national gas transmission

ENGINEERING JUSTIFICATION PAPER (EJP)

OFFICIAL- SENSITIVE

Valves - Actuators

Version: 1.0

Issue: Final

December 2024

Click here for our Main Business Plan

Click here to view our published document list

RIIO-GT3 NGT_EJP23

Contents

1 Summary Table

Table 1: Summary table for Actuators EJP

<table>
<tr><td>Name of Project</td><td colspan="3">Actuators</td></tr>
<tr><td>Scheme Reference</td><td colspan="3">NGT_EJP23_Valves: Actuators_RIIO-GT3</td></tr>
<tr><td>Primary Investment Driver</td><td colspan="3">Legislation / Asset Health / Obsolescence</td></tr>
<tr><td>Project Initiation Year</td><td colspan="3">FY2026</td></tr>
<tr><td>Project Close Out Year</td><td colspan="3">FY2032</td></tr>
<tr><td>Total Installed Cost Estimate (£m, 2023/24)</td><td colspan="3">Baseline: [redacted]</td></tr>
<tr><td>Cost Estimate Accuracy (%)</td><td colspan="3">[redacted]</td></tr>
<tr><td>Project Spend to date (£m, 2023/24)</td><td colspan="3">0</td></tr>
<tr><td>Current Project Stage Gate</td><td colspan="3">Stage 4.0</td></tr>
<tr><td>Reporting Table Ref</td><td colspan="3">6.4</td></tr>
<tr><td>Outputs included in RIIO-T2 Business Plan</td><td colspan="3">No</td></tr>
<tr><td rowspan="2">Spend apportionment</td><td>RIIO-T2 (£m, 2023/24)</td><td>RIIO-GT3 (£m, 2023/24)</td><td>RIIO-GT4 (£m, 2023/24)</td></tr>
<tr><td>[redacted]</td><td>[redacted]</td><td>[redacted]</td></tr>
</table>

2 Executive Summary

2.1.1 This paper proposes £17.2m of baseline funding. This investment is to address defects/obsolescence on 271 (3.9%) of the actuator population in RIIO-GT3. It is part of our Valves Investment Decision Pack (IDP) which requests a total of £286.3m in 2023/24 prices. This is shown in Table 2 below. The delivery of this program will be measured through our Asset Health Network Asset Risk Metrics (NARMs) Price Control Deliverables (PCDs).

Table 2: Valves IDP investment request (£m, 2023/24)

Valves	Actuators	Pressure & Flow Control Valves	Bypass Installation & Modification	Total
Baseline: 110.64 Uncertainty Mechanism: 3.32 Total: 113.96	Baseline: 17.20	Baseline: 77.25	Baseline: 36.91 Volume Driver: 41.01 Total: 77.92	Baseline: 242.00 Uncertainty Mechanism: 3.32 Volume Driver: 41.01 Total: 286.33

2.1.2 The primary drivers for these investments are addressing defects and obsolescence across the actuator population. It is important to have functional actuators as they operate critical valves that are used to isolate sections of the network for planned and unplanned maintenance and valves that provide Emergency Shut Down (ESD) functionality for sites. This helps to prevent loss of containment, give our network resilience, prevent disruption and maintain security of supplies to customers. This will also help us be compliant with legislation such as Pressure Systems Safety and Regulations (PSSR), Dangerous Substances and Explosive Atmosphere Regulations (DSEAR) and IEC61508 Functional Safety Standards.

2.1.3 There are 271 actuator interventions required to reduce increasing risk across RIIO-GT3 while also factoring deliverability of the interventions in terms of outage, resource and supply chain constraints. These are part of our preferred option (Option 1A post deliverability) for our Valves IDP [Valves, Non-Return Valves (NRVs) Actuators, Pressure and Flow Control Valves and Valve Bypasses]. Actuator interventions have a NARMs Long-Term Risk Benefit (LTRB) of £1.36m.

2.1.4 Our actuator assets include manually operated actuators and power operated actuators (Electric, Gas Hydraulic, Direct Gas etc). We considered interventions across the actuator portfolio to establish an optimal programme that would deliver desired regulatory outputs. In summary, we are proposing the following intervention mix shown in Table 3.

Table 3: Volumes of replacement vs overhauls for actuator investments

	Funding	Replacement	Overhauls	Total
RIIO-GT3 volumes	Baseline	[redacted]	[redacted]	271

2.1.5 In RIIO-T2 we will have delivered more actuator interventions than our original allowance of 284 as we have identified an increasing volume of defects. This is shown in Table 4 below. The RIIO-GT3 proposed interventions and investment is very similar to RIIO-T2. Ideally, we would like to do more interventions than this to maintain stable risk across the asset class but have constrained the plan to ensure all interventions are deliverable.

Table 4: Volumes of investment in in RIIO-T2 compared to RIIO-GT3

	RIIO-T2 Business Plan	RIIO-T2 Forecast Delivery	RIIO-GT3 Business Plan
Intervention count	284	369	271
Investment (£m, 2023/24)	16.6	13.5	Baseline: 17.2
% of Actuator population	4%	5.2%	3.9%

2.1.6 We must deliver the proposed actuator defect rectification during RIIO-GT3 to ensure future network risk levels are not compromised. Deferring work would mean increased network risk levels in the short term and leaving defective, legislation non-compliant and obsolete actuators operating critical valves across the network.

2.1.7 Table 5 below shows the intended actuator investment profile in RIIO-GT3

Table 5: Actuators RIIO-GT3 funding request spend profile (£m, 2023/24)

Asset	2026	2027	2028	2029	2030	2031	2032	Total	Funding Mechanism
Actuator Control Replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**3.62**	Baseline
Actuator Overhauls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**0.15**	Baseline
Actuator Replacements	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**13.44**	Baseline
Total	0.13	1.37	2.43	3.16	2.67	7.04	0.41	**17.2**	Baseline

3 Introduction

3.1.1 This EJP provides justification for RIIO-GT3 investments in our 10-year actuator programme. These interventions have been developed to manage the health of actuators across the fleet, address defects, obsolescence, and safety concerns of 3.9% of actuator population in RIIO-GT3.

3.1.2 Valves can be operated in different ways, using manual gearboxes, turn wheels or through actuators. Actuated valves can be controlled locally or remotely from the Gas National Control Centre (GNCC). Several actuators and their control packages suffer from defects or obsolescence, or both. This can cause significant delays returning an installation to service after a failure if spares are not available. Many of the electrically powered actuators currently in service cannot be shown to meet the requirements of the Dangerous Substances and Explosive Atmosphere Regulations 2002 (DSEAR) legislation or IEC61508 (Functional Safety standards) for safety systems. Pneumatic (gas or air) actuators need to be inspected and maintained as part of Pressure System Safety Regulations (PSSR).

3.1.3 Learning from investment building and submission experience in RIIO-T1 and RIIO-T2, we have moved from a qualitative and quantitative decision approach to a data driven asset management approach. The actuator programme is a bottom-up plan built on existing defects on our assets plus a list of obsolete actuators across the network that need replacing to ensure critical valves can be operated when required.

3.1.4 Interventions developed were from known actuator defects, obsolete actuators and to ensure risk levels were maintained across the network.

3.1.5 The scope of this document is aligned with our Asset Management System (AMS) and relates to our "Delivering a resilient network fit for the future" Business Plan Commitment (BPC). More information on our AMS and a description of our commitments is provided in our **NGT_A08_Network Asset Management Strategy_RIIO_GT3** and our BPCs are detailed within our **Main Business Plan**.

3.1.6 The decisions made upon assessing the Actuator investments as part of Valves Investment Decision Pack (IDPs) have interactions with other Investment Decision Packs:

- **NGT_EJP17_Pipeline_RIIO-GT3 –** If defective actuators aren't intervened on in critical valves for In-line inspection (ILI) runs such as Pipeline Inspection Gauge (PIG) trap isolation valves, block valves and feeder valves, this may delay the ILI run which means inspection wouldn't be carried out.
- **NGT_EJP18_Pressure Vessels_RIIO-GT3 –** If defects on actuators aren't remediated for pig trap isolation valves, the valve may not be operable and therefore will not be used to isolate the pig trap to conduct PSSR inspections.
- **NGT_EJP12_Electrical Infrastructure: Site Lighting, Earthing and Lightning Protection_RIIO-GT3 –** DSEAR defects that are raised on actuators may not be an issue with the actuator operation in itself and may be an issue with the electrical cabling that the actuator is connected to. There has been no double counting of DSEAR related interventions between this EJP and the Electrical Infrastructure EJP i.e. only resolution of actuator specific defects is covered in this paper.

4 Equipment Summary

4.1.1 Actuators provide the "muscle" required to operate valves. They can be manually operated or remotely controlled depending on the purpose of the valve to which they are connected. The duty of the valves operated can vary from those used as block valves to isolate pipeline sections, through to those used as part of an Emergency Shut Down (ESD) system at site such as a compressor station or terminal.

4.1.2 The actuator mounted to a valve can either be:

- **Manually operated** – The motive force to drive the actuator is generated, for example, by a manually operated hydraulic hand pump that an operative can use to drive the actuator.
- **Power operated** – The motive force to drive the actuator can be generated in a number of ways. Types of operation include electric, electro-hydraulic, direct gas, direct hydraulic or pneumatic (using either compressed air or natural gas), gas/hydraulic or gas-over-oil powered. In the case of Electric actuators, an electric motor is used to drive a gearbox that operates the valve. In the case of Gas-Hydraulic or Direct Gas, natural gas either at line pressure, or at a reduced pressure is used as the driving medium.

4.1.3 Table 6 shows the equipment count for different actuator types.

Table 6: Actuator types and their counts

Actuator types	Equipment counts
Actuators	1203
Actuators-Direct Gas	171
Actuators-Electric	1359
Actuators-Electrohydraulic Non-Venting	31
Actuators-Gas Hydraulic	750
Actuators-Gas Over Oil	129
Actuators-Manual Gearbox	3393
Total	**7036**

4.1.4 Powered actuators can typically be:

- **Remotely operable** – they can be operated by the Gas National Control Centre (GNCC). The valves to which these actuators are mounted are known as Remotely Operable Valves (ROVs). They can also be operated by means of automated command from a control system such as at a Compressor Station. The valves to which these actuators are mounted are known as Process Valves (PV).
- **Locally operable** – They are operated at the site location using controls mounted at, or in proximity to the actuator by Site Operations. The valves to which these actuators are mounted are known as Locally Operable Valves (LOVs).

4.1.5 Actuators other than electrically operated typically have a control pack associated with them. Figure 1 below shows the schematic and photo of an actuator and its control pack.

