Appendix 09.13

Brunel Bridge Crossing Refurbishment

RIIO-2 Spend: XXXX

Cadent
Your Gas Network

Investment Decision Pack Overview

This Major Project Engineering Justification Framework outlines the scope, costs, and benefits of our proposals for the Brunel Bridge Crossing. This project will cost in excess of **XXXX**; therefore, it will be highlighted as a separate scheme in BPDT 3.06 and we have prepared a Major Project Justification Paper (this appendix) and Cost Benefit Analysis.

Overview

Brunel Bridge and its associated brick-arched viaducts carry the railway line from Windsor & Eton to Slough across the River Thames to the north of Windsor. Cadent operates a 12" steel Medium Pressure (MP) crossing of length 230 metres suspended from the bridge and viaducts by pipe hangers, feeding the Alexandra Gardens district governor in Windsor. Access to the crossing requires substantial planning and liaison to arrange both above-water work and full possession of the railway line for access from the bridge itself.

The pipeline crossing supplies approximately 3,500 customers. At demands greater than 80% of 1 in 20-year peak demand, loss of the crossing would cause loss of supply to these customers.

Brunel Bridge Crossing has the following issues:

- Access Deterrent Measures (ADM) are only fitted at each end of the main bridge span. There is no intermediate ADM. This is a breach of safety requirements, which must be corrected in line with Cadent's risk-based approach to crossings investments.
- The crossing pipe has areas of degraded coating that are allowing surface corrosion to take place.

Given the observed condition of the crossing, we have considered remediation or replacement to ensure continued security of supply, compliance with Cadent's responsibilities under the Occupiers' Liability Acts (1957 and 1984), protection of health, safety and the environment, and minimisation of disruption to rail passengers.

The following **options** have been considered to address the issues with the existing crossing:

- **Baseline**: Reactively repair the pipe crossing on failure.
- **Option 1**: Proactively refurbish, restoring coating condition and improving ADM.
- **Option 2**: Proactively replace the crossing by installing a new MP main to a new governor at Alexandra Gardens. Decommission and remove the existing pipe crossing.

The baseline option has been dismissed because, while the likelihood of immediate failure is low, the consequences are high in terms of potential loss of supply to 3,500 properties and disruption to the railway. We performed CBA for Option 1, which showed that this option is cost beneficial relative to the baseline position.

The very high cost of Option 2 (9 times more expensive than Option 1) led us to discount it prior to completing our CBA.
We have therefore selected proactive refurbishment (Option 1) as the preferred option.

Summary of preferred option	
RIIO-2 Expenditure (2018/19 price base)	Redacted due to commercial sensitivity
Project NPV	

Material Changes Since October Submission

Since October, we have refined the costs for main works and access, and replaced estimated BAPA (Basic Asset Protection Agreement) costs with values calculated from rates provided by Network Rail. Total installed cost of the preferred option has increased from **XXXX** in our October submission to **XXXX** (2018/19).

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2. Summary Table

Name of Project	Brunel Bridge Crossing Refurbishment		
Scheme Reference	Cadent Line Reference #194		
Primary Investment Driver	Asset health		
Project Initiation Year	2022		
Project Close Out Year	2023		
Total Installed Cost Estimate (£)	**XXXX**		
Cost Estimate Accuracy (%)	+/-14%		
Project Spend to date (£)	None		
Current Project Stage Gate	Feasibility		
Reporting Table Ref	3.05 Other Capex/Other Capex Individual Projects/Brunel Bridge		
Outputs included in RIIO-1 Business Plan	No		
Spend apportionment	**RIIO-1**	**RIIO-2**	**RIIO-3**
		100%	

Table 1: Summary table for refurbishment of Brunel Bridge pipe crossing (2018/19 price base)

3. Project Status and Request Summary

This is a new project.

The proposal is for refurbishment works at the Brunel Bridge Medium Pressure (MP) steel pipe crossing of the River Thames north of Windsor. Investment of this nature is a standard part of our asset management activity; we have refurbished many pipeline crossings in RIIO-1.

A feasibility study has been completed, establishing the optimum solution to mitigate the identified risks. The outline and detailed design, and delivery of the proposed scheme will be completed in RIIO-2.

4. Problem Statement

Brunel Bridge[1] and its associated brick-arched viaducts carry the single-track railway line from Windsor & Eton Central to the Great Western mainline at Slough across the River Thames and Baths Island to the north of Windsor (Figure 1).

Cadent operates a 12” steel Medium Pressure (550 mbar) crossing suspended on the east (downstream) side of the bridge and viaducts[2] by pipe hangers (Figure 2 and Figure 3) to feed the Alexandra Gardens district governor. Alexandra Gardens governor supplies approximately 3,500 customers in north-east Windsor and parts of Eton. Network analysis has shown that loss of this governor (therefore, by implication, loss of the Brunel Bridge crossing) at demands greater than 80% of 1 in 20-year peak demand would cause loss of supply to these customers

Access to the crossing requires substantial planning and liaison to arrange both above-water work and full possession of the railway line (with associated costs due to the impact on services) for access from the bridge itself.

