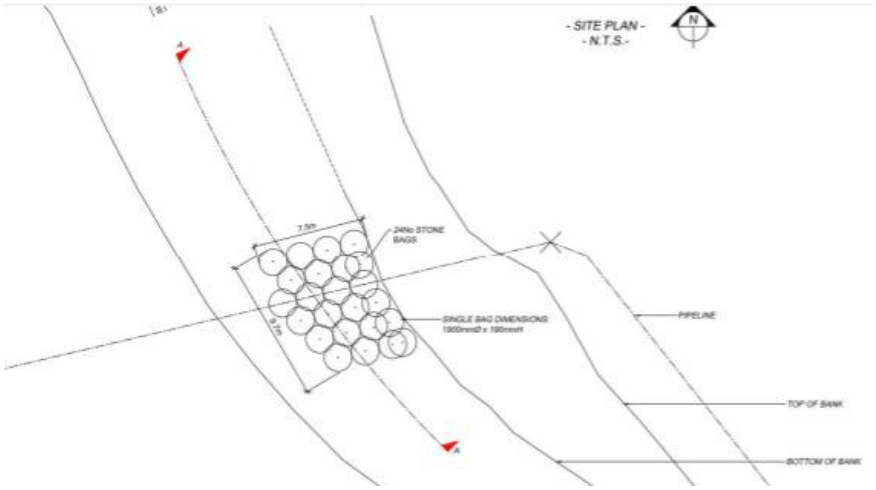

Figure 5 Emergency temporary protection works carried out in 2023 - view from the top

4. Problem / opportunity statement

NGN owns and operates the Catton to Cummersdale, 18-inch gas transmission pipeline. It is nearly 50km long and connects two above-ground installations in the regions of Northumberland and Cumbria. The topography of these mountainous areas is highly intricate and includes important bodies of water, both large and environmentally significant. Consequently, the pipeline encounters multiple challenges, including crossing the River Allen. The pipeline is exposed in the riverbed and has been subject to remedial work proposals as well as increased monitoring. A long-term solution is now required to ensure a safe and resilient supply to the over 100,000 customers that it serves. NGN, with the help of our expert contractors, explored various options seeking to protect the pipeline in situ, and although initially, this appeared to be a possibility, upon extensive investigation, hydraulic modelling, and collaboration with government agencies, namely the Environment Agency and Natural England, the conclusion drawn was that the pipeline diversion should be pursued. The analysis is detailed in section 6 below.

Hydraulic modelling

Return period (AEP)	Velocity (m/s)	Water Depth (m)	Flow (m^3/s)	Max stage (m AD)
2 (50%)	2.09	3.79	106.28	144.79
5 (20%)	2.25	4.03	131.66	145.04
10 (10%)	2.31	4.18	145.98	145.18
30 (3.3%)	2.35	4.41	165.96	145.41
50 (2%)	2.35	4.45	175.24	145.52
75 (1.33%)	2.36	4.61	183.20	145.61
100 (1%)	2.37	4.68	189.18	145.68
200 (0.5%)	2.40	4.84	204.26	145.84
1000 (0.1%)	2.48	5.3	254.62	146.34

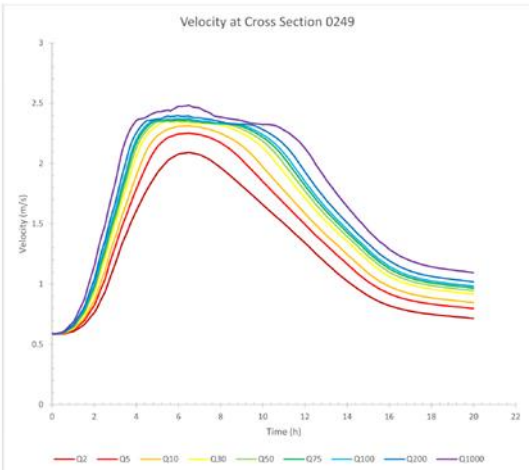

Figure 6 Hydraulic modelling results showing the range of water velocity within the watercourse

Several challenges associated with this project include the technical aspects of the pipeline, access requirements and the environmental concerns surrounding the impacted area. The pipeline operates at a pressure of 19 bar

and is a key asset acting as a single source of supply of gas to Cumbria. Hydraulic modelling of the river Allen has shown that there is a potential for boulders of up to one-meter diameter to be moved down the river during high flow periods. This therefore is a serious risk to supply in the event of a boulder impacting the pipeline. Another challenge is the rugged landscape that falls within the North Pennine Area of Outstanding Natural Beauty.

There are further additional environmental and ecological considerations such as the [redacted] and nearby [redacted] both of which have been designated as Sites of Specific Scientific Interest (SSSI). And a Grade II liste [redacted] bridge downstream of the Gravels. All of which are to be addressed as part of the proposals.

The pipeline has been subject to some remedial works recently to ensure safety during the detailed planning and review process of the long-term solution, and the final option is aimed to be installed in the first year of RIIO-GD3. The success of this project is defined by increased long-term pipeline security, without disturbance to the SSSIs or listed bridge.

[redacted]

[redacted]

In summary:

Why are we doing this work and what happens if we do nothing?

This project is being carried out to guarantee the long-term security and safety of the Catton to Cummersdale gas transmission pipeline. Without intervention, the pipeline faces risk from environmental factors like flooding and boulder impacts, which can erode its wall thickness over time or cause sudden failures, thus endangering the gas supply for over 100,000 customers. This alone could constitute the cost of more than £32m (107,161 properties at £300 each, as per NGN calculated Loss of Supply metric).