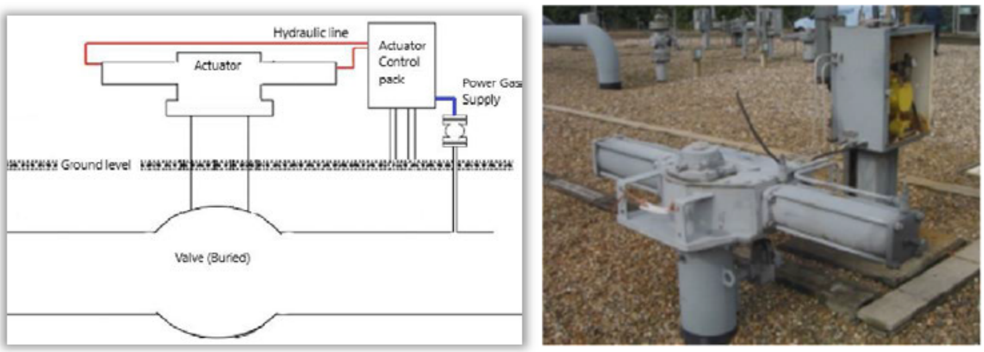

Figure 1: Actuator and its schematic

4.1.6 Actuator control packs are the means to supply and control the gas pressure used to operate the actuator and may contain some or all of the following: Filter, pressure regulator, relief valve, oil tank, solenoid operated valve, control valve, check valves and hand pump. The diagram in **Appendix 1** shows the control schematic for a [redacted] actuator.

4.1.7 Electrically powered or controlled actuators will fall under the requirements of the DSEAR. These regulations require specific checks on the condition of the electrical equipment to avoid risk of fire or explosion. Actuated valves may also fall under the mechanical requirements of the DSEAR regulations.

4.1.8 Pneumatically (gas or air) actuated valves fall under PSSR inspections and maintenance. These regulations place requirements on the suppliers and operators of such equipment to ensure that it is fit for purpose throughout its lifecycle and specifically a requirement to inspect such equipment in accordance with a written scheme of examination.

4.1.9 Valve actuators of type [redacted] Rotary valve – (Gas over oil) contain pressure vessels that operate between 7 bar and 94 bar and are therefore subject to the requirements of PSSR.

Criticality of valves and actuators

4.1.10 Actuators for critical valves are also considered critical and are maintained at the same frequency as their valve.

4.1.11 Reasons for actuators to be deemed critical are if they operate valves that carry out the following:

- ESD functionality
- Prevention of over-pressurisation
- Provide isolation of sections for planned or unplanned maintenance.

4.1.12 These critical actuators due to importance will require investment if obsolete, defective or non-compliant with legislation.

4.1.1 Additional information on this equipment group such as the health score at the beginning and end of the price control and monetised risk are provided in the accompanying **NGT_IDP10_Portfolio EJP Valves_RIIO-GT3**.

5 Problem/Opportunity Statement

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

5.1.1 The key drivers for investment on actuators are:

- Legislation
- Obsolescence
- Asset deterioration

Legislation affecting actuators

5.1.2 NGT must comply with the following legislation that also affects actuator maintenance and investment. For more information, see **Appendix 1**:

- PSSR – Meant to ensure the mechanical integrity of our pressurised assets to prevent loss of containment and gas escape.
- DSEAR – Meant to prevent risk of fires and explosions that may be caused by dangerous substances in the workplace.

5.1.3 **IEC 61508 Functional safety –** Any valves together with their associated electrical or electronic control and actuation systems that form part of a protective system are subject to the requirements of IEC 61508 "Functional Safety of Electrical / Electronic / Programmable Electronic Safety related systems" and the related IEC61511 "Functional safety – Safety instrumented systems for the process industry sector". Although compliance with these standards is not a legal requirement, they are de facto standards across a wide range of industries and any non-compliance would be regarded negatively by the Health and Safety Executive (HSE), particularly if non-compliance led to a safety incident.

5.1.4 Compliance with the standard is necessary to demonstrate that the safety case is robust i.e., when you have actuators that operate isolation valves and they are required to manage major accidents, maintaining the actuators to this standard gives confidence that they will work.

5.1.5 [redacted]

Actuator obsolescence

5.1.6 There are several models of actuator that are approaching or exceeding their original design life and are now becoming obsolete. Original Equipment Manufacturers (OEM) either no longer exist or are no longer supporting or providing spares for these assets. Examples of actuators where the actuator or subsidiary components that make up the control packs are unsupported include:

- **Pre-1983 [redacted] gas-over-oil actuators** – There is a safety concern notified by the OEM, related to the [redacted] handpumps for these actuators. Due to this, the OEM will not supply spare parts for any handpump older than [redacted] vintage. [redacted] can also not be fitted to systems with [redacted] without significant changes to the control pack.
- [redacted] – OEMs no longer offer spares for these actuator models.

HSE mandate to address safety concerns with obsolete [redacted] actuators

5.1.7 HSE issued NGT with an action legal under Health & Safety at Work Act. A technician was injured during activity to diagnose a fault on a [redacted] actuator. The actuator in question had apparently failed to stroke the valve, onto which it was attached, to the position commanded by the control system. As part of the fault-finding exercise, in accordance with guidance in the OEM operating manual, covers were removed from the actuator to facilitate fault-finding and diagnosis. During that fault-finding activity to confirm the nature of the fault, the valve actuator moved unexpectedly causing injury to the technician's finger. The injury was such that the tip of the injured party's finger was later amputated.

5.1.8 NGT reached agreement with the HSE that the only viable way to address safety concerns and prevent injury risk to technicians in the future, was to replace all concerned actuators and this expectation would be met at the end of RIIO-GT3. More details are discussed in **Appendix 2**. This required a data collection exercise to confirm the location of all similarly configured [redacted] actuators across the NTS. An obsolete [redacted] actuator is shown below in Figure 2.

5.1.9 112 [redacted] actuators were identified across the NTS. This included [redacted] (30 of which are scheduled for replacement in RIIO-T2) and 50 across the rest of the network.

Figure 2: Obsolete [redacted] actuator

Difficulty obtaining spares from OEMs

5.1.10 Obsolescence creates challenges obtaining spare parts due to lack of support from OEMs. It is sometimes necessary to attempt refurbishment of existing parts or attempt "reverse engineering of parts". This increases both the cost and time to repair in the event of a failure.

5.1.11 OEMs on older actuator types would not provide the certification required to demonstrate compliance with the standard, making it hard for NGT to obtain spares for the actuators. There have been instances where NGT has provided serial numbers to OEMs in support of enquiries related to spares availability. Subsequent responses from the OEM are that - due to the age of the equipment – they cannot find, or no longer possess, details relating to the equipment in their records.

5.1.12 Spares are also extremely limited internally. Sometimes, even if refurbishment were possible and pattern parts can be located or reverse engineered, the work, potential cost and project risk involved would make actuator replacement a preferred investment.

Asset deterioration

5.1.13 Actuators are deteriorating due to wear and age and can no longer meet their primary obligation of operating valves for isolations and emergency shut down systems. These all have **safety environmental,** and **availability/reliability** impacts under NARMs service risk measures and could require investment to rectify issues. Examples include:

- Electric actuators suffer from DSEAR non-conformances including damage to flame paths and other defects. The flame path is the interface between two parts of an enclosure, (e.g., the body and the lid). It allows gases to exit the enclosure and to cool down during the passage, so that they are no longer able to ignite when exposed to outside atmosphere. For that reason, the flame path must be sufficiently long and with an interstice narrow enough to guarantee the cooling of flue gases. Any damage to flame path (e.g., corrosion) means that the safety of the equipment is compromised.

- Hydraulic / Gas hydraulic actuators suffer from damage to pistons/ cylinders due to wear. Age related deterioration to seals also leads to leaks.
- Gas hydraulic actuators suffer from wear e.g., corrosion to control box enclosures and small-bore control pipework.
- Local /remote selector switch on the actuator could fail due to age/corrosion, causing issues with remote operability by NCC. These are common on [redacted] and no replacement parts are available as both models are obsolete.
- All actuators suffer from oil leaks from the gearbox making the actuator not function properly.
- Actuators have handpumps that are corroded past the point of repair. An example would be Shafer actuators which are prone to corrosion on pressure pistons that prevent operations.
- Actuator control cabinets corrode with time, leading to ingress of water, causing subsequent damage to internal sub-components.
- Damage /wear to valve position indicator present on actuator over time making it difficult to see position of the valve during operation.

5.2 What is the outcome we want to achieve?

5.2.1 All actuators recommended for intervention as per **NGT_IDP10_Portfolio EJP Valves_RIIO-GT3** comply with legislative requirements including DSEAR and IEC61508.

5.2.2 Critical actuators as per **NGT_IDP10_Portfolio EJP Valves_RIIO-GT3**can be appropriately maintained without reliance upon obsolete parts.

5.2.3 Maintain risk levels across the network to prevent increasing defect rates across actuators.

5.2.4 Actuators recommended for intervention as per **NGT_IDP10_Portfolio EJP Valves_RIIO-GT3** can serve their function of controlling valves that isolate the NTS for maintenance or in the event of an emergency or valves that provide and ESD function. This keeps us in line with IEC standard and safety case as discussed above.

5.2.5 All obsolete [redacted] actuators are removed from the NTS as per HSE mandate to ensure safety of technicians.

5.3 How will we understand if the spend has been successful?

5.3.1 The spend will have been successful if issues with actuators recommended for interventions due to defects, obsolescence, legislative non-compliance have their issues resolved.

5.4 Narrative real-life example of the problem

5.4.1 The sections below provide typical examples of the common problems that are being experienced with actuators across the NTS.

Defective Ledeen Gas Hydraulic actuator at [redacted] installation

5.4.2 A [redacted] actuator, shown in Figure 3, was inspected during routine maintenance and was found to have the following defects.

5.4.3 The actuator for [redacted] and its operating components were in a poor condition. During valve validation operations, the actuator required approximately 11 litres of hydraulic oil to operate correctly. High consumption of hydraulic fluid during operations was due to failure of the hydraulic piston seals or defects due to wear or corrosion to the piston head or cylinder bores/liner.

5.4.4 No visible external leaks to indicate where the fluid was leaking from, indicated the possibility that the fluid was leaking past the piston seals and piston rod seals and into the actuator’s carter housing and from there possibly past the yoke seal and into the valve stem extension.

5.4.5 Shuttle valve of the actuator was sticking and required non-standard means to rectify the problem indicating the shuttle valve was worn possibly due to corrosion or seal failure.