The pipe crossing is approximately 230m long. It includes the following features:

- Joints are flanged, other than at the above/below ground transitions.
- Most above-land flanges have been encapsulated (Figure 3, for example) but not the above-water joints.
- The south-side transition is welded and includes a socket-and-spigot joint. There are no Access Deterrent Measures (ADM) at this transition, which is in a public park (Figure 4).
- The north-side transition has ADM in place but is heavily overgrown and cannot be examined visually (Figure 5).
- Expansion bellows are fitted at each end (Figure 6).

The following issues and observations have been noted:

- ADM is only fitted at each end of the main bridge span (Figure 7). There are no spinners or other intermediate ADM.
- The types and conditions of external treatment of the piping fall into three categories:
    - Between the north expansion bellows (expansion joints) and the south end of the main bridge span, the piping appears to have broadly well-adhered coating, although with areas of degradation that are allowing surface[3] corrosion (Figure 2).
    - Almost all of the remainder of the crossing has little or no coating, with extensive surface corrosion (Figure 3, Figure 4, Figure 8).
    - There is also a short section with tape wrapping (Figure 9).

  Reasons for these inconsistencies are not known.

We have a cyclical programme of crossing inspection and refurbishment to extend asset life and prevent safety or interruption failings. Given the observed condition of the crossing, remediation or replacement is now necessary to ensure continued integrity.

[1] The bridge is Grade II* listed. It is the world’s oldest wrought-iron railway bridge still in regular use.
[2] Note that, while Brunel Bridge itself is the wrought-iron main span across the Thames, generic references to ‘Brunel Bridge crossing’ should be taken as including piping suspended from the bridge **and** viaducts, as well as above/below-ground transitions.
[3] As far as can be determined visually from the river banks.

Figure 1: Location of Brunel Bridge & Alexandra Gardens governor


Figure 2: General view of main bridge span at crossing's north end

Figure 3: Typical pipe hanger & encapsulated flange on brick viaducts south of main bridge span

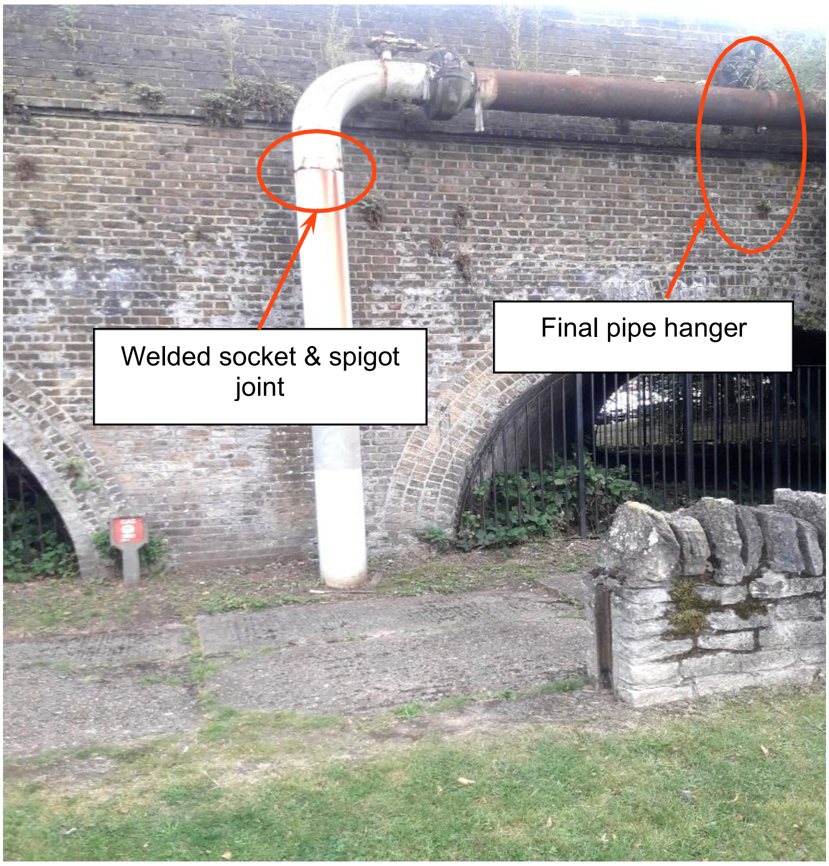

Figure 4: South-side transition piece — note absence of ADM

Figure 5: North-side transition piece

Figure 6: Expansion bellows, north side (left) & south side (right)

Figure 7: ADM at main bridge span, north side (left) & south side (right)

Figure 8: Examples of partially coated and uncoated sections

Figure 9: Part of tape-wrapped section

Investment drivers

The investment proposed here has a two-fold purpose:

a) To install or remediate barriers to the known threats from external corrosion (to maintain safety and security of supply) and third-party interference (trespassers[4]). This ensures that asset health is maintained in accordance with Pipeline Safety Regulations (PSR) 1996, and that we comply with the Occupiers Liability Acts (1957 and 1984).

b) To enable inspections that will provide a baseline of the crossing's condition to inform future inspection and maintenance activities.

The driver for this proposed investment is to ensure continuing integrity (leak-tightness) of the crossing, given that:

- The crossing is known to be affected by extensive ongoing external corrosion.
- There may be other damage, which will be checked as part of the preferred option for intervention here.
- The crossing is also accessible to members of the public, with associated potential for damage to the pipeline as well as risk to anyone trespassing on the pipeline. The latest ADM risk score was 27 (High) in December 2017. We have a risk-based programme of improving ADM compliance, under which this crossing is due for intervention in RIIO-2.

