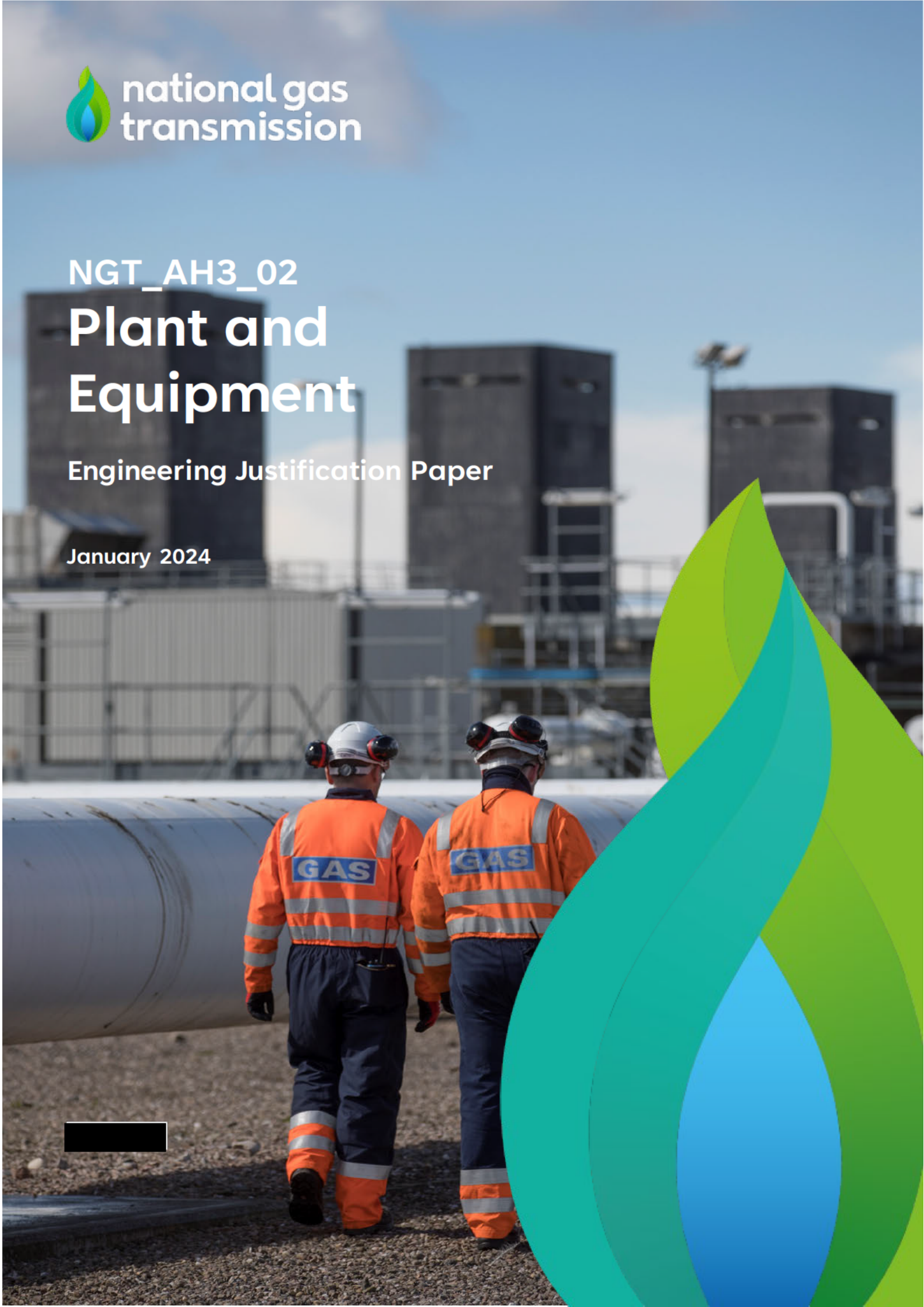
national gas transmission

NGT_AH3_02

Plant and Equipment

Engineering Justification Paper

January 2024



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Executive Summary

This Engineering Justification Paper (EJP) summarises the justification for the planned investment in selected National Gas Transmission's (NGT) Plant and Equipment Assets in RIIO-2 in line with the agreed Uncertainty Mechanism (UM) approach included in Ofgem's 2020 Final Determination (FD) of NGT's RIIO-2 business plan. It is submitted in accordance with the NTS Gas Transporter Licence Condition 3.14 Asset Health Re-opener, Price Control Deliverable Reporting Requirements and Methodology Document and RIIO-2 Re-opener Guidance and Application Requirements Document.