Under what circumstances would the need or option change for this project?

The need or option for this project may change if there are significant alterations in environmental conditions, advancements in engineering solutions that provide a more feasible in-situ protection, or changes in regulatory requirements from agencies such as the Environment Agency and Natural England.

What are we going to do with this project?

We will be diverting the pipeline to ensure its protection. This involves designing and constructing a new route for the pipeline east and west of the River Allen, isolating the currently exposed section while maintaining the gas flow in the Catton to Cummersdale pipeline.

What makes this project difficult?

Several factors make this project challenging:

- The technical aspects of the pipeline, which operates at a high pressure of 19 bar.

- The rugged landscape within the North Pennines Area of Outstanding Natural Beauty (AONB). The logistics of transporting plant, equipment and materials, taking into consideration ground conditions and access/egress to the construction site.

- Environmental, ecological and stakeholder relations challenges, including Sites of Specific Scientific Interest (SSSI) like the [redacted] and [redacted] as well as the Grade II listed [redacted]

What are the key milestone dates for project delivery?

Due to the urgent need to find a lasting solution to this problem, the final option is aimed to be installed in the first year of RIIO-GD3, although specific milestone dates are not provided in the current document.

How will we understand if the project has been successful?

Success will be measured by the increased long-term security of the pipeline without disturbing the SSSIs or the listed bridge, ensuring a safe and resilient gas supply to the served customers.

4.1. Related projects

RIVER CALDEW: Catton – Cummersdale Diversion

Figure 9 River Caldew diversion construction sites

During RIIO-GD2 we carried out a comparable diversion near Carlisle, in Cumbria. Following an inspection, it was identified that the 18" pipeline had a compromised depth of cover under the River Caldew. Due to the failure of past remedial works, the only viable option was the diversion of the pipeline to ensure adequate depth of cover for the river crossing. This project was constructed in parallel with a nearby third-party diversion enabling the building of a link road near Carlisle (CSLR), to ensure efficiency in delivery.

This project can be compared directly with the currently proposed diversion at River Allen as it affected the same pipeline, thus the attributes of the pipeline are identical (see Figure 3). The location for the River Caldew diversion was, arguably, less challenging due to there being no complications associated with SSSI, listed structures or high-profile landowners using the land for commercial purposes.

The cost of this diversion has come to £5.42m, including overheads.

4.2. Project boundaries

To be included: -

All necessary project elements such as design, procurement of materials, construction, and commissioning and included in this proposal.

Specifically, the project will consist of: -

- Design of the most cost-effective, ecologically acceptable, and appropriate routing to divert the existing pipeline East and West of the river Allen to allow the currently exposed section of the pipeline to be isolated, whilst still maintaining flow in the Catton to Cummersdale pipeline.
- Design to be based on current approved specifications.
- Design to include valve and stopple arrangement on both sides of the river to allow bypass and tie-in whilst maintaining flow from Catton to Cummersdale.
- Design of best tunnelling process to avoid any disturbance to the nearby SSSI's and listed buildings.
- Design of the best routing to avoid any disturbance to the nearby SSSI's and listed buildings.
- Design of the best routing to avoid future pipeline exposure.

5. Project Definition

5.1. Supply and demand scenario discussion and selection

Different supply/demand scenarios have not been considered during our modelling as the current NARM Methodology does not include analysis for this. This is a future update to NARM in gas distribution that has been identified within the Methodology document and will be reviewed by the networks through NARM working groups. Overall, we are forecasting a slow recovery from the impacts of the cost-of-living crisis and total domestic demand is forecast to return to 2021 levels between 2029 and 2031 for the NE and NO distribution zones of our network. This is based on established econometric modelling and demand forecasting methodologies.

Although the NARM Methodology does not account explicitly for, supply-demand scenario analysis, the fault and failure data we currently base our modelling calculations on includes data collected over a period of historic years, which goes back to before 2021. Consequence data from company systems also reflects the latest available view for our asset base at 2023/24 and is also based on data from historic events collected over some time. Therefore, we do not anticipate demand to have a material impact on our investment decisions or their benefits during RIIO-GD3.

Our Commitment to Resilience

Chapter 5 of our Business Plan demonstrates our longstanding commitment to ensuring that we can operate and maintain a resilient network. We have formalised our Resilience Framework and developed several individual resilience strategies which allow us to maintain our high standards. Our Resilience Framework ensures that we continually review the hazards facing our business and assess whether the mitigations that we have in place remain sufficient or need to change. This is relevant to our asset management strategies as we need to take into account exogenous factors when considering both short and long-term investment plans. Our Network Asset Management Strategy which is set out in Appendix A18 brings this all together.

We have introduced a range of other resilience strategies, such as Appendix A8 – Climate Resilience Strategy. A climate risk assessment sets out the risks facing NGN currently, in 2050 and 2100, as set out in section 1.5.2 of the strategy. The climate scenario risk analysis did not identify high risks for either the 2oC or worst-case 4oC warming scenarios assessed. As such, this recognises our resilience to material climate change risks in the long to very long term (2050+). This is due to our comprehensive asset integrity and management procedures that are in

operation to ensure asset condition and performance. In addition, there is inherent resilience afforded by gas infrastructure assets being a sealed, pressurised system principally located underground. Resilience levels to climate change risks will be greater in lesser warming scenarios should they arise, due to lower climatic extremes. The likely current and future climate risk has been factored into our preferred strategies across our LTS assets from the outset by utilising our SME knowledge and risk assessments mentioned above.