In summary the key investment drivers are therefore:

- **Security of Supply:** the unplanned loss of this pipeline at flow rates > 80% peak 1 in 20-year demand would cause a loss of supply to 3,500 customers at a time when they most need gas for heating.
- **Compliance with Occupiers Liability Acts (1957 and 1984):** The current pipeline has insufficient ADM in place. Under the 1984 Act Cadent would be liable if a 'trespasser' was to fall and injure themselves when climbing on the pipe bridge.
- **Health & Safety:** A gas leak from the failure of the pipe would put rail-users and the general public at risk from fire and explosion. Regulation 13 of PSR 1996 requires networks to ensure that the pipelines they operate are maintained in an efficient state, in efficient working order and in good repair. These duties are absolute and there is strict liability.

[4] Protection from trespassers will also prevent them from injuring themselves.

- **Disruption to Rail Passengers:** Any maintenance and remediation (planned or reactive) causes a potential disruption to rail users due to the need to close the train line. This disruption will be much more acute under reactive circumstances.

Project challenges and complexities

Whilst pipeline crossing refurbishment is a standard activity for Cadent, this project has the unusual challenges of accessing a long crossing, with over-water and over-land sections, that is attached to a frequently used railway bridge and viaduct in an environmentally sensitive and popular public location close to major tourist destinations. It will require careful planning and project management, in liaison with Network Rail, the Environment Agency, and Windsor and Maidenhead Borough Council. Cadent is experienced in delivering similar projects.

Key milestone dates

There is not yet a detailed delivery plan for this work. Cadent intends that planning, which as noted is expected to require considerable coordination with other bodies, will start early in RIIO-2. Scheduling of main works will depend critically on agreement with Network Rail; it currently seems reasonable to expect the works will take place in the summer of 2022.

Understanding project success

The outcome of this project will to be to provide a safe, reliable and cost-effective gas network in the Windsor area.

Successful completion of this project will have the following outputs:

- Providing a reliable supply to customers south of the river by extending the life of the existing assets (recoating of the complete crossing, including transition pieces) or by providing gas supply by another means.
- Presence of fit-for-purpose ADM at all access points and along the piping (or removal of the crossing to achieve the same objective) — protecting the public.

In addition, while it is not a directly-visible output, this project will lower the risk of disruption to rail passengers by reducing the likelihood of a gas leak in the vicinity of the railway line.

4.1. Related Projects

There are no related projects.

4.2. Project Boundaries

This project includes all above-ground parts of the Brunel Bridge crossing between transition pieces at each end (included), including pipe hangers and brackets, and protections against trespassers.

It does not include any below-ground works or works on the structures of bridges and viaducts themselves.

5. Project Definition

5.1. Supply & Demand Scenario Discussion and Selection

The base case scenario used here is the 1 in 20 peak demand of 3,900 scm/h at Alexandra Gardens Governor.

No other scenarios have been considered as the relevant parts of Windsor and Eton are mature developments with limited potential for substantial demand changes.

5.2. Project Scope Summary

The proposed work has the following elements.

- Abrasive blasting and application of new coating to the entire crossing.
- Installation of ADM spinners along full length of pipe.
- Installation or remediation of ADM to latest standards to prevent access at above/below ground transition pieces and at land/water boundaries.
- Removal of tree branches that impinge on the pipe or otherwise offer an access route to unauthorized third parties.
- Close visual inspection and targeted Non-Destructive Examination (NDE). The scope and methods for NDE will be determined through threat assessment. This work is expected to include ultrasonic wall thickness measurements and may require other approaches such as weld inspection where relevant (for example, at the south transition’s socket and spigot weld).

6. Options Considered

The following Options were considered for the Brunel Bridge crossing:

- **Baseline**: Reactively repair the pipe crossing on failure.
- **Option 1**: Proactively refurbish the pipe crossing before failure, restoring coating condition and improving ADM. This option would also support inspection activities while there is access to the crossing. Within this option we have considered different combinations of ADM (see Appendix 09.36 Pipeline Crossings for more details on ADM options).
- **Option 2**: Proactively replace the crossing by installing a new MP main to a new governor at Alexandra Gardens. Decommission and remove the existing pipe crossing.

We have used CBA to assess the optimum solution. The approach and basis of calculation for our cost benefit analysis is included in Appendix 2.

6.1 Baseline: reactive repair on failure

This option implies reactive repairs if a leak occurs at the crossing. The likelihood of this is unknown because there is little objective information about the crossing's condition. However, even if the likelihood is very low in the short term, there are high consequences of failure in terms of:

(a) Protracted loss of MP gas to the Alexandra Gardens governor and associated potential for loss of LP supply to 3,500 customers, and

(b) Potential disruption to a busy railway line.

Cadent therefore considers the qualitative risk from the reactive repair option to be unacceptably high. This option has been considered as our baseline in the Cost Benefit Analysis (CBA).

Such an approach would also be a breach of PSR (1996) Regulation 13.

6.2 Option 1: proactive refurbishment before failure

The option to refurbish the crossing covers the scope described in Section 5.2. It is proactive in correcting known issues with the crossing and is consistent with our wider approach to the management of crossings. It will deliver a reliable supply to our customers and reduce the risk of reactive rail disruption.