The total funding request being made through this paper is **£45.778m** comprising RIIO-2 interventions. The price base used throughout this document is 2018/19 unless otherwise specified.

The Plant and Equipment investment theme covers a wide range of primary assets that contain and control the gas flows at the Above Ground Installations on the NTS. These assets are covered by safety legislation and in many cases have been in operation for over their original design life which for some assets are in excess of 40 years.

The majority of Plant and Equipment assets deteriorate, resulting in poor performance which leads to further deterioration and eventually failure. The consequence of failure has varying impacts on availability, the environment, safety, and finance. Plant and Equipment asset failure can result in an inability to operate portions of the National Transmission System (NTS).

This investment is required now to ensure that NGT continue to provide a resilient network, undertaking the necessary continuous asset health interventions needed as the network matures.

If these assets are not operating effectively, they make the NTS unsafe and inoperable, leading to an increased risk to the availability of gas supply. This in turn leads to a network unable to meet customer needs.

The cost build for 2024/25 and 2025/26 Plant and Equipment related interventions has been primarily based on similar identifiable works completed in years one to three (2021/22, 2022/23 and 2023/24) of RIIO-2. All costs are based on appropriate site and asset specific scope comparative to completed and tendered works. Cost confidence and accuracy is based on outturn costs for activities completed with similar scope for years 4 and 5 interventions and rigorous build-up of costs.

Long Term Risk Benefit (LTRB) for the proposed interventions will be reported in FY24's NARMs RRP as part of the forecast position. The target rebasing for NGT is proposed to happen after Ofgem's final determinations across all three Asset Health re-opener submissions[1].

Key risks include additional scope requirements (including mechanical, design and civil) leading to scope change and/or scope creep, outage cancellation post mobilisation, and increase to materials prices impacting project launch. Key opportunities include bundling of works at each site or across sites and long lead procurement efficiencies through early bulk purchasing or utilising spares.

A key point of note in the submission is that for CP Systems on sites deemed as 'Complex' where the existing below ground CP Assets have high interaction levels, in all cases the preferred solution to remedy CP defects is aligned to installation of a new CP system. This is because fixing just the

[1] The rebasing will follow the process outlined in Special Condition 3.1, Part C: Rebasing of Baseline Network Risk Outputs.

defect(s) in isolation can sometimes lead to the advent of further CP issues and defects manifesting resulting in continued future issues. This is explained in more detail later in the paper.

The Plant and Equipment asset health programme is split across three broad sub-themes:

- **Above Ground Pipework, Cladding and CP Systems** – across RIIO-2 NGT is scheduled to complete interventions at circa 32% of the total number of locations within this subtheme.
- **Filters, Scrubbers and Preheaters** – across RIIO-2 NGT is scheduled to complete interventions at circa 15% of the total number of locations within this subtheme.
- **Pressure Reduction, Flow Control** – across RIIO-2 NGT is scheduled to complete interventions at circa 10% of the total number of locations within this subtheme.

The key drivers for investment across the three themes include, but are not limited to asset deterioration, obsolescence-resulting in increased operational risk impact on failure, asset performance, legislation, safety and environment have also been considered in generating works for RIIO-2.

Work planned under Pipework modifications - compressor surge issues ([redacted]) was completed at the end of RIIO-T1, requiring only a minor modification. We have therefore included the return of Baseline allowances in this submission.

The following table summarises the volumes of interventions, by UID, delivered in years 1 to 3 and those planned for years 4 and 5 of RIIO-2. The total cost across RIIO-2 associated with each UID is also summarised in the table. One St Fergus UID, included in this submission for true up, falls into the Above Ground Pipework, Cladding and CP Systems subtheme.

Subtheme	UID	Intervention	RIIO-2 UID Volumes			Total Costs (£m)
			Yrs.1-3 (Delivered)	Yrs.4&5 (Planned)	Total	
Above Ground Pipework, Cladding and CP Systems	[redacted]	Pipework Modifications Compressor surge issues	[redacted]			
		Pipework Modifications Minor Capex				
		AGI Pipework Painting (Full, Partial or Patch)				
		CM/4 Corrosion Defects Resolution				
		Replace Cladding on AGIs				
		Replacement of Failed IJs on AGIs				
		Resolve Existing AGI CP Priority 1 Defects				
		Resolve Existing AGI CP Priority 2 Defects				
Filters, Scrubbers and Preheaters		Filters PSSR Inspection & Major Overhauls				
		Replace Strainers with Filters/Separators				
		Scrubber & Condensate Tank Internal Inspections & Estimated Major Refurbs				
		Preheater AGI Boiler Replacement				
		Preheater Minor Refurb				
		Preheater PSSR Revalidation, WBH Inspection & Major Refurbs				
		Preheater Upgrade - Compressor Fuel Gas @ Wooler				