We are taking a similar approach to RIIO-GD2 in putting together our investment plan, taking a balanced approach to asset management to ensure a safe, reliant, and compliant network – ensuring we can continue to meet our licence obligations whilst at the same time minimising costs for customers.

5.2. Project scope summary

The scope of this project is to address an exposed pipeline crossing of the River Allen at the [redacted]. Due to the location and convergence, this section of the river is fast-flowing and highly susceptible to bed and bank erosion, as well as capable of carrying large amounts of debris and rock downstream. Due to erosion of the riverbed, the pipeline has become exposed and is now at risk of damage and potential failure from the impact of debris and rock from upstream.

Pipeline integrity and security of supply considerations necessitate urgent action to mitigate the risk to the pipeline, and surrounding area, of failure.

6. Options considered

Ofgem CBA Template Assumptions

For all CBAs in our RIIO-GD3 submission, we used an assumed weighted average cost of capital (WACC) of 3.92% based on Ofgem guidance (a real average basis). We have assumed a depreciation Acceleration Factor of 100% across all CBAs and scenarios, i.e. no additional acceleration of depreciation. For Capex CBAs we have assumed a capitalisation rate of 33.7% based on our Totex forecasts in BPDTs and 100% for Repex CBAs. First year of expenditure outflow is set to 2027 in all scenarios for consistent relative NPV calculations. This is in line with Ofgem guidance for RIIO-GD3 and the approach taken in RIIO-GD2. We consider that the plausible ranges of these parameters would not materially affect CBA outcomes and have provided only one version of templates with these consistently applied (as they can be adjusted by Ofgem in any case).

We have not provided direct Opex associated with each CBA scenario as it would require us to artificially and subjectively divide up our maintenance and repair expenditure into each sub-asset class (CBA) and make a judgement on how this would be affected by each scenario. We do not record or report data at this level and we have no robust basis on which to provide it. In reality, maintenance and repair teams attend to multiple asset classes in single visits as part of an efficient function. Instead, we have provided the objectively calculated VF Financial risk, which is based on agreed industry NARM based calculations for estimating impacts on Opex under each CBA scenario. For those asset groupings not covered by NARM we have only included benefits and impacts of key benefits e.g. leakage. We consider this to be a more robust and objective approach to our CBAs. We have completed the NARM monetised risk memo lines from values in the NARM BPDT for baseline and preferred where they are available and relevant.

6.1. Baseline – Do minimum/nothing

This option does not consider any additional Capex investment and relies on the existing temporary protection measures without a plan of action when these measures are no longer effective. The Catton to Cummersdale pipeline is an integral part of the distribution network in the North of England. Its exposure in the bed of a substantial and volatile watercourse creates a level of risk that is unacceptable from a safety and reliability point of view, therefore doing nothing is not being considered as a viable option. The loss of supply risk alone amounts to £7.23m at the beginning of RIIO-GD3, rising by 2% every year thereafter. Furthermore, the existing rock bag protection which has been installed since 2023 as an emergency protection measure is not a permanent solution to the entire issue. Any flooding event will likely move the bags further downstream, again exposing the pipeline to the dangers within the watercourse. We have already experienced this during RIIO-GD1, when 150mm concrete cobble mats were installed to protect the exposed pipeline in 2015, but then washed away during a flooding event in 2019.

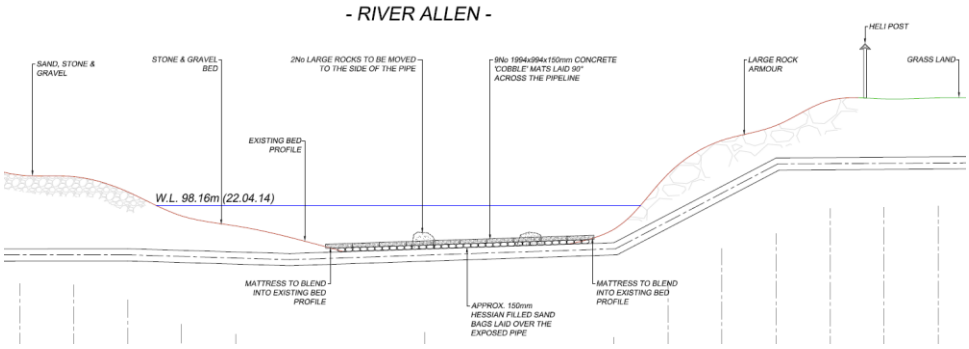

Figure 11 Concrete cobble mats installed in 2015

The environmental cost of return visits due to access requirements, as well as foreign material being continuously introduced into the watercourse, is not a sustainable, long-term solution and this has been indicated by the Environment Agency not to be acceptable. Furthermore, there is clear evidence of riverbank erosion, which at best will lead to the pipeline becoming exposed along the riverbank in the future. At worst it could cause significant damage to the pipeline, leading to costly emergency measures having to be implemented to avoid potential catastrophic failure.