5.4.6 Local/remote selector switch on the actuator was broken due to age/corrosion and couldn’t be locked into the remote position. This brought about a possibility it could be inadvertently moved to the local position disabling remote control.

5.4.7 During operation, gas leakage was noted coming from the fittings on the direction shuttle valve.

5.4.8 Manual override hand pump piston and clevis pin were in poor condition due to corrosion and over coating.

Figure 3: Defective [redacted] Gas-Hydraulic actuator

5.4.9 Due to defects listed above, the actuator wasn't operable without investment. [redacted] The actuator type and model were unsupported by Ledeen making it impossible to obtain replacement parts. The actuator was therefore replaced to ensure operational reliability.

Issue with OEM providing support for an old [redacted] actuator

5.4.10 Manuals were required for the muscle and the control pack to operate a defective [redacted] actuator and [redacted] were contacted for support. This actuator was an old [redacted] model supplied in the 1970s. [redacted] Actuator and its control cabinet are shown in Figure 4 below:

Figure 4: [redacted] actuator and its control package

5.4.11 The OEM asked for the serial number of the actuator with the hopes of using it to verify if they had support documents for the actuator in their manuals.

5.4.12 The plate in the actuator's control cabinet was used and sent to the OEM. They couldn't provide any documentation to support the actuator as all documentation relating to actuators of this vintage had been removed from their archives. This highlights the issue with obtaining support for obsolete equipment.

5.5 Project Boundaries

5.5.1 The proposed spend in this EJP are all identified interventions on actuators (handpump and fuel driven gearboxes) installed on the NTS to keep them safe and operational over RIIO-GT3.

5.5.2 The intervention volumes at [redacted] in the AMP are forecast volumes for future defects and raised obsolescence on actuators that will come from future inspections and maintenance. There is no double counting between interventions in this paper and those discussed in **Bacton FOSR**.

5.5.3 Outside the scope of spend in this EJP are:

- Actuators that will be replaced as part of valve replacements – These are covered in **NGT_EJP22_Valves: Valves_RIIO-GT3**. Actuator replacements in this paper replace the actuator only.
- Actuator interventions specifically at the St Fergus gas terminal – these will be covered under the **NGT_EJP29_St Fergus: Valves and Actuators_RIIO-GT3.**
- Actuator replacements at the Bacton terminal based on known defects and issues – these will be covered in the **Bacton reopener submission**.

6 Probability of Failure

6.1 Failure Modes

6.1.1 Probability of failure (PoF) has been assessed both utilising historical defects but also utilising our Network Asset Risk Metric (NARMs) model built within our Copperleaf asset management decision support tool to assess the forward-looking probability of failure. This provides a different lens to consider in addition to looking at historic defects.

6.1.2 Not all modelled failures will result in real-world asset failure and this forecast is not a prediction of how many defects will be identified. Failures help determine the likelihood of a consequence occurring for each asset. Assets can have multiple failure modes and the impact of failure depends on factors like the asset's age, location and criticality. A failure may lead to various service risks, including environmental, health and safety, availability and reliability, societal or financial impact.

6.1.3 Likely failure modes for actuators with an average proportion of failures of 0.5 or above are provided in Table 7, the full list of failure modes is available in the NARMS methodology.

Table 7: Actuator failure modes

Failure mode	Average proportion of failures
Structural damage leak affecting electrical control equipment loss of control/monitoring	0.87
Loss of power – gas supply instrument trip	0.53
Corrosion on pipework – no leak	0.52
Loss of local control	0.50
Loss of unit – instrumentation of electrical fault	0.50

6.1.4 When applied to the asset count with an assumption that no investment is made, a forecast of failures across the RIIO-GT3 period is produced, shown in Table 8. The average failure rate represents the proportion of that asset type with an unresolved failure. The forecast failures per year shows the quantity of new failures modelled to occur each year. Please see **NGT_A01_Asset Management Plan (AMP)_RIIO_GT3** for more details on failures vs defects.

Table 8: Forecast actuator failure rates and failures per year.

Asset Type	No. of Assets	Cumulative Average Forecast Failure Rates					Forecast Failures per Year				
		2027	2028	2029	2030	2031	2027	2028	2029	2030	2031
Actuators	7036	0.59	0.60	0.62	0.63	0.64	91	94	94	96	102

Historical Defects

6.1.5 Defects are raised through inspection and maintenance activities and captured within our Maximo defect management system.

6.1.6 A sample of 763 actuators from 329 sites were collected to ensure it was a representative sample of the network and defects were reviewed for each actuator. 1346 defects were identified from 2006 – 2023 and this helped inform a rate for average number of defects per year. It is important to note the following:

- Not all defects lead to CAPEX interventions for the valves and may be resolved with maintenance.
- Actuators can also have several defects raised on them at once. You can therefore see a greater number of defects than actuators in a sample.

Table 9: Historical defect rates for different actuator failure modes

Asset	Volume of Historical Defects (2006 – 2023)	Average no. of Defects per year
Actuators (sample)	1346	75
Actuators (extrapolating for the fleet)	**12413**	**690**

6.1.7 The phasing of these defects from the sample of valves over the last 18 years is shown in Figure 5 below. Number of defects raised has increased in recent years. This is due to increased levels of inspection towards the end of RIIO-T1 and RIIO-T2 and deterioration of the actuators due to age and wear (actuator asset life is 30 years, and some actuators are exceeding this).

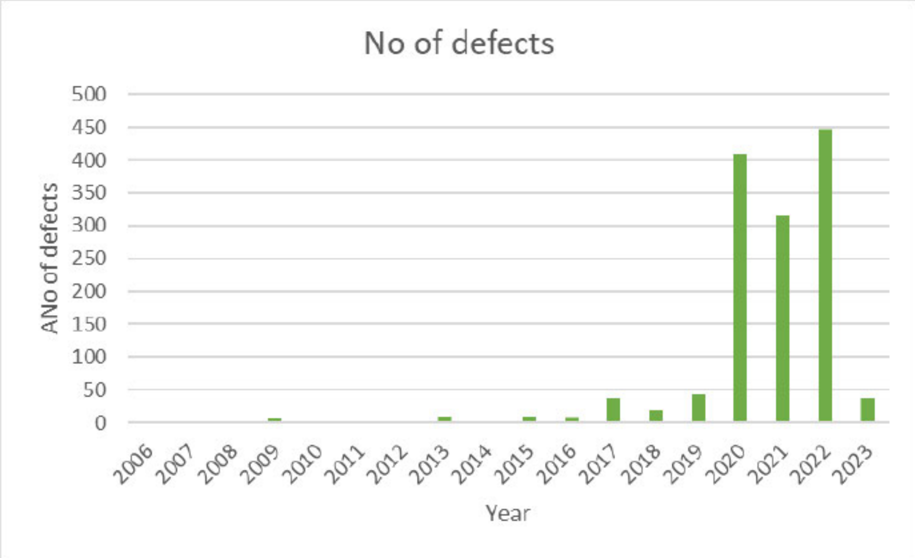

Figure 5: Historic defects raised each year for actuators.

Historical Failure modes

6.1.8 An actuator is considered to have failed if it cannot be used to operate a valve. This may cause the valve to be inoperable and unable to carry out various NTS functions such as acting as an ESD, isolating the network for planned and unplanned maintenance, and controlling flow to meet network demand.

6.1.9 Some common actuator failure modes from historical defects are shown in Table 10 below. For the same sample of actuators discussed above, the frequencies of the discussed failure modes compared to the total number of defects raised (1346) was calculated.

Table 10: Failure modes and frequencies for actuators sample

Failure mode	Count	Failure Mode Frequencies (%)
Corrosion to hydraulic cylinders	6	0.45
Failure of seals causing oil leaks	20	1.49
Failure of components due to wear	3	0.22
Deterioration of flame paths	29	2.15

Probability of Failure Data Assurance

6.1.10 Probability of failure data presented above has been determined based on NGT's Defect Management System. An extract from the system was undertaken in July 2023, with data analysis undertaken based on the columns of data exported from the system.

6.1.11 The NARMS Probability of Failure data was sourced from a Power BI dashboard, with data supplied from our Copperleaf asset management decision support system.

6.1.12 Defects were collected for each actuator and a methodology determined to assign cost effective interventions to the actuators. The interventions were verified by technicians from Site Operations to ensure they remediated defects of key actuators on our operational sites.

7 Consequence of Failure

7.1.1 Actuators deteriorate over time and with use. This in turn prevents them from performing their required functions and can also result in them no longer complying with legislative requirements. In addition, the obsolescence of some actuators can mean there is a risk of increased impact if they fail.

Inability to isolate equipment and / or systems

7.1.2 If an emergency situation where a valve is required for isolation and a remotely operable actuator fails to close a valve on command, it will take substantially longer to isolate the affected section of feeder (for block valves and feeder isolation valves). This potentially increases the severity and prolongs the duration of any incident. Inability to appropriately manage a pipeline incident as a result of failure of an actuator puts NGT as risk of failing to conform to Pipeline Safety Regulations (PSR) and Gas Safety (Management) Regulations (GS(M)R).

7.1.3 If the valve is inoperable due to the actuator failing and the isolation boundary needs to be extended outside the site, that will lead to more venting of gas to the atmosphere and negative environmental impact for consumers. This also has a time and resource impact due to needing to mobilise to other locations. It could also subsequently affect other planned maintenance.

Impact upon Availability of sites, equipment, or systems

7.1.4 Where an actuator that delivers an ESD function fails; the related site, unit, or system that is affected by the failure will be required to be declared unavailable until repair or replacement can be achieved. This could affect supply to customers.

7.1.5 With actuator failures affecting isolations and ESD systems, there are further impacts across all NARM service risk measures. This is discussed in consequence of failure section of **NGT_EJP22_Valves: Valves_RIIO-GT3.**

Baseline risk changes for actuators across RIIO-GT3

7.1.6 Figure 6 below presents the modelled baseline risk over RIIO-GT3 for actuators assuming no investment in the period. It shows that for actuators, monetised risk starts in RIIO-GT3 at £1.92m and ends at £2.06m during the period, an increase of ~6.9%

7.1.7 Consequence of failure is unlikely to change with supply and demand patterns as maintenance is still required for actuators.