Subtheme	UID	Intervention	RIIO-2 UID Volumes			Total Costs (£m)
			Yrs.1-3 (Delivered)	Yrs.4&5 (Planned)	Total	
Pressure Reduction, Flow Control and Slamshut Systems	[redacted]	Pressure Reduction - Flow Control Valve Upgrade	[redacted]			
		Pressure Reduction Offtakes - Regulator Replacement				
		Pressure Reduction Skid Replacement - Compressor Stations				
		Pressure Reduction Streams - Major Overhauls				
		Pressure Reduction - Flow Control Valve Upgrade				
		Pressure Reduction Offtakes - Regulator Replacement				
		Pressure Reduction Skid Replacement - Compressor Stations				
		Pressure Reduction Streams - Minor Overhauls				
Totals (£m)			**460**	**605**	**1,065**	**114.305**

The total RIIO-2 forecasted spend is £114.305m as summarised in the following table. Baseline funding of £68.527m[2] was awarded. Therefore, though the total RIIO-2 spend is £114.305m the total funding request being made through this paper is £45.778m.

Description			**Totals (£m)**
Baseline Interventions (yrs. 1-3)	***Baseline Breakdown (£m)***		
	Actual spend	[redacted]	
	Awarded FD spend	*68.527*	
	Actual - Awarded	[redacted]	
Years 4&5interventions			[redacted]
Total RIIO-2 spend			114.305
Awarded baseline spend			**68.527**
Funding request being made through this paper			**45.778**

All works proposed under this submission have been reviewed and assessed with NGT delivery vehicles to ensure stable delivery within the remainder of the RIIO-T2 price control period.

[2] This includes Baseline allowances for two St Fergus UIDs, other Baseline allowances for Bacton and St Fergus under the Plant and Equipment theme are excluded. The treatment of those UIDs is described in section 6 of the Overarching Document (NGT_AH3_01).

1 Summary

Name of Scheme/Programme	Plant and Equipment
Primary Investment Driver	Asset Health
Scheme reference/ mechanism or category	[redacted]
Output references/type	Special Condition 3.1 Baseline Network Risk Outputs (NARMt and NARMAHt) Special Condition 3.14 Asset health Re-opener (AHt)
Cost (2018/19 price base)	Submitted cost of chosen scheme: Yr 1-3 interventions delivered through Baseline allowances - [redacted] Yr 4 interventions delivered through Baseline allowances - [redacted] Yr 4&5 interventions delivered through additional allowances requested (UM) - **£45.778m.**
Delivery Year	RIIO-2: FY22 – FY24 completed and inflight baseline funded interventions. FY25 – FY26 UM funded interventions.
Reporting Table	Costs and Output tables 6.3 and 6.4
Outputs included in RIIO T2 Business Plan	Yes

2 Introduction

2.1.1 This paper seeks to agree volumes and unit costs for works completed, and in flight, in years 1 to 3 and proposed for years 4 and 5 following assessment of internal defects data and independently externally conducted condition assessment site surveys.

2.1.2 Most Plant and Equipment related asset health investments at St Fergus have been subject to previous uncertainty mechanism submissions, which are detailed in the Overarching Document (NGT_AH3_01) and are not included in this EJP. For two UIDs at St Fergus, true up has been requested as part of this submission, which have been included within this EJP.

2.1.3 This document summarises the justification for the required investment in National Gas Transmission's (NGT) Plant and Equipment assets for works planned for 2024/25 and 2025/26 as part of the Uncertainty Mechanism. This programme of works is underpinned by NGT's completed and ongoing funded works covering the period of 2021/22 to 2023/24. The purpose of **Plant and Equipment** infrastructure is to:

- **Above Ground Pipework, Cladding and Cathodic Protection** - contain natural gas flow and conduct it under pressure between processes, flow control, pressure control, gas quality, compression, metering, scrubbers and pipework inspection equipment, mitigate noise, provide thermal insulation, provide protection to personnel. Cathodic Protection does not work on above ground pipework. In terms of AGIs, some are above ground, but other elements of the 'AGI' are also below ground. CP provides the secondary corrosion protection to below ground assets.