The record of option assessment by our specialist consultants is available in appendix "Options Memo".[1]

6.2. First option summary – In-channel remediation

NGN engaged expert contractors to review and propose long-term remedial options to tackle the existing exposure of the pipeline as well as the ongoing riverbank erosion. Several remedial options were appraised for both the bed and the bank. The riverbed proposals included the installation of a rock mattress over the pipeline to protect it from direct impact, the introduction of large boulders strategically into the watercourse to encourage natural sediment build-up over the pipeline or the introduction of wood features angled into the watercourse encouraging it to re-shape itself and to create a more centrally dominant flow path and reduce riverbed scour where the pipeline is currently exposed. These are categorised as "in-channel" works. Remediation measures focusing on the riverbank were also proposed, ranging from vegetation being planted to support the bank to

[1] Page 5; option 1 – "Do nothing".

more extensive measures such as importing large boulders to create riprap or covering the bank in specialist matting. Whilst a combination of these measures was initially prioritised as the preferred option, notwithstanding our previous experience with in-channel works referenced in section 6.1, upon further investigation, which included liaison with stakeholders and topographical and hydraulic modelling, it became apparent that any combination of in-channel works should no longer be pursued. Considering surrounding circumstances such as the high energy of the river and environmental concerns, the final resort of a diversion was deemed to be the only viable option.

The record of option assessment by our specialist consultants is available in appendix "Options Memo".[2]

6.3. Second option summary – Divert below ground (preferred option)

Having considered the viability of remediation options, diversion is considered the only option available that will adequately mitigate the risk to the pipeline and ensure continued integrity and security of supply. Relocation of the pipe to a greater depth under the river will prevent any likelihood of impact from debris on the riverbed, further erosion or undermining of the pipeline and further exposure on the riverbank, removing a considerable risk to the transmission system. Additionally, diversion removes the requirement for line-of-sight inspection and ceases any impact on the surface SSSI area the pipeline is currently exposed within. Through the FEED study, several diversionary options are being considered to determine the best routing, trenchless crossing methodology, and most cost-effective approach to ensure pipeline integrity is secured for the future.

The diversion option would ensure that the pipeline integrity is protected and a well-designed route, including adequate depth, would eliminate the need for any additional remedial actions for the foreseeable future.

The cost of the diversion option is significant. The estimate was derived using the most recent comparable diversion across River Caldew described in section 4.1. We have spent £5.42m on the River Caldew diversion, including overhead.

Several factors substantiate the difference in the River Caldew and River Allen diversion costs.

Initially, as highlighted in section 4.1, the River Caldew diversion gained efficiencies due to two nearby diversions, one of which was funded by a third party. We have applied an estimated 16% increase to account for the absence of this efficiency at River Allen.

Additionally, diverting the River Allen has financial implications due to environmental and landowner considerations in contrast to the River Caldew. The River Allen's rerouting is within an Area of Outstanding Natural Beauty and impacts an SSSI, unlike the scenario with the River Caldew. Enhanced ecological and environmental risk mitigation measures are required for the River Allen, leading to an estimated additional cost of around 5%. Furthermore, the land around the crossing is managed by the Whitfield Estate, which uses some areas for commercial purposes such as hunting or private rentals. We predict that compensation for the landowner will be approximately 2%.

Additionally, we are incorporating a level of risk into the estimate to cover the uncertainty associated with this significant scheme. We applied a 15% uplift to account for this. This uplift is necessary to manage the variability and potential unforeseen complications that may arise during the execution of the project. Given the complexity

[2] Pages 5 and 6; options 2 through to 9 – "Do something – in-channel works"

and scale of the River Allen diversion, it is prudent to ensure that sufficient contingencies are in place to safeguard the project's success and maintain fiscal responsibility.

To summarise, the cost estimate is based on the following uplifts. These uplifts have been elicited by investigating completed projects and the impact of efficiencies, compensation payments and uncertainty on the overall cost. We applied these factors conservatively to ensure that the estimate is as realistic as possible: we reduced each, efficiency and uncertainty uplift, by 5% from the actual figures elicited by the exercise described above and halved the compensation factor. The environmental uplift factor has been estimated based on the costs already incurred due to the Environment Agency and Natural England requirements.

Compared to River Caldew's cost			
Item	**% increase**	**£ increase**	**Running total**
Starting position	n/a	n/a	£5.42m
Efficiency	16%	£867k	£6.3m
Environmental	5%	£271k	£6.6m
Compensation	2%	£108k	£6.7m
Applied to River Allen's total			
Uncertainty	15%	£1m	£7.7m

Table 1 Cost comparison between River Caldew and River Allen diversions

The record of option assessment by our specialist consultants is available in appendix “Options Memo”.[3]

For pipeline details, refer to Figure 3. See below the route proposed for estimating a diversion cost. Please note that the final route will wholly depend on the outcome of the FEED study due to be completed in early to mid-2025.

[redacted]

[3] Pages 5 and 6; options 2 through to 9 – “Do something – in-channel works”

6.4. Third option summary – Divert above ground

The diversion option also involved evaluating the installation of above-ground pipework. We considered the feasibility of rerouting the pipeline and constructing the overcrossing either at the listed downstream from the current location or by building a new structure to support the above-ground section upstream, near the existing crossing.