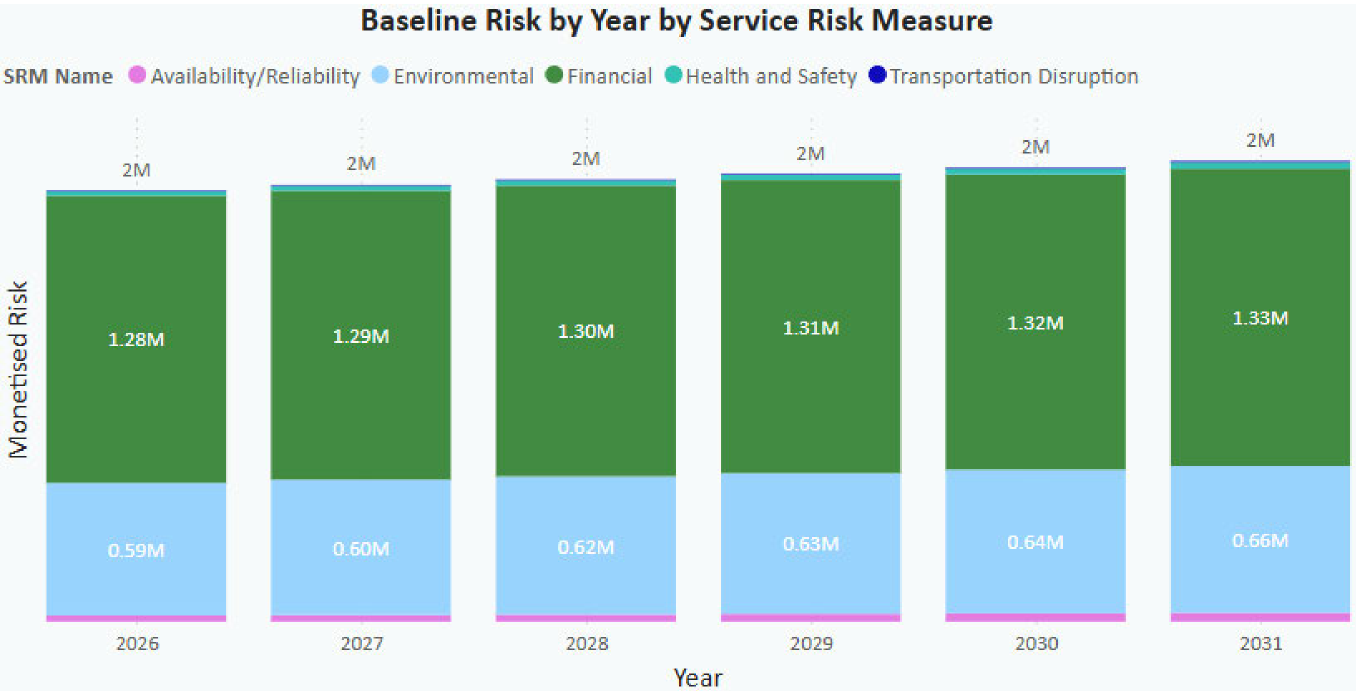

Figure 6: Baseline risk for actuators across RIIO-GT3.

8 Interventions Considered

8.1 Interventions

8.1.1 The following interventions have been considered to address the various issues articulated in the problem statement such as legislation non-compliance, defect remediation, and obsolescence.

8.1.2 In considering the available interventions, our objective has been to develop a plan that balances and optimises cost, risk, and performance.

8.1.3 Deferring spend was not considered due to the need to address defects to provide adequate functionality for actuators to operate critical valves. Obsolete critical actuators also need to be able to provide their function to operate valves that isolate feeders and provide emergency shutdown systems. If Interventions are deferred, there will be increasing risk across actuators which we are trying to prevent.

8.1.4 Please see below to see descriptions of interventions considered.

Counterfactual (Do Nothing)

8.1.5 Actuators are maintained as per policy discussed above. If defects are raised on the actuator, this intervention option involves minor activities (OPEX) to fix it. If these minor activities resolve the defects on actuator and actuator control package, there will be no need for CAPEX intervention.

8.1.6 This intervention option presents the lowest cost but is not suitable when minor activities cannot resolve the issues due to leaving critical actuators defective, obsolete or both. This means they cannot provide their function.

Actuator Overhaul

8.1.7 If minor interventions do not improve actuator performance, components of the actuator and gearbox are repaired. This does not re-life the actuator completely, only extending its useful life. This intervention is beneficial as it’s lower cost than a replacement and is suitable if actuator model is still supported by the OEM or refurbished spare components are available internally to remediate the defect.

8.1.8 This was done in RIIO-T2 as OPEX but will be CAPEX in RIIO-GT3 due to the intrusive nature of the work that is required on the actuator.

Actuator replacement (including gearbox)

8.1.9 If the minor interventions do not improve actuator performance or there is a lack of refurbished spare parts internally to remediate the actuator defects and the model is not supported by the OEM, the actuator will be replaced with a modern equivalent actuator or gearbox. The benefit of this option is that it completely re-lifes the actuator and allows obsolete actuators to be replaced with actuators that can be maintained.

8.1.10 This intervention will require an outage to be carried out.

Actuator control package replacement

8.1.11 Replacement of the control package with a modern equivalent, matched to the operating parameters of the 'muscle'. This would resolve actuator control packages with defects identified through our defect assessment.

8.1.12 This would bring the actuator control package back to service but not the actuator.

8.2 Intervention Summary

8.2.1 See Table 11 below for Technical Summary Table showing the intervention comparison.

Table 11: Actuators interventions technical summary table

Intervention	Equipment Design Life (Years)	Positives	Negatives	Taken Forward
Counterfactual (Do Nothing)	N/A	There is no CAPEX investment required for the actuator	Intervention does not completely relife the actuator so higher chance of failure in the future compared to actuator replacement. Investment not possible if actuator is obsolete or unsupported by the OEM	No
Actuator overhaul	15	Smaller CAPEX investment is required for the actuator compared to an actuator replacement	Intervention does not completely relife the actuator so higher chance of failure in the future compared to actuator replacement. Investment not possible if actuator is obsolete, unsupported by the OEM or spares aren't available internally.	Yes
Actuator replacement	30	New actuator so decreased risk of failure in the future. Investment is viable when actuator is obsolete or not supported by OEM	Investment is highest cost out of all the interventions proposed	Yes
Actuator control package replacement	30	Smaller CAPEX investment is required for the actuator compared to replacing the actuator and its control package.	Intervention does not relife the actuator so higher chance of failure in the future compared to actuator replacement. Investment not possible if actuator is obsolete or unsupported by the OEM. Doesn't allow us to convert non-desirable (e.g, gas venting actuator) control pack rather than convert to electric	Yes

8.3 Volume Derivation

8.3.1 Figure 7 below shows the process for building interventions for actuators.

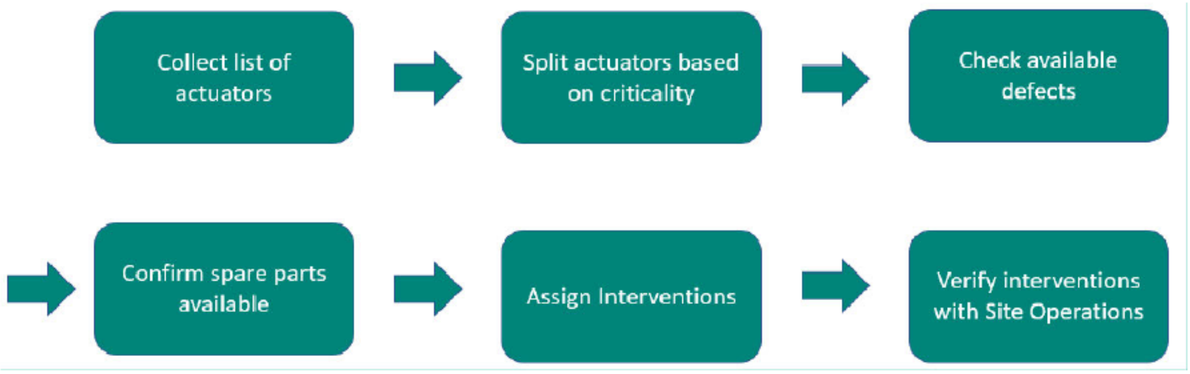

Figure 7: Methodology for developing actuator investments.

8.3.2 Table 12 below shows the methodology in assigning asset health interventions to actuators based on criticality, defects, and obsolescence. The key takeaway is that obsolescence alone was not reason enough to recommend replacement for actuators.

8.3.3 For critical actuators, it was due to importance of actuators in isolating sections for maintenance and ESD functions. For non-critical actuators, actuators also had to have defects to recommend replacement. If spare parts were available internally, actuators were recommended for overhauls rather than replacement.

Table 12: Methodology for assigning interventions for actuators and their control packages.

Actuator replacement vs Actuator overhauls vs Do nothing				
Actuator critical	Actuator defective	Actuator obsolete	Spare parts available	Intervention
Yes	Yes	No	Yes	Actuator overhaul
Yes	Yes	Yes	No	Actuator replacement
Yes	Yes	No	No	Actuator replacement
No	Yes	No	Yes	Actuator overhaul
No	Yes	Yes	No	Actuator replacement
No	No	Yes	No	Do nothing
Yes	No	Yes	No	Actuator replacement

Yes	No	No	Yes	Do nothing
Actuator control replacements vs Do nothing				
Actuator critical	Actuator defective	Actuator obsolete	Spare parts available	Intervention
Yes	Yes	No	No	Actuator control replacement
No	Yes	No	No	Actuator control replacement
Yes	No	Yes	No	Actuator control replacement
Yes	No	No	No	Do nothing

8.3.4 All obsolete [redacted] actuators across the network were selected to be removed due to the incident with the technician operating said actuator and getting finger amputated. Do nothing is not an option due to the safety risk to technicians when operating and subsequent fines and / or prosecution if actuators are not removed.

8.3.5 Table 13 below shows the development of bottom-up actuator intervention volumes that are based off known defects and obsolescence issues for RIIO-GT3. Actuator replacements recommended at Bacton terminal were based on run-rates of defects and obsolescence issues raised in RIIO-T2.

Table 13: Development of bottom-up volumes for RIIO-GT3

Intervention	Volume	Unit of Measure	How this volume has been developed
Actuator overhaul	[redacted]	Per Asset	Number of actuators that required overhauls were based on defective actuators that weren't obsolete and either had spare parts available or could be sourced externally.
Actuator replacement	[redacted]	Per Asset	Number of actuator replacements were based off defective actuators that were beyond repair or obsolete critical actuators. These volumes were verified by site operations as actuators needing replacement. In order to replace HSE [redacted] actuators as per HSE mandate, volumes were added to make sure all [redacted] actuators were removed in addition to those that had already been identified for removal due to open defects on the actuator. Some actuators replacements at Bacton were added to the plan based on forecast defects and raised obsolescence that will be discovered through future inspection and maintenance.
Actuator control package replacement	[redacted]	Per Asset	These were based off number of defective actuator control packages/cabinets and obsolete control packages for critical actuators.