As for all our crossings investments, we have used current inspection results to prioritise pipeline crossing interventions throughout RIIO-2 and RIIO-3 as illustrated in the flow chart below (taken from Appendix 09.36 Pipeline Crossings).

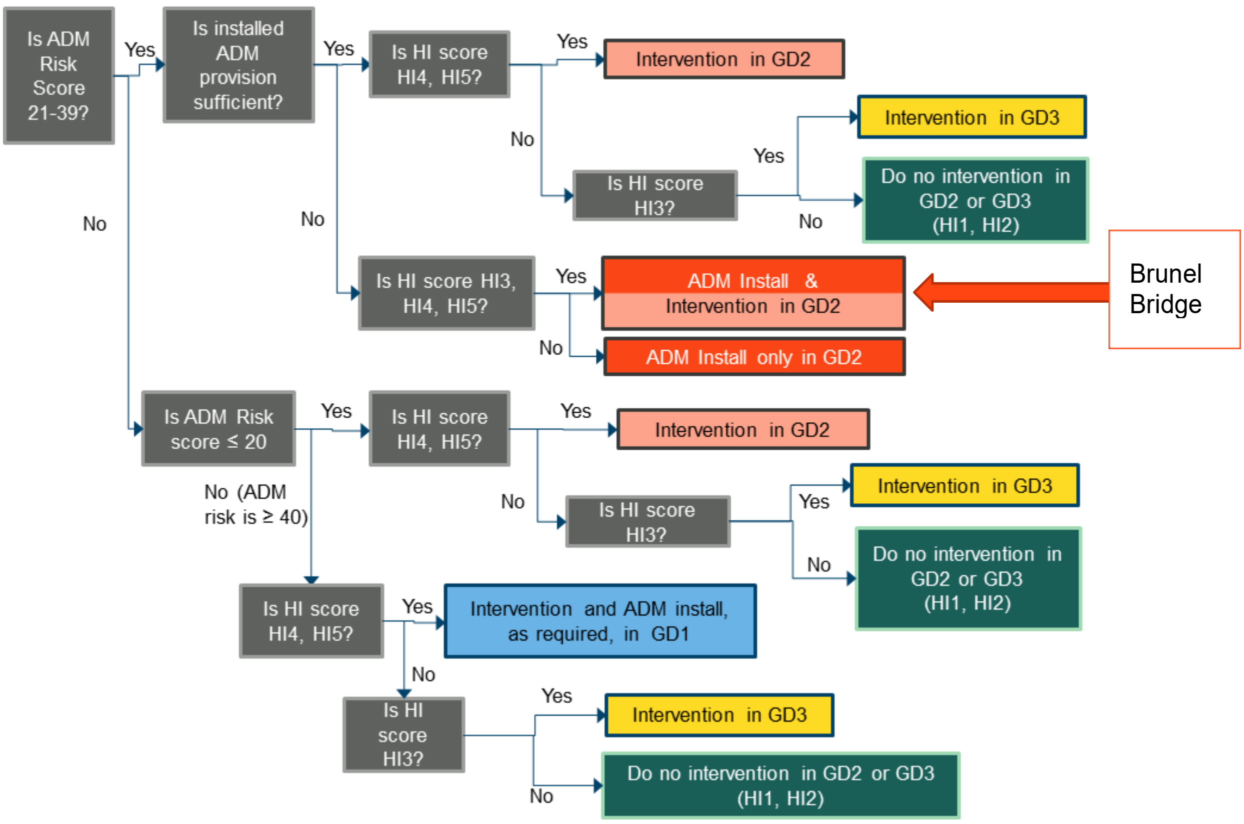

Figure 10: Intervention decision flow chart for below-7bar crossings

The implications for Brunel Bridge are:

- The need for remediation to the Access Deterrent Mechanisms (ADM), or the absence of an ADM, is the initial driver for intervention at Brunel Bridge in RIIO-2. Brunel Bridge has an ADM risk score of 27 and the installed ADM is insufficient.

- Brunel Bridge Crossing was given an HI3 health index for pipework at its most recent assessment. HI3 pipeline risks are assumed to be intervened in RIIO-3, unless an ADM is being installed and then for cost-efficiency the HI3 risk will be remediated at the same time as the ADM. This is the case for Brunel Bridge. As the substantial access costs including scaffolding and BAPA are required to install the ADM it is cost-effective to undertake remedial work on the pipeline at the same time.

  We note that a site visit undertaken as part of the preparation of this Engineering Justification suggested that the pipework health index might now be HI4, which would require intervention in RIIO-2 even if the ADM score was 20 or less. However, the actual ADM risk score of 27 means that intervention and ADM installation is required in RIIO-2 whether the health index is 3 or 4.

6.3 Option 2: proactive replacement and removal

This option was drawn up to allow removal of the crossing, replacing its MP supply by laying a 1.1 km PE main from the 2-bar supply at Osborne Road/Alma Road, along Alma Road to a new governor at Alexandra Gardens. Appendix 1 shows the scope of this option.

The very high costs for this option[5] (**XXXX**, approximately **XXXX** times more expensive than Option 1) meant that it was discounted as unaffordable and not value for money. For completeness we have shown the cost estimate details in Section 6.4.

As part of the development of this option we also reviewed the possibility of decommissioning the pipeline and removing the supply. This would involve 'buying out' the relevant customers through compensation to replace heating systems etc., and would require the agreement of all affected customers. This sub-option was also discounted due to the high level of customer disruption and high cost.