The costs for this option vary. The certainty level is also low, in particular when looking at the construction of a new pipe bridge as we do not have an established cost base for this activity. We can, however, be confident that the overcrossing options would be more costly than the tunnelling or drilling alternative described in option 3. The base cost of the diversion, regardless of the route [redacted] or upstream of the current pipeline location) would remain broadly in line with the option 3 estimate. This is because the engineering and environmental considerations will not differ significantly due to location and even some of the construction methods (such as drilling or tunnelling) may have to be employed to route the pipeline across the nearby road or under the wooded area to preserve the established woodland. On top of the diversion cost, the new pipe bridge may also cost in the region of £500k-£900k.[4] The construction of the overcrossing at the side of [redacted] theoretically would be less costly than the new pipe bridge, however scaffolding alone would cost in the region an additional £50k. Without additional costs for exploratory work like structural surveys, the feasibility remains uncertain.

Besides evidently higher cost when compared to option 3, this option was also rejected based on several other factors. Firstly, [redacted] s a "listed building," so any modifications, such as installing pipe supports, would undergo strict scrutiny and likely face disapproval. The diversion required to route the pipeline towards the bridge would be significantly longer and pose additional engineering challenges due to the wooded terrain. To avoid extensive deforestation, tunnelling or drilling methods would still be necessary, impacting the SSSI [redacted] at the receiving site. Moreover, significant in-channel work would be essential for scaffolding erection to access the bridge, adding further complications given the bridge's age and listed status.

Similarly, constructing a new structure to support a section of above-ground pipework would present additional difficulties. This approach would involve working within the same environmentally sensitive area, and the structure must be appropriately sited to maintain a safe distance from the existing pipeline during the construction activities. The river, including the SSSI [redacted] spans approximately 40m in width in the vicinity of the current crossing. Although the diversion might theoretically be shorter, the supporting structure would need to be substantial to accommodate both the current river width and the eroding riverbank.

Each of these alternatives would cause significant disruption to the area during construction, assuming they even receive approval. Additionally, they have long-term implications for both time, cost and risk as integrating another overcrossing into our portfolio would elevate overall risk related to above-ground pipework (as outlined in our Overcrossings Engineering Justification Paper) and necessitate ongoing inspection and maintenance commitments. Finally, IGEM TD1 advises that overhead crossings should be avoided where possible, however if one must be installed, the design must ensure the pipeline remains internally inspectable. Thus, the space constraints and obtuse bends required may render this infeasible. In conclusion, this option introduces numerous additional challenges without providing any benefits.

[4] This cost has been estimated using a budget indication supplied by the City of Bradford Metropolitan District Council in 2023 to replace a footbridge deck. The estimate is very high level and has not been progressed any further due to the disruption and complications associated with this option.

The record of option assessment by our specialist consultants is available in appendix "Options Memo".[5]

6.5. Options cost estimate details

Diversion is the only viable option being taken into FEED study. The total estimated cost is £7.7m.

Item	*Note*	*% of Total Installed Cost*
Engineering Design	*FEED*	2%
Project management	*Detailed design (detailed design cost will depend on the outcome of FEED)*	n/a
Project management	*See indirect company cost*	n/a
Materials	*Bulk materials – subject to FEED outcome*	13%
Main Works Contractor	*See direct company cost*	n/a
Specialist Services	*Pre-construction activities such as surveys etc*	1%
Vendor Package costs	*n/a*	n/a
Direct Company Costs	*Overall build cost (excludes procurement)*	63%
Indirect Company Costs	*Overhead and PM costs within the design and build packages*	10%
Contingency	*Contingency included in base cost estimate*	15%
Cost Estimate Accuracy	*This is an important element to give confidence that the engineering is mature and the costs can be relied upon.*	60% *Although we have undertaken comparable works recently and therefore have a solid understanding of the costs involved, the cost accuracy for this project remains relatively low. This is because the majority of the spending is associated with the procurement and construction activities, which need a defined route of the diversion and the method of installation. These elements will only be determined by the FEED study, the results of which will not be available until early to mid-2025.*

Table 2 River Allen cost breakdown

[5] Page 7; option 10 – "Do something – pipe re-direction"

6.6. Options technical summary table

Option	Start date	Commissioning date	Project Design Life	Operating costs	Total installed cost	Cost estimate accuracy
1	*Do nothing option rejected – see section 6.1*					
2	*In-channel remedial rejected – see section 6.2*					
3	*October 2023*	*September 2026*	*50+ years*	*£0.3m*	*£7.7m*	*60%**
4	*October 2023*	*September 2028*	*15 years (before the next Capex intervention)*	*£0.3m*	*£7.8m-£8.6m*	*50%*

Table 3 Options summary

** Although we have undertaken comparable works recently and therefore have a solid understanding of the costs involved, the cost accuracy for this project remains relatively low. This is because the majority of the spending is associated with the procurement and construction activities, which need a defined route of the diversion and the method of installation. These elements will only be determined by the FEED study, the results of which will not be available until early to mid-2025*

7. Business case outline and discussion

We have conducted a thorough options analysis to identify an appropriate solution for the current pipeline exposure in the riverbed and to protect the riverbank, thereby preventing a landslide that could potentially impact the segment of the pipeline adjacent to the river.

In our cost and benefit analysis, we calculated the probability of failure pre-investment to be around 1 in 100 years. This is a very conservative estimate as, without any protection, the likelihood of the pipeline being impacted and damaged by debris is higher. If the pipeline is damaged, the probability of consequence is very likely, and even certain, if the pipeline were to fracture because of the damage due to this being a single feed to over 100,000 customers. We also looked at the duration of the loss of supply incident, should one occur, and it has been estimated that a temporary repair (installation of a bypass above ground) and restoration of supply could take over two months which could result in a cost of £32m (107,161 properties at £300 each, as per NGN calculated Loss of Supply metric).