8.4 Unit Cost Derivation

8.4.1 Costs have been derived using known data for activities which share the scope with the interventions within this EJP. We have mapped RIIO-GT3 interventions to RIIO-T2 Unique identifiers (UIDs) and assessed the available historical outturn and/or forecasted completion costs.

8.4.2 Where historical outturn or tendered costs have not been available, we have undertaken estimating by sourcing quotations from the supply chain to calculate the Estimated Cost of Completion (ECC) or have estimated from first principles if no tendered information is available.

8.4.3 Table 14 summarises the cost sources and data points used to inform the unit costs in this EJP. All relevant cost breakdowns are found in **Appendix 3**.

Table 14: Actuator intervention cost sources and data points (£m, 2023/24)

Intervention	Unit Cost	Unit of Measure	Cost Accuracy	Number of Data Points	Source Data
Actuator overhaul	[redacted]	Per Asset	+/- 10%	0	First principles – derived using known rates/activities
Actuator replacement	[redacted]	Per Asset	+/- 10%	75	Historical outturn, Estimate at Cost of Completion
Actuator control package replacement	[redacted]	Per Asset	+/- 10%	0	First principles – derived using known rates/activities

8.4.4 As an example of how we've developed these costs, the unit cost of [redacted] for actuator replacement is representative of the cost of replacing actuators utilising RIIO-T2 delivery data from 27 sites and total of 75 actuators. Actuators replaced range from 200mm (8") – 1200mm (48"). The mode of actuation also varied from electric to gas hydraulic, hydraulic etc. Electric actuators tended to be priced more with an average unit cost of [redacted] compared to non-electric actuators of [redacted]. With 44% of bottom-up actuator replacements in the plan being electric actuators, this led to a weighted average unit cost of [redacted].

9 Options Considered

9.1 Portfolio Approach

9.1.1 In developing our plans, we focused on value for money and deliverability, while managing the risks of aging assets. We evaluated the cost-effectiveness of our investment program through a full Cost Benefit Analysis (CBA) using the NARMS Methodology within the Copperleaf Decision support tool.

9.1.2 While this EJP emphasises interventions on actuators, we have assessed the benefit from options across the entire Valves portfolio including valves, actuators, pressure control valves and flow control valves (PCVs & FCVs), to meet investment drivers, business plan commitments, and consumer priorities. Therefore, a single CBA convers this EJP, **NGT_EJP22_Valves: Valves_RIIO-GT3, NGT_EJP24_Valves: PCVs and FCVs_RIIO-GT3 and NGT_EJP25_Valves: Bypass Installation and Modification_RIIO-GT3.**

9.1.3 The options considered combine the interventions discussed previously, and those in the other valves EJPs, in varying combinations and volumes to identify the optimal investment for valves.

9.1.4 In line with HM Treasury Green Book advice and Ofgem guidance, we assessed the value of investing in actuators across the RIIO-GT3 period by analysing the cost benefit over a 20-year horizon.

9.1.5 We derived bottom-up intervention volumes using the engineering assessments described in the previous chapters. Each intervention was assessed via the Ofgem-approved NARMS Methodology embedded in Copperleaf, quantifying risk reduction and Long-Term Risk Benefit (LTRB). Analysing this performance, Copperleaf Predictive Analytics is then able to select further NARM driven interventions to create further options to satisfy certain criteria, such as stable risk across the portfolio.

9.1.6 Only interventions assigned to a specific asset have been assessed in the CBA, as benefits cannot be applied to interventions that are assigned to various locations (e.g., based on forecast defects). Therefore, some [redacted]r actuator replacements have not been modelled or included in the option costs.

9.2 Options

9.2.1 Using the Predictive Analytics Optimisation Module (PA) within Copperleaf, our Valve assets have been optimised against the NARMS Methodology to ensure the portfolio achieves a variety of outcome risk levels, to satisfy stakeholder needs.

9.2.2 All the options described below have been assessed against out Option 0 Counterfactual (Do Nothing) option, which considers no investment over and above maintenance and corrective repairs.

9.2.3 In all options (except the counterfactual) we include investment volumes that have been developed through our bottom-up intervention development, to address known defects and obsolescence issues. These are consistent in all options (except 1A). A table of these intervention volumes is shown in **Appendix 4** and is included in the top row of each respective option. **NOTE:** All values provided for each option are rounded to 2 dp. Total given is correct but might be different to sum of interventions due to rounding.

9.2.4 The Options 1-6 are therefore differentiated on the volumes outside of the core bottom-up build, the volumes identified in these options have been developed from a combination of bottom-up build plus modelling using Predictive Analytics. This comprises categories as follows: Actuator Overhaul, Actuator Replacement, Pressure Regulator PSSR Inspection Remedial Works, Replace Individual Regulator, Valve Overhaul, Valve Replacement.

Option 1: Total Monetised Risk Stable to RIIO-T2 Start

9.2.5 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain the level of NARMS risk at the end of the RIIO-GT3 period to remain consistent with the levels of risk at the start of the RIIO-T2 period. Individual NARMS service risk measures are not individually constrained, however overall risk outcome is.

9.2.6 The total spend of proposed interventions in this option is £541.0m (2023/24) which addresses known and forecast defects.

Table 15: Option 1 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26

Actuator Overhaul	[redacted]	0.65
Actuator Replacement	[redacted]	27.66
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.02
Replace Individual Regulator	[redacted]	0.18
Valve Overhaul	[redacted]	28.53
Valve Replacement	[redacted]	170.74
Total	**3769**	**541.04**

Option 1A: Post Deliverability

9.2.7 In this option, our programme of investments on valves assets from Option 1 has been taken through a deliverability assessment which factors in network outage, resource and supply chain constraints. Due to the constraints, this is the only option that does not have the same bottom-up volumes as the others. The total spend in this option is £286.3m (2023/24) and the intervention breakdowns are shown in Table 16 below.

Table 16: Option 1A Intervention and spend summary.

Intervention	Total Volume in RIIO-GT3	Total spend in RIIO-GT3 (£m, 2023/24)
Bolted/Flanged NRV overhaul	[redacted]	2.86
Welded/Buried NRV Overhauls	[redacted]	3.32
NRV replacement	[redacted]	2.08
Replace Regulator Stream (Single)	[redacted]	32.09
Replace FCV Stream (Single)	[redacted]	13.84
Fuel Gas/Domestic Gas Supply Pressure Regulator Skid Replacement	[redacted]	2.51
Replacement of Multistage Pressure Reduction Skid	[redacted]	3.86
Replace Regulator Stream PCV/FCV (Single)	[redacted]	4.20
Rye House Redundant Asset Decom	[redacted]	0.18
Moffat Redundant Asset Decom	[redacted]	0.21
Brigg Redundant Asset Decom	[redacted]	0.77
Actuator Control Replacement	[redacted]	3.62
Stem seal replacement	[redacted]	1.83
Tighten/ Adjust Stem Seals	[redacted]	1.16
Sealant Port Adaption	[redacted]	0.87
Vent & sealant line replacement	[redacted]	1.71
Replace plug valve with double block and bleed valve	[redacted]	3.16
Pipethrough of block valve site	[redacted]	2.57
Pipethrough of single valve on a site (uncongested)	[redacted]	9.76
Valve strip and condition assessment	[redacted]	1.82
Valve spares	[redacted]	1.36
Block Valve Replacement	[redacted]	26.66
Block Valve modification after pits have been broken out	[redacted]	1.31
Overpressure protection study and replacement of relief valve	[redacted]	5.94
Stopple & Bypass	[redacted]	19.55
HIPPS FEED Study	[redacted]	1.78
Installation of Terminal HIPPS	[redacted]	11.60
Removal of Valve 13 and flanging at Roudham Heath	[redacted]	0.14
Installing a new standard Valve Bypass Arrangement at Arbroath	[redacted]	0.31
Silk Willoughby Redundant Asset Decom	[redacted]	0.32
Aldfield Redundant Asset Decom	[redacted]	0.46
Alrewas Redundant Asset Decom	[redacted]	0.43

Carlisle Redundant Asset Decom	[redacted]	0.75
Thornton Curtis Redundant Asset Decom	[redacted]	0.30
Horndon Redundant Asset Decom	[redacted]	0.66
Bretford Redundant Asset Decom	[redacted]	0.40
Install bypass pipework	[redacted]	18.46
Modify bypass pipework	[redacted]	59.46
Bottom-up volumes total	[redacted]	**242.32**
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.26
Actuator Replacement	[redacted]	13.44
Actuator Overhaul	[redacted]	0.15
Valve Replacement	[redacted]	29.76
Valve Overhaul	[redacted]	0.41
Total	**2437**	**286.33**

Option 2: Additional 10% Risk Reduction

9.2.8 In this option we have utilised our Copperleaf Portfolio optimisation tool to achieve a 10% additional monetised risk reduction by the end of the RIIO-GT3 period. Copperleaf has selected the most cost-effective investments to meet the lower risk constraint.

9.2.9 The total spend of proposed interventions in this option is £560.0m (2023/24), addressing known and forecast defects. This option has greater spend than option 1 as the model has to work harder to achieve benefit on assets that provide less benefit than those selected in Option 1.

Table 17: Option 2 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	[redacted]	313.26
Actuator Overhaul	[redacted]	0.73
Actuator Replacement	[redacted]	29.44
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.02
Replace Individual Regulator	[redacted]	0.18
Valve Overhaul	[redacted]	21.55
Valve Replacement	[redacted]	194.82
Total	**3856**	**560.01**

Option 3: Lowest Whole Life Cost (WLC)

9.2.10 In this option, we applied optimisation to select interventions with the lowest WLC. Copperleaf identifies the most beneficial interventions, and no investment is selected if the cost exceeds the asset's lifetime benefit, as per the NARMS methodology. None of our service risk measures (Availability & Reliability, Safety, Environmental, Societal and Transport) have an outcome constraint applied.

9.2.11 The total spend of proposed interventions in this option is £680.3m (2023/24). In this option PA has made a decision to intervene on any asset where the cost is outweighed by the benefit no matter how small the margin. While generally it will reduce risk more over the life of the asset, it may make decisions that are not possible i.e., trying to do too much work.

Table 18: Option 3 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	2.70
Actuator Replacement	[redacted]	63.36
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.26
Replace Individual Regulator	[redacted]	5.24
Valve Overhaul	[redacted]	0.82
Valve Replacement	[redacted]	294.67
Total	**4844**	**680.30**

Option 4: Availability and Reliability Risk Stable to RIIO-T2 Start

9.2.12 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain our availability and reliability service risk measure to achieve a stable risk at the end of RIIO-GT3 to the start of RIIO-T2. No other service risk measures have been constrained.