Therefore, it is preferable to maintain the current crossing and gas supply rather than to decommission it.

[5] The diversion, as shown in Appendix 1, would be mainly along Alma Road, which is a mature area of small businesses, hotels, a police station, and private residential properties along a two-way thoroughfare. This presents challenges of working with substantial pre-existing buried infrastructure, managing traffic and access, and gas supply management, all of which extend the works' duration and increase the contractors' costs.

6.4. Options Cost Estimate Details

Option 1: proactive refurbishment before failure

Item	Cost (£m)	% of Total Installed Cost
Total Installed Cost		
Engineering Design		
Project Management		
Materials	Redacted due to commercial sensitivity	
Main Works Contractor		
Specialist Services		
Vendor Package Costs		
Cadent Direct Costs		
Cadent Indirect Costs		
Contingency		
		Cost Estimate Accuracy = ±14%

Table 2: Cost estimate details (ex-VAT) for Option 1 — proactive refurbishment of existing crossing (2018/19 price base)

We note that approximately 47% of the total installed cost relates to accessing the crossing (Table 3) including Basic Asset Protection Agreement (BAPA) payments to Network Rail[6] and, as such, would be incurred if either the ADM or remediation were to be undertaken in isolation.

[6] Calculated from rates provided by Network Rail in November 2019 'Asset Protection – Estimate Calculation Sheet' Rev 1.

Item	Cost (£m)
BAPA payments for access to the railway **Access to North side of the River Thames, and site security**	Redacted due to commercial sensitivity
Site security	
Scaffolding, including environmental protection	
Total	

Table 3: Access costs (2018/19 price base)

Option 2: proactive replacement

Item	Cost (£m)	% of Total Installed Cost
Total Installed Cost		
Engineering Design		
Project Management		
Materials		
Main Works Contractor	Redacted due to commercial sensitivity	
Specialist Services		
Vendor Package Costs		
Cadent Direct Costs		
Cadent Indirect Costs		
Contingency		
		Cost Estimate Accuracy = ± 20%

Table 4: Details of estimated cost (ex-VAT) for Option 3 — proactive replacement of existing crossing (2018/19 Price Base)

6.3. Options Summary

Option Title	Baseline Fix upon failure	Option 1: Proactive Refurbishment	Option 2: Proactive Replacement
Start Date	N/A	2022	2022
Commissioning Date	N/A	2022	2024
Design Life (yrs)	N/A	15	40
Operating Costs (£m)		-	-
Total Installed Cost (£m)	Included as benefits in the option	XXXX	XXXX
Cost Estimate Accuracy		±14%	±20%

Table 5: Summary comparison of costed options (2018/19 price base)

Cost confidence

We have a preliminary plan for Option 1 expenditure with a cost confidence of ±14%. We have made an initial estimate for BAPA using rates supplied by Network Rail. This is one of the most material (and potentially uncertain) elements of the project cost, as such we have engaged with Network to produce a first stage estimate.

7. Business Case Outline and Discussion

As discussed in Appendix 2, we have undertaken a CBA to select the preferred solution for remediation of Brunel Bridge pipe crossing.

We have taken a different approach to modelling our baseline option for this investment case.

Our approach to defining the baseline is the option where we do not invest proactively in our assets, but we do inspect and maintain assets in line with our obligations, and repair assets under a fix on fail strategy. This is the absolute minimum investment we can make in our assets. Other options are then considered which represent increments of investment over and above the baseline.

However, for areas of investment such as this one the forecast baseline cannot be assessed due to its highly uncertain nature. In these circumstances, the baseline is set at zero and in the options the changes in costs are considered — that is, we include the costs of reacting to a failure occurring as avoided costs in each option, rather than as absolute levels of anticipated costs in the baseline.

Within our CBA we have included the following benefits / costs, within our proactive repair:

- Avoided costs: avoiding the need to reactive repair the pipe following a failure
- Social benefits from avoiding a supply interruption
- Avoiding the transport disruption (railway disruption)

7.1. Key Business Case Drivers Description

The choice of the preferred option within the CBA is driven primarily by the benefit of avoiding the risk of reactively responding to a failure.

Other benefits included are:

- Avoiding the risk of disruption to the rail network.
- Avoiding the risk of failure leading to interruptions to supply

These results of the CBA are discussed in Section 7.3.

7.2. Supply & Demand Scenario Sensitivities

As noted in Section 5.1, no alternatives to the base case scenario have been considered.

A substantive change to demand in the Eton and Northeast Windsor area would be required to alter the justification for the proposed work. For example, significantly reduced demand would make reconfiguring the LP system and removing the crossing and Alexandra Gardens governor more attractive, while increased demand strengthens the need to retain Brunel Bridge crossing. However, the likelihoods of such changes are regarded as low (Section 5.1).

7.3. Business Case Summary

We have assessed the following options for Brunel Bridge.

Option Title	Baseline Fix upon failure	Option 1: Proactive Refurbishment	Option 2: Proactive Replacement
Start Date	N/A	2022	2022
Commissioning Date	N/A	2022	2024
Design Life (yrs)	N/A	15	40
Operating Costs (£m)	Included as benefits in the option	-	-
Total Installed Cost (£m)		**XXXX**	**XXXX**
Cost Estimate Accuracy		±14%	±20%

Table 6: Business Case Summary (2018/19 price base)

Option 2 has been discounted prior to any CBA analysis due to its very high capex expenditure. As discussed above, we have adopted an alternative approach to modelling our baseline for this investment case, hence why the NPV for the baseline option is blank.