The key issue that we're looking to solve is the existing pipeline exposure in the riverbed. We have therefore focused the latest optioneering on remedying that specific issue. We explored eight in-channel remedial options, all of which are listed in the document produced by our specialist contractor in appendix "Options Memo".[6]

In addition to the riverbed exposure, we must also consider the riverbank erosion which, if unremedied, will lead to the pipeline being exposed. Our initial optioneering in 2019 considered this issue in more depth and a summary of this can be found in the document produced by our specialist contractor appended to this Engineering Justification Paper, named "Presentation".[7]

To simplify, we combined the eight in-channel works and riverbank remedies into the "remediate" option detailed in section 6.2 and explored below. This guarantees that we remain clear and succinct, avoiding a focus on specific low-level options that have already been deemed unfeasible. We also considered the diversion option

[6] Pages 5-7
[7] Page 10

separately as it is our preferred solution. Finally, our contractor proposed a pipe bridge and an overcrossing, but we opted not to proceed due to high costs, maintenance needs, and increased risks with above-ground pipes.

7.1. Key business case driver description

The Catton to Cummersdale pipeline is a vital asset enabling safe and reliable gas distribution in the North of England. Several key considerations came into focus when the drivers for investment were outlined. Primarily, the significance of this asset in the distribution system means that its failure would lead to far-reaching consequences. Due to the pressure tier and size of the pipeline, the consequences of a failure are likely to be catastrophic – over 100,000 customers could face loss of supply and the disruption associated with repair. One of the main objectives for any gas distributor is to ensure that supply is maintained and done so safely, therefore it is unacceptable to continue sustaining such a significant level of risk. Furthermore, destruction of a large surrounding area which is environmentally significant, evacuation of and damage to the residential property nearby, closures and damage to infrastructure, such as the nearby road (A686), grade II listed [redacted] nd other utilities. This may result in major injuries to nearby residents or passers-by or even fatalities. **This has led to the rejection of the Do Nothing/Minimum option.**

Option 4, which involved a diversion above ground – a **pipe bridge and an overcrossing, was also rejected** for several key reasons. Firstly, the financial implications of constructing a pipe bridge and an overcrossing were deemed too expensive. The cost of this option is overall higher than the below-ground option described in section 6.4. Secondly, the ongoing maintenance requirements for above-ground pipes were considered impractical. Lastly, there were elevated risks associated with above-ground pipes when compared to below-ground diversion, such as vulnerability to environmental factors and potential damage. This is reflected in IGEM/TD1 by advocating avoidance of overhead crossings. These factors collectively rendered Option 4 less desirable compared to a below-ground diversion.

Optioneering, which has taken place during RIIO-GD2, allowed us to explore investment routes that would address the immediate concerns described above. Each option was considered in the light of *effectiveness*, *longevity*, *constructability*, *stakeholder impact* and *value for money* (also linked to NPV in the below sections).

Effectiveness

Remediation: Placing protection over the pipeline would be effective as it creates a barrier between the pipeline and the threats within the watercourse. The bank would need a separate intervention, however, upon installation, bank protection measures have been shown to slow down the erosion process. The probability of failure would be significantly reduced. This option, therefore, can be deemed partially effective, to the extent that it mitigates the level of risk.

Diversion: Diverting the pipeline, placing it at an appropriate depth and distance from the riverbank would re-life this section for the foreseeable future. The probability of failure would be virtually eliminated. This option, therefore, can be deemed effective.

Longevity

Remediation: Riverbank protection is likely to slow down the erosion process, therefore greatly reducing the likelihood of pipeline exposure for the foreseeable future. However, there is a risk of bank erosion progressing further upstream: evidence of this is clear with the current bank protection having been installed in the past. Moreover, the riverbed is highly unpredictable and, due to the volatility of the watercourse, the protection measures are likely to be washed away leading to the pipeline becoming exposed again in the next 1-5 years. The longevity of this option, therefore, is insufficient.

Diversion: See effectiveness. This option is deemed long-lasting (50+ years).

Constructability

Remediation: A small stretch of riverbank protection is already installed near this location and would have to be extended to cover the section in question. The optioneering analysis suggested that the measures put in place to stop erosion may have contributed to it migrating to the currently affected area, therefore there is a risk of "moving the problem". The riverbed protection has been installed in the past also, proving that the option is constructible, although not particularly long-lasting.

Diversion: Diversion is a highly invasive intervention and will require extensive planning. The rural location brings with it advantages as there is vast space available to create the least intrusive pipeline route and lay down areas. There are however multiple environmental considerations to take into account. Regardless, NGN has already worked closely with specialist contractors to deliver comparable diversions during RIIO-GD2, therefore providing confidence in the constructability of this option.

Stakeholder impact

Primary stakeholders affected by any intervention are the landowner, occupiers of the residential property nearby and government agencies such as the Environment Agency and Natural England.