9.2.13 The total spend of proposed interventions in this option is £655.6m (2023/24).

Table 19: Option 4 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	2.70
Actuator Replacement	[redacted]	58.94
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.27
Replace Individual Regulator	[redacted]	5.05
Valve Overhaul	[redacted]	45.36
Valve Replacement	[redacted]	230.00
Total	**4755**	**655.60**

Option 5: Health and Safety Risk Stable to RIIO-T2 Start

9.2.14 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain our health and safety service risk measure to achieve a stable risk at the end of RIIO-GT3 to the start of RIIO-T2. No other service risk measures have been constrained.

9.2.15 The total spend of proposed interventions in this option is £547.5m (2023/24).

Table 20: Option 5 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	2.51
Actuator Replacement	[redacted]	44.45
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.24
Replace Individual Regulator	[redacted]	2.39
Valve Overhaul	[redacted]	19.29
Valve Replacement	[redacted]	165.33
Total	**4124**	**547.48**

Option 6: Environmental Risk Stable to RIIO-T2 Start

9.2.16 In this option we have utilised our Copperleaf Portfolio optimisation tool to constrain our environmental service risk measure to achieve a stable risk at the end of RIIO-GT3 to the start of RIIO-T2. No other service risk measures have been constrained.

9.2.17 The total spend of proposed interventions in this option is £655.5m (2023/24).

Table 21: Option 6 Summary (£m, 2023/24)

Intervention	Volumes	RIIO-GT3 Value (£m, 2023/24)
Bottom-up interventions	2535	313.26
Actuator Overhaul	[redacted]	2.70
Actuator Replacement	[redacted]	58.94
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.19
Replace Individual Regulator	[redacted]	5.05
Valve Overhaul	[redacted]	45.36
Valve Replacement	[redacted]	230.00
Total	**4745**	**655.51**

9.3 Option Summary

9.3.1 Table 22 shows the technical summary table comparing Options 0 to 6.

Table 22: Portfolio Options Technical Summary table

Option	First Year of Spend	Final Year of Spend	Total Volume of Interventions	Investment Design Life	% of Assets intervened on	Total Spend Request (£m 2023/24)
Option 0: Counterfactual (Do Nothing)	FY25	FY32	N/A	N/A	0	0
Option 1: Total Monetised Risk Stable to RIIO-T2 start	FY25	FY32	3769	0 – 30 years	15.0	541.04
Option 1A: Post Deliverability	FY25	FY32	2437	0 – 30 years	9.8	286.33
Option 2: Additional 10% Risk Reduction	FY25	FY32	3856	0 – 30 years	15.4	560.01
Option 3: Lowest WLC	FY25	FY32	4844	0 – 30 years	19.4	680.30
Option 4: Availability and Reliability Risk Stable to RIIO-T2 start	FY25	FY32	4755	0 – 30 years	19.0	655.60
Option 5: Health and Safety Risk Stable to RIIO-T2 start	FY25	FY32	4124	0 – 30 years	16.5	547.48
Option 6: Environmental Risk Stable to RIIO-T2 start	FY25	FY32	4745	0 – 30 years	19.0	655.51

10 Business Case Outline and Discussion

10.1 Key Business Case Drivers Description

10.1.1 Valve assets (Valves, NRVs, Actuators, Pressure and Flow Control Valves and Valve Bypasses) deteriorate over time and with use. This in turn prevents them from performing their required functions and can also result in them no longer complying with current and future legislative requirements.

10.1.2 Therefore, in developing our desired outcomes we have considered the impact of the following drivers for investment on valve assets:

- Legislation requirements
- Asset deterioration, linked to our ageing asset base and asset type.
- Change of operational requirement (redundancy)
- Obsolescence
- Health and safety
- Decommission and remove assets that are no longer required to manage overall whole life cost and risk.
- Reducing the environmental risk of emissions

10.1.3 Managing the number of defects that are being raised on our assets is important in ensuring they continue to deliver the required network capability. Our proposed investment in the valve assets will ensure that we maintain an appropriate level of risk across all these outcomes. In developing our plans and making our decision we have been fully cognisant of the need to develop plans that are value for money, acceptable, affordable, and deliverable, whilst achieving a suitable level of risk of our aging assets.

10.2 Business Case Summary

10.2.1 In considering the most effective combination of efficient interventions, we have challenged whether our preferred programme of investments is the most cost-beneficial by carrying out a full cost benefit analysis (CBA) utilising our Copperleaf Portfolio Optimisation tool.

10.2.2 Only interventions assigned to an asset have been assessed in the CBA because no benefits can be applied to interventions that are assigned to various locations (i.e., Based on forecast defects).

10.2.3 A variety of technical interventions have been considered and combined to create a range of CBA options, the results of which are presented in Table 23.

Table 23: Option summary of headline business case metrics (£, 2023/24)

Option	Total Volume of Interventions	Total Spend Request (£m)	Outcome Risk End of RIIO-GT3	% change in comparison to start of RIIO-T2	PV Benefit	PV Cost (£m)	NPV (£m)	Payback Period from 2031	% change in service risk measures compared to start of RIIO–T2				
									Financial	Availability / Reliability	Environmental	Health and safety	Societal
Option 0: Counterfactual (Do Nothing)	0	0	19.12	134.20	N/A	N/A	N/A	N/A	97.01	170.00	113.83	167.86	176.51
Option 1: Total Monetised Risk Stable to RIIO-T2 start	3769	541.04	13.39	94.01	160.20	521.01	360.81	Does not payback in the period	90.99	148.60	105.62	81.22	117.76
Option 1A: Post Deliverability	2437	286.33	16.66	115.96	97.57	275.73	178.16	Does not payback in the period	92.73	160.35	108.10	131.96	145.71
Option 2: Additional 10% Risk Reduction	3856	560.01	12.61	88.48	178.93	539.27	360.34	Does not payback in the period	90.84	147.69	105.27	67.95	110.82
Option 3: Lowest WLC	4844	680.30	11.33	79.55	217.80	655.11	437.32	Does not payback in the period	89.51	95.47	103.16	54.27	75.64
Option 4: Availability and Reliability Risk Stable to RIIO-T2 start	4755	655.60	11.06	77.63	218.84	631.32	412.48	Does not payback in the period	89.32	94.56	102.27	50.11	74.53
Option 5: Health and Safety Risk Stable to RIIO-T2 start	4124	547.48	13.29	93.28	159.95	528.06	368.11	Does not payback in the period	90.05	94.90	103.46	90.81	75.55
Option 6: Environmental Risk Stable to RIIO-T2 start	4745	655.51	11.05	77.55	219.05	631.24	412.19	Does not payback in the period	89.32	94.56	102.01	50.11	74.53

10.2.4 In Figure 8, we have plotted the cumulative Payback period for different options presented in Table 23.

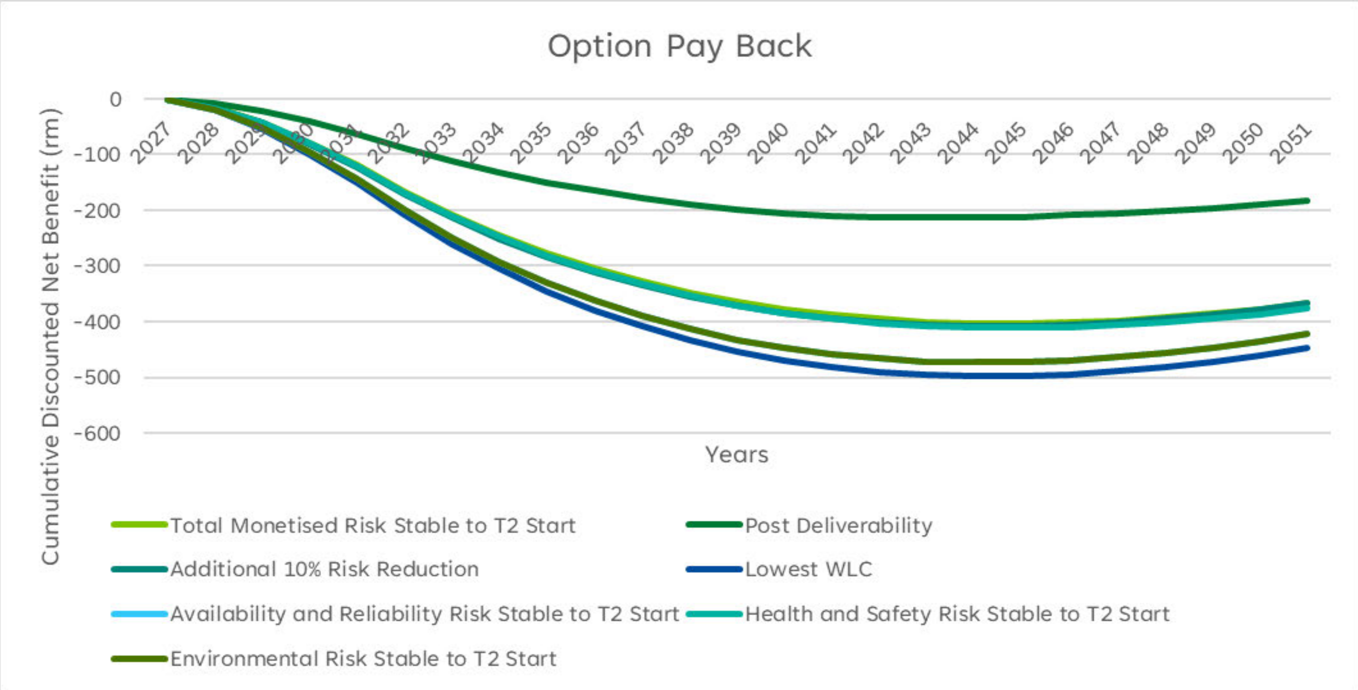

Figure 8: Cumulative payback period for all valves options

10.2.5 A variety of technical interventions have been considered and combined to create a range of CBA options, the results of which are presented in Figure 8 above. The graph illustrates the Net Present Value (NPV) of each option over a 20-year period, from 2031 (the end of RIIO-GT3), to 2051. As can be seen from the graph, Option 1A Post Deliverability shows the lowest net NPV, illustrating a greater benefit. Option 3 lowest WLC has the worst return of the options on offer. Options 4 and 6 are almost identical. The graph also shows that none of the options provide enough benefit from the investment being proposed to allow them to be paid back within the 20-year period.