The detailed CBA approach and results are included in Appendix 2.

The CBA results clearly show that the Option to proactively refurbish the crossing is cost beneficial, with an NPV of **XXXX** and payback by **XXXX**. The NPV is not materially impacted by the removal of the willingness to pay benefits from avoiding supply interruptions (reducing the NPV by only **XXXX**)

We have also tested sensitivity to the uplift assumed for reactive repair costs compared with more-efficient proactive repairs (Table 7).

Our base assumption is that each time we respond to a reactive failure, it will cost 20% more capex because we are carrying out the same repair under duress / emergency situations which removes our ability to achieve lowest unit rates and deliver the work efficiently. It is reasonable that in some scenarios these costs could be significantly more or less than this 20% uplift. The following table summarises the impact of the level of uplift for reactive repair costs, on the overall NPV of the scheme.

Sensitivity Scenario	Reactive Repair Uplift	Avoided Costs pa	PV Expenditure	NPV	Difference in NPV from Central Estimate	Payback Year
Higher Costs	50%					
Central Estimate	20%	Redacted due to commercial sensitivity				
Lower Costs	5%					

Table 7: Sensitivity of NPV to assumed uplift in cost of a reactive repair (costs in £m)

The table shows that even with reduced reactive costs (to just 5%) the project is still cost beneficial.

Based on all the above analysis, our proposed proactive repair option (Option 1), is the optimum solution for RIIO-2, because it avoids significant risks of rail disruption and possible interruptions to supply. This proactive repair option also ensures we fully comply with our legal mandate under the PSR (1996) Regulation 13.

8. Preferred Option Scope and Project Plan

8.1. Preferred Option for this Request

The preferred option is to refurbish the crossing and install appropriate ADM (Option 1), additionally using the necessary temporary access arrangements to carry out close visual inspection and targeted non-destructive examination.

8.2. Project Spend Profile

2021 / 2	2022 / 3	2023 / 4	2024 / 5	2025 / 6	2026 / 7	2027 / 8	2028 / 9	2029 / 30	2030 / 1
Redacted due to commercial sensitivity									

Table 8: Total annual spend for preferred option (£m) to project completion (2018/19 Price Base)

8.3. Efficient Cost

Our RIIO-2 forecasts, as well as adjusting for workload and work mix factors we have included ongoing efficiencies flowing from our transformation activities including from updating and renewing our contracting strategies. Our initiatives are outlined in Appendix 09.20 Resolving our benchmark performance gap. For Capex activities this seeks a 2.9% efficiency improvement by 2025/26 on the end of RIIO-1 cost efficiency level. No efficiency has been applied to this specific investment area.

Brunel Bridge Crossing Refurbishment has various estimates of confidence stages. Elements of this project are at Detailed Design stage whilst others such as BAPA have less confidence and can be defined as being at Conceptual Design. When applying a weighted position our confidence is defined as being at Detailed Design stage with a range of +/-14%.

8.4. Project Plan

There is not yet a GANTT project plan for this work. The key milestone will be the ‘ready on site’ date, which is expected to be early in Q2 2022. The ‘ready on site’ date will have limited flexibility if works are to be completed as envisaged during summer 2022. This will require liaison and negotiations to begin early in RIIO-2 to arrange timely access, alongside main contractor engagement and materials procurement. We have already made initial contact with Network Rail — the key stakeholder

8.5. Key Business Risks and Opportunities

The key risks for this project are:

- Our ability to negotiate with all key stakeholders in a timely way to be in a position to remediate the pipe early in RIIO-2.
- The costs and complexities associated with the scheme may increase as stakeholder discussions begin during the design phase.

Reference	Risk Description	Impact	Likelihood	Mitigation / Control
09.13 - 001	Supply & Demand deliverability risk of Resource availability within the Gas industry	Potential cost increases in labour / commodity markets as demand is greater than supply	Low	Intelligent procurement and market testing. Apprenticeship and Training programmes to fill skills gaps
09.13 - 002	Stretching efficacy targets may not be deliverable (unit costs increase)	Outturn costs are not met increasing overall programme costs.	Low	Established market place - ability to manage the known commodity market
09.13 - 003	Unforeseen outages and failures restrict access for planned work	Programme and delivery slippage due to delay of planned outages and or site access	Low	Proactive asset management with ongoing condition surveys and response plans to prevent failures
09.13 - 004	Unseasonal weather in 'shoulder months', Autumn and Spring reduce site access/outage windows	Increased demands affecting access to sites and planned outages delay and cost increases	Low	Controlled forecasting and maintenance of flexibility to react to unforeseen events. Detailed design solutions to minimise outages and reduce exposure.
09.13 - 005	Unexpected / uncommunicated obsolescence during RIIO-2 period of equipment components	Inability to maintain equipment at full capacity with risk of impact upon supply	Low	Maintain a close relationship with equipment supply chain and manage a proactive early warning system where spares / replacements become at risk.
09.13 - 006	Legislative change - There is a risk that legislative change will impact the delivery of our work.	Potential increase in the amount of consultation and information exchange required and require us to align our plans with the safety management processes operated by 3rd Party landowner / asset owners. The potential impact is more engagement and slower delivery	Med	We have established management teams to address these issues. We have also identified UMs for key areas.
09.13 - 007	Access to 3rd party land / assets - inability to agree methodologies		Med	Early engagements and coordination of approach with 3rd parties and Contractors

Table 9: Risk Register

8.6. Outputs Included in RIIO-1 Plans

This work was not included in RIIO-1.