Remediation: We have already carried out some remediation in this area and as such, have built up a rapport with the above-named stakeholders. The feedback received so far indicates that whilst there is an appreciation of the nature and necessity of such works, the longevity of the installed solution plays an important role. The Environment Agency has expressed concerns about the impact the protection measures would have on the river, particularly if the visits would have to be repeated. Additional riverbank protection measures could influence the route of the river and may cause erosion elsewhere, with lasting effects. Also, the materials introduced into the river, whether in the form of rock bags, mattresses or anything else to protect the exposed pipeline are at high risk of being transported downstream by the river flow, particularly during flooding events, which are becoming more regular. This can cause the material to be backed up elsewhere downstream leading to changes to river route and flow, flooding and impact on the species within the watercourse. This risk cannot be accepted by the Environment Agency. Furthermore, repeated visits associated with this option cause a significant impact on the landowner, residents nearby and the environment. Heavy machinery needed to transport and install the material damages the natural habitat which is protected by law. Finally, repeated visits cause ongoing inconvenience to the landowner and residents which they are likely to require compensation for.

Diversion: The intrusive nature of this option will be subject to the same stakeholder scrutiny and is likely to generate the same issues as described above. However, the longevity associated with the diversion eliminates the concerns around repeated visits and ongoing inconvenience. It also eliminates the concerns expressed by the Environment Agency associated with foreign material being repeatedly introduced into the watercourse.

Value for money

Remediation: The financial cost associated with this option is far less significant than that of a diversion. However, if the longevity argument is taken into consideration, the overall value of money declines rapidly. In-channel remediation in this watercourse cannot be guaranteed due to the nature of the river. We already experienced protective measures being washed away in just 4 years previously and the recent hydraulic modelling analysis supports this conclusion. Furthermore, the cost to the environment and the likely event of a diversion being required shortly anyway make the value for money of this option questionable.

Diversion: The high financial cost results in significant scrutiny for this option, however, the above-quoted analysis as well as that in section 7.3 shows that we can expect positive Net Present Value (NPV) for this

investment within just 3 years, as well as the highest NPV in 2070 when compared to other options discussed points to the conclusion that overall, this option does provide the best value for money.

7.2. Supply and demand scenario sensitivities

The diversion and remediation options for the project are evaluated, considering environmental impacts, stakeholder concerns, and value for money. Diversion offers long-term solutions but at higher costs, whereas remediation is cheaper but less durable and environmentally riskier. Supply and demand scenarios were not factored into the modelling, but resilience strategies are in place to ensure network stability against climate change and other risks as described in section 5.1.

7.3. Business case summary

Below is a summary of Cost and Benefit Analysis outcomes based on the loss of supply risk/cost, as well as the latest available cost estimates of the different options.

The Do Nothing option assumes that there is no further Capex-funded work to be done at this location unless a failure occurs. This is a high-risk strategy that is not acceptable for us as a safe Gas Distribution Network operator, therefore is used as a baseline for another option comparison.

The remedial option has been thoroughly considered, however, following the latest investigation by our expert contractors, there cannot be any guarantees on the longevity of the measures installed due to the volatility of the watercourse. Furthermore, the issue of riverbank erosion will become more prevalent with time and, based on the evident historical rate of erosion, the pipeline is likely to become exposed in the bank around 2057. This is reflected in the Net Present Value (NPV) of this option – whilst the initial payback is very early, long-term NPV is negative.

The above-ground diversion option does not pay back. The reason for this is the high initial cost as well as the fact that exposed above-ground pipework requires regular maintenance and will incur additional Capex costs approximately every 15 years. The Probability of Failure deterioration applied is in line with that used in the Overcrossings CBA for consistency.

The below-ground diversion option pays back within 3 years, despite the high Capex cost. Additionally, this option has the highest long-term NPV further supporting this investment as the preferred investment.

Option	Total installed cost	Cost estimate accuracy	Project operating lifespan	Project NPV (2035)	Project NPV (2070)
Do nothing – REJECTED	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Remediation - REJECTED	*£300k*	*20%[i]*	*1-5 years from 2028*	*£9.7m*	*(£51.7m)*
Diversion - PREFERRED	*£7.7m*	*60%**	*50+ years from 2028*	*£30.2m*	*£160.3m*
Overcrossing - REJECTED	*£7.8m-£8.6m[o]*	*50%*	*15 years[o] from 2028*	*(£9.6m) – (£10m)*	*(£191.4m) – (£191.9m)*

Table 4 Cost and Benefit Analysis summary

[i]*Variety of in-channel works proposed/reviewed (8 different options) and all will differ in cost and constructability. The cost estimate used is a very high level average and based on specialist contractor advice which is heavily caveated.*

** Although we have undertaken comparable works recently and therefore have a solid understanding of the costs involved, the cost accuracy for this project remains relatively low. This is because the majority of the spending is associated with the procurement and construction activities, which need a defined route of the diversion and the method of installation. These elements will only be determined by the FEED study, the results of which will not be available until early to mid-2025.*

[o] *This only includes the initial outlay, however, the CBA also takes into account ongoing maintenance costs in the form of regular overcrossing interventions, such as refurbishment on average every 15 years. The refurbishment cost is a Capex cost.*

8. Preferred option scope and project plan

8.1. Preferred option

The preferred option for this request is the diversion of the pipeline below ground, detailed in Option 3 of section 6, subsection 6.3.