10.2.6 Based on a combination of factors such as addressing known issues, maintaining network risk levels across valves assets, cost to consumer and deliverability of intervention volumes, Option 1A was selected to have the best balance of all factors. All other options will reduce overall risk compared to the start of RIIO-T2 but will come at a significantly higher cost, lower benefit and aren't deliverable due to constraints.

10.2.7 We are aware of the risk of choosing Option 1A as it doesn't meet our organisational objective of maintaining stable risk of our assets back to RIIO-T2 start but other options are not possible due to supply chain constraints identified in our deliverability assessment where only 40 valves per year and 80 actuators could be delivered. We will work with our suppliers to ensure more assets can be delivered in future price controls to prevent risk across valves assets increasing at an undesired rate. In the meantime, to mitigate this risk, internal groups will assess defects across valve assets based on severity, and short-term requirement for valves assets (i.e., if it's required for isolation to facilitate an outage) and those will be prioritised for remediation to prevent any incidents or delay to capital delivery of our plan. Interventions have been prioritised for defective valves and actuators involved in PSSR inline inspections (ILI) for pipelines to enable the valves to be able to seal during the ILI run to prevent deferring legislative work.

10.2.8 Option 1A does not pay back within the period. This is due to NARMs not capturing the full consequence of valves asset failures (valves, actuators, NRVs, PCVs / FCVs) and their intrinsic value to the network. It is also important to note that Option 1A majority of the interventions address known issues on a subset our assets.

11 Preferred Option and Project Plan

11.1 Preferred Option

11.1.1 Option 1 (Total Monetised Risk Stable to RIIO-T2 start) is our preferred option in an idealistic sense where all its intervention volumes are deliverable. Our programme of investment on valves has been taken through a deliverability assessment which assesses this programme of works against outputs across our entire capital investment plan. This results in a slightly adjusted Option 1A (Post Deliverability) which becomes the preferred option and includes the mixture of interventions listed in Table 16.

11.1.2 We have developed these investments both from engineering assessment of the identified problems but also through undertaking risk-based assessments using our Copperleaf asset management decision support tool, underpinned by our NARMS framework. This combined plan forms our preferred programme of work on our Valves assets (Valves, NRVs, Actuators, Pressure and Flow Control Valves and Valve Bypasses).

11.1.3 For actuators, our preferred option of interventions manages known obsolescence risks, addresses safety risks posed by our current assets, ensures legislative compliance, and manages rising levels of defects on these assets to ensure they can carry out their critical function of operating valves that isolate the network for planned and unplanned maintenance. Actuator interventions from our preferred option are shown in Table 24. Please see **NGT_IDP10_Portfolio EJP Valves_RIIO-GT3** for more information.

11.1.4 Actuator interventions proposed give a NARMs Long-Term Risk Benefit (LTRB) of £1.36m.

11.1.5 The plan is funded through baseline as volumes have been built using known defects and obsolescence issues on our actuator assets and costs have been estimated using outturn data from RIIO-T2 and bottom-up estimates. **NOTE:** There are no PA interventions for actuators in our preferred option as they all got removed as part of our deliverability assessment.

11.1.6 The outputs from this investment will be included in the Asset Health NARMs PCD reporting mechanism and cost variance managed through the TOTEX Incentive Mechanism (TIM).

Table 24: Actuators RIIO-GT3 preferred option summary (£m, 2023/24)

Intervention	Primary Driver	Volume	Unit of Measure	% Assets Intervened Upon	RIIO-GT3 Cost	Funding Mechanism	PCD Measure
Actuator Overhauls	Asset health (known defects)	[redacted]	Per Asset	[redacted]	0.15	Baseline – NARMS PCD	A1
Actuator Replacement	Asset health (known defects) and Obsolescence	[redacted]	Per Asset	[redacted]	13.44	Baseline – NARMS PCD	A1
Actuator Control Replacements	Asset health (known defects) and Obsolescence	[redacted]	Per Asset	[redacted]	3.62	Baseline – NARMS PCD	A1
Total		**271**	**Per Asset**	**3.9**	**17.20**	**Baseline**	

11.2 Asset Health Spend Profile

11.2.1 The below spend profile provides an indicative view on when the above interventions are to be carried out. More information is discussed in **Chapter 11.4**.

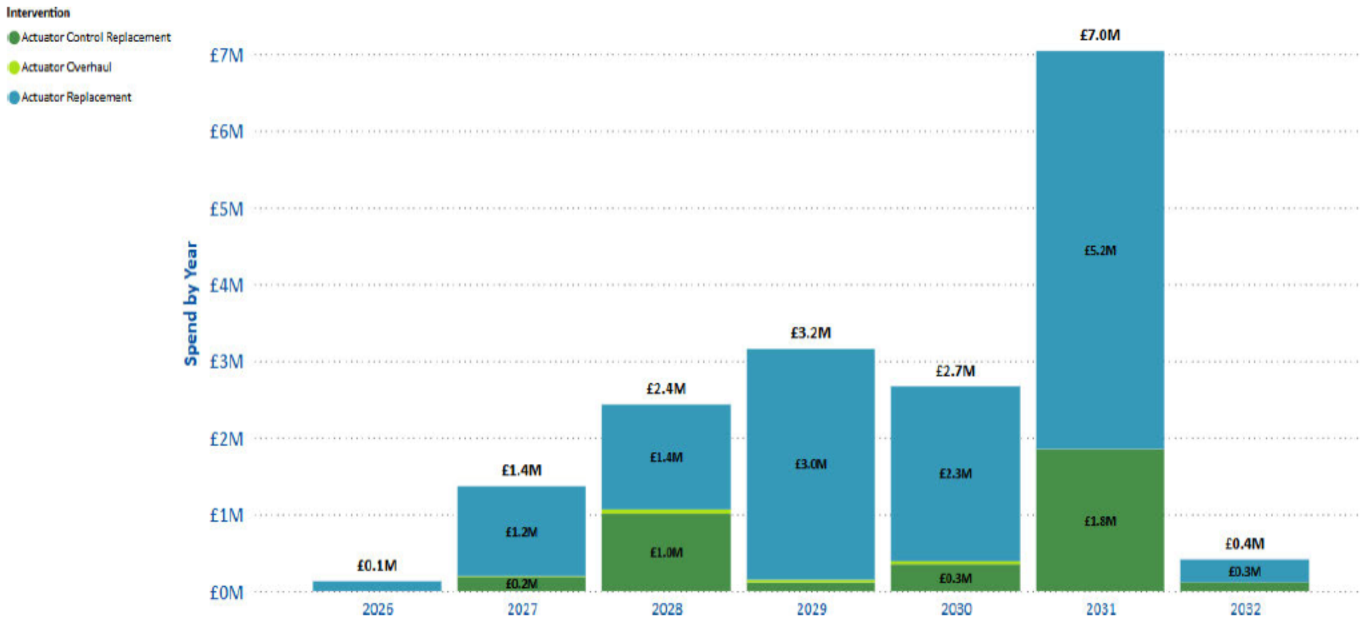

Figure 9: Actuators preferred option investment spend profile.

11.3 Investment Risk Discussion

11.3.1 The interventions scopes identified within this EJP are identified and understood. We have delivered similar scopes in RIIO-T2 for actuator replacements and actuator control replacements, and actuator overhauls were done in RIIO-T2 as OPEX.

11.3.2 Key risks and currently identified mitigations are summarised in Table 25 below.

Table 25: Actuator key risks and identified mitigations.

No.	Risk	Mitigation (based on current view)
1	There is a risk of additional site surveys, delaying the project and leading to additional costs.	Try to minimise number of surveys by getting multiple contractors to site for each aspect of works
2	There is a risk of increase to materials prices impacting project launch	Project team to work with Main works Contractor (MWC) to make sure that materials are procured in a timely manner and multiple quotes for materials from a number of supplies to ensure value for money
3	There is a risk of diluted operational resource support due to a number of concurrent projects running on site	Assessed through our deliverability assessment and shall be monitored through our plan delivery.
4	There is a risk of additional scope requirements (including electrical, design & civil) leading to scope change / scope creep	Close engagement with contractor and site operations, development of standard scopes to capture baseline requirements early in the development process.
5	There is a risk of outage issues (prior, during or post mobilisation)	Assessed through our deliverability assessment and shall be monitored through our plan delivery.
6	There is a risk of policy changes impacting upon project requirements	Close engagement with Safety Engineering to any upcoming specification updates.
7	There is a risk of unavailability / delayed delivery of long lead items, e.g., actuators	Frequent communication with Contractor to ensure that Long Lead Items are ordered,
8	There is a risk of lack of contractor availability	Engagement with the market has been undertaken through our deliverability assessment to understand where constrains may apply and factored into our investment planning.
9	Our costs have been built through unit cost analysis and estimates from the market, however there is a risk that costs of materials may increase due to macro-economic conditions and customer and stakeholder demand	This shall partly be mitigated through the CPI-H inflation and real price effect mechanisms within our RIIO-GT3 regulatory framework

11.4 Project Plan

11.4.1 Project delivery has been split into three phases which align with our Network Development Process (ND500) as shown in Table 26 below. Commissioning dates are not relevant to all intervention types but take place at the end of the delivery phase.

Table 26: Delivery phase alignment with ND500

Delivery Phase	ND500 Stage Gate(s)
Preparation	T0, T1, F1 (Scope establishment), T2, F2 (Option selection), T3, F3 (Conceptual Design Development, Long Lead Items Purchase), T4
Delivery	F4 (Execute Project), T5, Available for Commercial Load (ACL), T6
Close Out	F5 (Reconcile and Close)

11.4.2 Table 27 below shows the summary plan and provisional delivery phases for actuator related sanctions within RIIO-GT3. Internal stakeholder engagement has identified when we can obtain network access, where required, to complete these works. It has also identified who will deliver the work between our construction team and National Gas Services (NGS).

Table 27: Actuator Portfolio Programme for RIIO-GT3 period

Sanction	RIIO-T2		RIIO-GT3					RIIO-GT4
	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32
T3 Bacton Valves						Preparation	Delivery	Close Out
T3 Sites AGI Construction FY28			Preparation	Delivery	Close Out			
T3 Sites AGI Construction FY29				Preparation	Delivery	Close Out		
T3 Sites AGI Construction FY30					Preparation	Delivery	Close Out	
T3 Sites AGI Construction FY31						Preparation	Delivery	Close Out
T3 Sites AGI NGS FY27		Preparation	Delivery	Delivery	Delivery	Delivery	Close Out	
T3 Sites AGI NGS FY28			Preparation	Delivery	Close Out			
T3 Sites AGI NGS FY29				Preparation	Delivery	Close Out		
T3 Sites AGI NGS FY30					Preparation	Delivery	Close Out	
T3 Sites AGI NGS FY31						Preparation	Delivery	Close Out

11.4.3 Both actuators and actuator control packages are assets that have long lead times for delivery and therefore these assets have an extended preparation phase. The work has been profiled based on a deliverability assessment across the whole NGT plan. Actuator replacements and overhauls for defective actuators on critical valves involved in PSSR In-line inspections (ILI) for pipelines, have been prioritised to be carried out to enable the valves to operate effectively to enable the ILI run happen smoothly.