9. Regulatory Treatment

This investment will not be processed through the NARMs reporting tool.

The workload will be reported through RRP and cost variance managed through the Totex Incentive Mechanism (TIM).

This investment is accounted for in the Business Plan Data Table 3.05 Other Capex XXXX

Appendix 1. Details of Option 2: proactive replacement

Redacted due to commercial sensitivity

Appendix 2. Approach and basis of calculation for cost benefit analysis

Introduction

We have used CBA to help us demonstrate that the proactive repair option (Option 1) is the optimum solution versus our baseline of fix-on-failure. The replacement option (Option 2) was dismissed due to very high capex investment required.

We have taken an alternative approach to modelling our CBA for the baseline option.

As set out in our Approach to CBA document, 'RIIO-2 Process: Approach to Cost Benefit Analysis' our approach to defining the baseline is the option where we do not invest proactively in our assets, but we do inspect and maintain assets in line with our obligations, and repair assets under a fix on fail strategy. This is the absolute minimum investment we can make in our assets. Other options are then considered which represent increments of investment over and above the baseline.

However, for areas of investment, such as this one, the forecast baseline cannot be assessed due to its highly uncertain nature. In these circumstances, the baseline is set at zero and in the options the changes in costs are considered — that is, we include the costs of reacting to a failure occurring as avoided costs in each option, rather than as absolute levels of anticipated costs in the baseline. This enables us to test the results for their sensitivity to the level of avoided reactive costs.

For this reason, our baseline option in our CBA data tables has been left blank, and the avoided costs have been included against Option 1 & 2 respectively.

Approach to Cost Benefit Analysis

This section describes our approach to CBA for the above options. A full cost benefit analysis has been undertaken to ensure value for money. Our approach is compliant with HM Treasury's Green Book and the relevant Ofgem guidance. We have followed the Ofgem approach, spreadsheet and societal benefit values and calculations.

The table below shows the options assessed using CBA modelling, with the costs and benefits used for each.

In order to test the sensitivity of the results to the Willingness to Pay (WTP) to avoid supply interruptions, we have modelled the chosen option both with and without the inclusion of WTP.

Option in Document	Option in CBA Data Table	Modelled Costs	Modelled Benefits
Baseline: Reactive repair on failure	Baseline	N/A Costs of reacting to failure are included as benefits (i.e. costs avoided) in Options 1a and 1b	N/A No activity is being undertaken
Engineering Option 1: Proactively refurbish before failure	**CBA Option 1**: Proactive Repair	RIIO-2 costs as submitted.	Private and social costs avoided by the option: • Reactive Costs • Interruptions to supply • Rail disruption
	CBA Option 2: Proactive Repair without WTP	RIIO-2 costs as submitted.	Private and social costs avoided by the option: • Reactive Costs • Rail disruption
Engineering Option 2: Proactively replace with new MP main	The option looked at diversion to a new MP main through the centre of Windsor. This option was dismissed as excessively expensive and did not offer value-for-money.		

Table: Basis of calculations in CBA template

The table below shows the detailed basis of calculation for benefits included in the CBA. All avoided costs were assumed to begin in 2027 at the end of RIIO-2, and to last for 23 years in line with average asset lives across the business. We consider this to be a reasonable assumption to make for this project as the investment consists of a mix of refurbishment, with a design life of 15 years, and ADM with a significantly longer asset life.

CBA element	CBA basis of calculation
Annual Avoided Reactive Costs	We have applied this for all CBA scenarios for engineering option 1. (Annual rate of reactive repair) x (Cost of reactive repair) We have assumed that: • The failure rate is 1 in 20 years. • A reactive repair in response to failure would be extended to undertake the full proactive refurbishment scheme. We took this view because many costs (such as access and environmental protection, site security, and BAPA) are part of both reactive and proactive intervention; once they have been incurred, the marginal cost of additional refurbishment work would be expected to be cost-effective. • The cost of a reactive repair is 1.2 times that of proactive repair. This is a conservative approach because evidence shows that emergency reactive costs are in the region of 40 to 60% higher than planned costs. Thus, the avoided reactive repair cost is: **XXXX**
Annual value of Interruptions to Supply	(Annual rate of interruption to supply) x (Number of properties affected) x (WTP to avoid interruption) We have assumed that: • The failure rate is 1 in 20 years. • The probability of properties being affected if there is a failure was estimated to be 0.01. A failure would only affect supply if demand > 80% of the peak 1 in 20-year value. • If demand is sufficiently high, then 3,500 properties would be affected by a failure. • Supply interruption would be between 24 hours and 1 week. The WTP to avoid an interruption of this length is **XXXX** Thus, the value of avoided interruptions to supply is: **XXXX** The annual value of interruptions to supply avoided is low as the chance of a failure impacting on supply is very low, requiring simultaneous occurrence of a failure and a high-demand day.