8.2. Project spend profile

Item	*Detail*	*Cost Estimate*
Engineering Design	*FEED Yr 4&5 RIIO-GD2* *Detailed design (subject to the outcome of FEED) Yr 4&5 RIIO-GD2* *Pre-construction surveys etc to support the design Yr 1 RIIO-GD3*	£89k £100k £114k
Project management	*Included within the design and delivery packages throughout the project cycle*	n/a
Materials	*Bulk materials subject to FEED Yr 1 RIIO-GD3*	£1.29m
Delivery	*Overall build cost Yr 1 RIIO-GD3*	£6.11m

Table 5 Project spend profile

8.3. Efficient cost

Costing for this project is based upon previous, comparable works undertaken, including River Caldew, as detailed in section 4.1 of this document. In addition to that, costs associated with the Environment Agency, Natural England and other stakeholder interactions have been accounted for based on the most recent works at this location.

As further efficiency in delivery, initial design works are being undertaken within RIIO-GD2, this will allow for sufficient planning, notice of procurement and main works tenders to ensure a competitive market and best price.

It should be noted that the costs included are estimates and subject to change due to changing market conditions for main works contractors and material availability. In addition, the scope may be subject to change as and when additional information on the constructability of the proposed project becomes available, following the completion of the FEED study.

8.4. Project plan

The below project plan is a high-level indication for project delivery, including reference to the key milestones, such as FEED, procurement, commissioning etc.

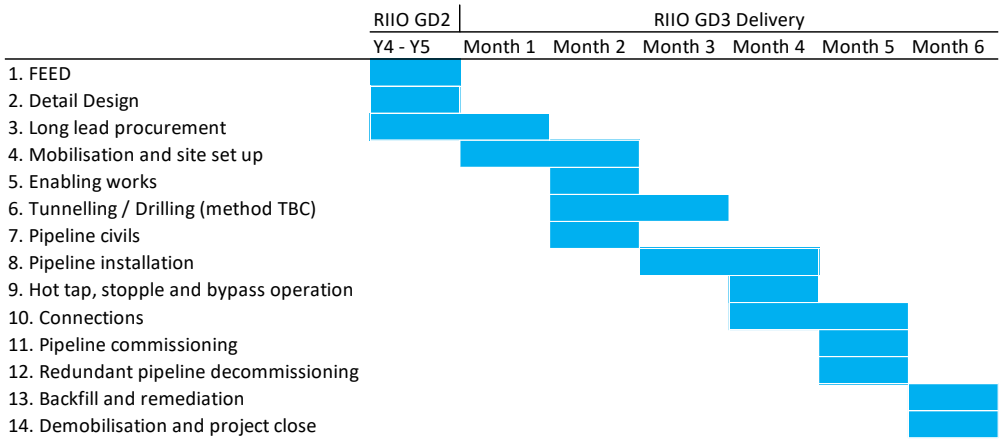

Figure 13 Project plan

8.5. Key business risks and opportunities

We have controls and processes in place throughout the development of our RIIO-GD3 Capital Expenditure programme to ensure we mitigate both our customers and our risk exposure. Scope and cost risks are inherent when any kind of forecasting is taking place. The bullet points below outline the risks we have identified and steps we have undertaken to ensure we limit these risks to provide an accurate capital programme:

- Trenchless crossing methodology: At this stage of the project it has not been confirmed what construction method will be utilised to install the new pipeline. Each installation type (HDD, microbore etc.) has specific requirements that can impact the duration of the work and cost of delivery. We have commissioned a FEED study in RIIO-GD2 to ensure that our proposals for final determination are as robust as possible.
- Deterioration of Riverbed/bank: Further deterioration of the riverbank may necessitate additional intervention to secure the integrity of the pipeline in the interim until the main diversionary works can be delivered. At present protective assets are in place and under increased frequency inspections to mitigate

any risk, however, if those protective measures are washed away during the next severe weather event, additional interventions may be necessary. Our only mitigation option is the increased frequency of inspections to ensure that any changes are flagged and addressed quickly.

- Third parties: Several key external stakeholders will be engaged with this project, including the Environment Agency, Natural England, HSE, residents and landowners. Variations to scope may be required if directed to ensure compliance with relevant agencies. We have already carried out extensive optioneering and have open channels of communication with these stakeholders, so can collaborate throughout the process to minimise any unplanned changes.
- Validity of optioneering: Options have been proposed by specialist consultants following extensive research and analysis. The process has been supervised and reviewed by our internal SMEs to ensure that it has been completed to our satisfaction.
- Cost certainty: Currently, the cost certainty for this project is quite low, largely because the detailed scope remains unclear (it will be defined once FEED is completed). However, having performed similar projects recently, and on the same pipeline, we have a strong reference point when it comes to the tender process for securing our design and delivery contracts.
- General project risk: These include scope and cost uncertainties, which can arise due to incomplete or evolving project details. Potential delays due to third-party interventions, such as regulatory approvals or community objections, can also pose significant challenges. Additionally, unforeseeable environmental impacts, like severe weather conditions or geological issues, may necessitate additional measures, potentially affecting the project timeline and costs.

Regarding strategy adjustments linked to net zero, only a comprehensive transformation and consequential modifications to the gas distribution system would affect this proposal. As long as the pipeline must stay operational, the recommended course of action is to divert the pipeline, as it is the sole feasible solution to address the immediate health and safety concerns posed by pipeline exposure.

8.6. Outputs included in RIIO-GD2 plans

Within the RIIO-GD2 plan a provision was made for Riverbed remediation to mitigate the risk of exposed pipelines. This project was initially envisaged as a remediation project, however following a detailed optioneering it was determined there were no viable options for remediation of the riverbed or bank that would mitigate the risk to the pipeline for any defined length of time.