11.5 Key Business Risks and Opportunities

11.5.1 Changes to system operation or supply and demand scenarios is unlikely to impact upon the proposal in this EJP. Significant changes could mean that particular sites and assets become redundant which would remove the need for some interventions but in general, assets will still need to be maintained until the point of decommissioning.

11.5.2 Fast tracking of the transition to hydrogen within RIIO-GT3, would mean any pipelines and sites chosen to be repurposed for hydrogen transport, would require maintenance on key assets such as actuators before they are repurposed. This would mean any open defects could be remediated earlier than initially phased.

11.6 Outputs included in RIIO-T2 Plans

11.6.1 We have deviated away from our baseline plan as we substitute similar interventions in the plan e.g., RIIO-T2 plan may have had an actuator replacement scheduled at site A but may have not been completed at Site A and was completed at Site B. We are overall delivering our LTRB target and value of the workbook submitted is equivalent to our business plan.

- Taking additional time at the start of RIIO-T2 to land on the correct solution for specific interventions has been a key focus and although this does show a backloaded programme, it is substantially clearer in terms of the work scopes to be executed which will result in fewer delivery challenges.
- Outage challenges, access challenges that made it difficult to intervene on actuators appropriately.

11.6.2 In developing the revised delivery approach, a programme of works has been devised that is deliverable within the remaining RIIO-T2 period.

12 Appendices

12.1 Appendix 1 – Internals of an actuator control package, relevant actuator legislation and actuator failure modes

Internals of an actuator control package

12.1.1 See Figure 10 below for internals of an actuator control package.

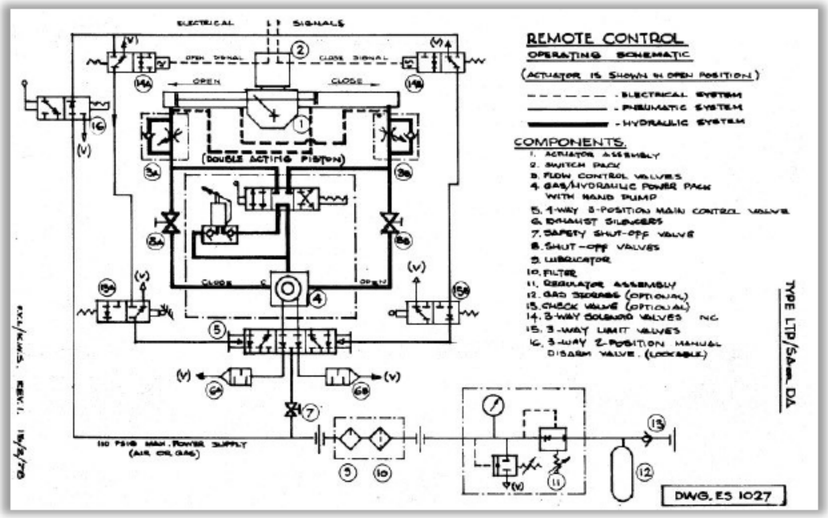

Figure 10: Internals of an actuator control package

Actuator PSSR requirements

12.1.2 **PSSR legislation** – There are severa[redacted] Rotary actuators (Gas Over Oil Actuators fitted with pressure vessels) and pressure relief valves installed within other types of actuators which fall within the remit of PSSR.

12.1.3 PSSR mandates periodic inspection of actuators to confirm sufficient mechanical integrity. Inspections are undertaken typically at yearly intervals for pressure relief valves and six yearly for the pressure vessels associated with the gas over oil actuators, this can be done more frequently if required by the inspector based on previous inspection results. Failure to comply with the requirements of the PSSR can result in a prohibition notice being served in cases where the condition of the asset is regarded as representing imminent danger.

Actuator DSEAR requirements

12.1.4 **DSEAR legislation –** Electrically powered actuators (whether directly or indirectly e.g., using electro-hydraulic actuators) or which have electrically powered components in their control systems fall under the remit of DSEAR. Typically, DSEAR related issues can be either inherent non-compliance in the original installation (DSEAR legislation only came out in 2002, some actuators that were installed before then wouldn't have been compliant with newest legislation) or a failure occurring because of deterioration or wear. Examples of deterioration related defects identified as part of DSEAR inspections include seized cable glands, adaptors, entry devices, seized termination lids. Many of the electrically powered actuators currently in service on the NTS cannot be shown to meet the requirements of DSEAR legislation and have had defects raised against them. DSEAR defects have been assessed as part of our plan development and investments have been included to address them.

12.1.5 All sites handling flammable or explosive materials are required to be divided into zones according to the risk of a flammable atmosphere being present. All electrical equipment used within a zoned area is required to be compliant with the applicable standards for design, installation, and maintenance for that zone. This is to ensure that the installations are maintained for satisfactory use within a hazardous area. If on testing a failure is found, then interventions will need to take place based on defined response criteria.

Actuator IEC61508 requirements

12.1.6 IEC61508 requires a Safety Integrity Level (SIL) to be determined based on the risks that the system is protecting against. It must be demonstrated that the system achieves the prescribed SIL based on component reliability, and it is then necessary to undertake regular proof tests to confirm that the system is functioning correctly and to undertake remedial action as necessary. ROVs and actuators that provide a safety related control function are subject to IEC 61508. We have committed to HSE and OFGEM that these valves will operate within 99% performance level i.e., less than 1% fail to operate upon instruction from GNCC.

Actuator detailed failure modes

12.1.7 If during routine maintenance, it is determined that the actuator does not operate correctly and may show signs of the following typical failure modes:

Gas / Hydraulic or Gas-Over-Oil actuators

- Gas passing internal seals of the actuator piston.
- Oil passing the internal seals of the actuator piston/vane.
- Manual hand pump failure
- Small bore pipework failure
- Corrosion i.e., internal cylinder, external cylinder tie bars

Electric actuators

- Relays, electric motor, or switch failure
- Drive shaft pin failure

12.1.8 Drive bush failure

DSEAR defects

- Seized cable glands, adaptors, entry devices.
- Seized termination lids (excessive painting/seized)
- Scratched flame paths.
- Unauthorised modification to equipment (invalidating certification)
- Uncertified equipment
- Unidentifiable equipment (unable to confirm certification)
- Damaged units

12.2 Appendix 2 – HSE [redacted] actuator removal mandate and NGT's response

12.2.1 Please see accompanying documents for more information:

- NGT HSE [redacted] actuator removal mandate 28.02.24
- NGT Response Pt1
- NGT Response Pt2

12.3 Appendix 3 – Actuator Interventions Cost Breakdown

12.3.1 Please see Table 28 below for actuator interventions cost breakdowns.

Table 28: Cost breakdown for Actuator Interventions

Intervention Name	External Cost	External %	NG Cost	NG %	Pre build Cost	Pre build %	Materials, Plant & Equipment cost	Materials, Plant & Equipment %	Risk & Contingency cost	Risk & Contingency (% of total cost)	RIIO-GT3 Unit cost (2023/24)
Actuator Control Replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Actuator Replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Actuator Overhaul	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

12.4 Appendix 4 – Bottom-up Interventions Considered in Every Option except 1A.

12.4.1 Table 29 below shows the bottom-up interventions in every CBA option considered except Option 1A.

Table 29: Bottom-up Intervention Volumes and Value

Intervention	Total Volume in RIIO-GT3	Total Spend in RIIO-GT3 (£m, 2023/24)
Bolted/Flanged NRV overhaul	[redacted]	2.86
Welded/Buried NRV Overhauls	[redacted]	3.32
NRV replacement	[redacted]	2.08
Replace Regulator Stream (Single)	[redacted]	32.09
Replace FCV Stream (Single)	[redacted]	13.84
Fuel Gas/Domestic Gas Supply Pressure Regulator Skid Replacement	[redacted]	2.51
Replacement of Multistage Pressure Reduction Skid	[redacted]	3.86
Pressure Regulator PSSR Inspection Remedial Works	[redacted]	0.26
Replace Regulator Stream PCV/FCV (Single)	[redacted]	4.20
[redacted] Redundant Asset Decom	[redacted]	0.18
[redacted] Redundant Asset Decom	[redacted]	0.21
[redacted] Redundant Asset Decom	[redacted]	0.77
Actuator Control Replacement	[redacted]	3.62
Actuator Replacement	[redacted]	19.43
Actuator Overhaul	[redacted]	0.15
Valve Replacement	[redacted]	28.95
Valve Overhaul	[redacted]	0.41
Stem seal replacement	[redacted]	1.83
Tighten/ Adjust Stem Seals	[redacted]	1.16
Sealant Port Adaption	[redacted]	0.87
Vent & sealant line replacement	[redacted]	1.71
Replace plug valve with double block and bleed valve	[redacted]	3.16
Pipethrough of block valve site	[redacted]	1.03
Pipethrough of single valve on a site (uncongested)	[redacted]	9.76
Valve strip and condition assessment	[redacted]	1.82
Valve spares	[redacted]	1.36
Block Valve Replacement	[redacted]	49.21
Block Valve modification after pits have been broken out	[redacted]	2.10

Stopple & Bypass	[redacted]	19.55
Overpressure protection study and replacement of relief valve	[redacted]	5.94
HIPPS FEED Study	[redacted]	1.78
Installation of Terminal HIPPS	[redacted]	11.60
Removal of [redacted]	[redacted]	0.14
Installing a new standard Valve Bypass Arrangement at Arbroath	[redacted]	0.31
[redacted] Redundant Asset Decom	[redacted]	0.32
[redacted] Redundant Asset Decom	[redacted]	0.46
[redacted] Redundant Asset Decom	[redacted]	0.43
[redacted] Redundant Asset Decom	[redacted]	0.75
[redacted] Redundant Asset Decom	[redacted]	0.30
[redacted] Redundant Asset Decom	[redacted]	0.66
[redacted] Redundant Asset Decom	[redacted]	0.40
Install bypass pipework	[redacted]	18.46
Modify bypass pipework	[redacted]	59.46
Total	**2535**	**313.26**