<table>
<tr><th>CBA element</th><th>CBA basis of calculation</th></tr>
<tr><td>Annual value for railway traffic disruption</td><td>(Annual rate of disruptions to national rail network) x (Number of days affected) x (Social cost of railway disruption)

We have assumed that:
The failure rate is 1 in 20 years.
A failure would disrupt the railway for 1 day.
The average social cost of disrupting a national railway per day is XXXX (which is consistent with the value for disruption of a national railway used in AIM model)
Thus, the avoided cost of railway disruption is:

XXXX

The social cost of rail disruption is based on a conservative analysis of Department for Transport data and assuming a single day of disruption.</td></tr>
</table>

Table: Basis of calculation for avoided costs within CBA calculations

The CBA Results

The results of the Brunel Bridge CBA are set out in the following table.

<table>
<tr><th>CBA Option No.</th><th>Option Name</th><th>Total NPV</th><th>Cost beneficial</th><th>Payback Year</th><th>RIIO-2 Spend</th><th>Ratio of NPV to RIIO-2 spend</th></tr>
<tr><td>Baseline</td><td>Baseline</td><td colspan="5" rowspan="3">Redacted due to commercial sensitivity</td></tr>
<tr><td>CBA Option 1</td><td>Proactive Repair</td></tr>
<tr><td>CBA option 2</td><td>Proactive Repair without WTP</td></tr>
</table>

Table: CBA results for Brunel Bridge crossing (£m)

The approach to assessing CBA:

- For each option, we estimate the Total NPV. This is the discounted sum of costs over time relative to our do-nothing position (known as the baseline position). In estimating NPV, we have considered costs over five risk categories: financial, environmental, safety, reliability and other costs.
- All costs are discounted in line with Ofgem’s recommended approach, for example financial impacts are discounted using the Spackman approach.
- A positive NPV means an option reduces the profile of costs relative to the do nothing (baseline) position and is therefore cost beneficial. The option with the highest positive NPV is the most cost beneficial option.
- Payback shows the year when the sum of costs associated with an option is lower than the baseline i.e. this is the point at which the option can be considered to be cost beneficial. This is driven by the profile of the costs and the capitalisation rate.
- The table shows the RIIO-2 proactive expenditure; the ratio of NPV to RIIO-2 spend shows how much NPV per £ spent in RIIO-2 the options generate. A positive figure means the investment is cost beneficial. The higher the figure the most cost beneficial the option is.

The table clearly shows that the Option to proactively refurbish the crossing is cost beneficial, with an NPV of **XXXX** and payback by **XXXX**.

Option 1b tests the sensitivity of this result to the WTP to avoid supply interruptions. Removal of these benefits reduces the NPV by only **XXXX** and does not affect the overall result that the investment is cost-beneficial. Note that removing WTP does not make a significant difference to payback year because the annual value of avoided interruptions to supply is so small.

The level of positive cost-benefit of the preferred option is demonstrated by the ratio of NPV to RIIO-2 expenditure of **XXXX**.

The table below shows the drivers underlying these positive results in more detail.

Option No.	Option Name	PV Expenditure & Costs	PV Environment	PV Safety	PV Reliability	PV Other	Total NPV
Baseline	Baseline						
CBA Option 1	Proactive Repair	Redacted due to commercial sensitivity					
CBA Option 2	Proactive Repair without WTP						

Table: Breakdown of CBA results for Brunel Bridge crossing (£m)

The table above shows the discounted present value (PV) of costs across the five risk categories.

- Costs are presented as negative values; cost reductions are presented as positive values.
- PV expenditure and costs shows discounted sum of proactive investment (replacement or refurbishment costs) over and above the costs of the baseline. All financial costs are discounted using the Spackman approach.
- PV environment shows the discounted sum of changes in leakage and shrinkage, using the base case cost of carbon.
- PV safety shows the discounted sum of the change in the risk of fatalities and injuries, as valued using the Ofgem stated costs per fatality and cost per non-fatal injury.
- PV reliability shows the discounted sum of the change in interruption risk, as valued using our own valuation research (e.g. the willingness to pay study into the cost of interruptions to homes and businesses).
- PV other shows the discounted sum of any other cost changes, as valued using our research into the cost of property damage and transport disruption.

The full cost benefit of the proposed refurbishment including all three types of benefit is set out in CBA Option 1. This is clearly cost-beneficial with an NPV of **XXXX**.

The positive NPV result is being driven mainly by the benefit of avoiding the cost of responding reactively to a failure (included in the PV Other column).

The results are not sensitive to the inclusion or removal of the value of supply interruptions (shown in the PV Reliability column), which have a very low PV of **XXXX** due to the low likelihood of interruptions. The proposed scheme remains cost-beneficial even if these are removed from the analysis as modelled in CBA Option 2.

We have also tested sensitivity to the uplift assumed for reactive repair costs compared with more-efficient proactive repairs. Option 1 remains cost-beneficial for all uplifts of reactive costs, with higher uplifts bringing forward the payback year.

Sensitivity Scenario	Reactive Repair Uplift	Avoided Costs pa	PV Expenditure	NPV	Difference in NPV from Central Estimate	Payback Year
Higher Costs	50%					2042
Central Estimate	20%			Redacted due to commercial sensitivity		2046
Lower Costs	5%					2048

Table: Sensitivity of NPV to assumed uplift in cost of a reactive repair (costs in £m)

The proactive repair option is therefore the preferred option and has a positive NPV.