- **Filters, scrubbers and Preheaters -** remove dust, debris and liquids from the gas flow. They provide protection to pressure reduction, flow control equipment or compression plant and regulate temperature of gas during the pressure reduction process.

- **Pressure Reduction, Flow Control and Slamshut Systems** - to allow control of gas pressure/flow characteristics from the NTS pressure to that required for use by customers, actuation of valves or to provide fuel gas to compressors.

2.1.4 The interventions completed and/or proposed for years 1 to 5 have been generated based on specific known issues identified through outputs of proactive surveys, asset management, routine maintenance, and ongoing asset health intervention programmes. Key drivers, not limited to legislation, safety and environment have also been considered in generating works for RIIO-2.

2.1.5 NGT's 2019 business plan submission was a request for the full five years of RIIO-2 funding. However, in their Final Determination of December 2020, Ofgem awarded baseline funding for years 1 to 3 and applied an Uncertainty Mechanism to years 4 and 5.

2.1.6 It was agreed that intervention volumes for the whole of the RIIO-2 period shall be set at the point of the re-opener, by which time NGT must have a clear understanding of the work required to address the asset health of the Plant and Equipment assets requiring intervention in RIIO-2. A 60% baseline allowance, covering activities in years 1, 2 and 3 of RIIO-2, was allowed to enable NGT to achieve this. Activities and costs for years 4 and 5 are subject to the UM and dependent on outputs of completed and forecast work, including surveys and prioritisation of works for years 4 and 5.

2.1.7 The three main subthemes being assessed are (i) Above Ground Pipework, Cladding and Cathodic Protection (CP) systems, (ii) Filters, Scrubbers and Preheaters, and (iii) Pressure Reduction, Flow Control and Slamshut Systems.

2.1.8 In addition, there are specific targeted projects/investments that fall within either one, or more, of the subthemes and UIDs included within this submission. These are new projects not included in the funding awarded through the RIIO-2 Final Determination but during the course of RIIO-2 have been added to the Plant and Equipment theme:

- **King's Lynn Multi Junction (MJ)** – investment required to remediate identified asset health issues at the multi junction. Defects, needing remediation, at the MJ were identified as part of the initial Final Determination subsidence study which revealed that subsidence was no longer a driver at the site.[3] However, it was recognised that there were other asset health issues that needed resolving at the site. Therefore, within the remit of the existing RIIO-2 works, specific Plant and Equipment surveys were conducted to identify the necessary asset health interventions to remediate the defects.

2.1.9 This report is submitted in accordance with the NTS Gas Transporter Licence Condition 3.14 Asset Health Re-opener, Price Control Deliverable Reporting Requirements and Methodology Document and RIIO-2 Re-opener Guidance and Application Requirements Document. Appendix 6 of the Overarching Document submitted alongside this EJP provides mapping to those requirements.

[3] Re-opener submission to return unused Baseline allowances has been submitted to Ofgem in March 2022.

2.1.10 In RRP23 NGT advised that whilst good progress had been made so far in RIIO-T2, for some of our price control deliverables notably asset health / Plant and Equipment, we have delivered lower volumes of works than anticipated. This has been due to a number of factors including global supply chain challenges influencing availability and procurement of critical materials (for example with regards to asset health, current global economic conditions have increased lead times for valves to 52 weeks a 50% increase on pre-COVID times), a shortage of skilled labour available in the market and the need to defer some of our 2022/23 programme of works due to high summer flows resulting in reduced access to the network to take outages. Despite these challenges, we have taken positive steps to accelerate delivery, implementing a change to the delivery strategy to increase the portion of the asset health interventions that can be delivered by inhouse resources and expanding our team through the recruitment of additional project engineers, project managers, and work supervisors. This, combined with the strategic planning we undertook in the first year of the price control, means we are overcoming these challenges and continue to ramp up delivery for the remainder of the price control.

2.1.11 Taking additional time at the start of the regulatory period 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 scope to be executed which will result in fewer delivery challenges.

2.1.12 All works and volumes proposed under the UM to take the theme to the end of the RIIO-T2 period have been stress tested with delivery teams to ensure that works are manageable and will execute to completion within the remaining regulatory period. This activity included removing items from scope that did not have all pre-requisite criteria in place such as outages, design work started, and resources allocated to execute the works within the period.

2.1.13 As part of a final check prior to submission the final volume count was assessed in line with all other RIIO T2 deliverables via the Uncertainty Mechanism government meetings which draws in heads of delivery for both NGT Construction and Operations teams executing the work.

2.1.14 Specific ramp up in delivery is shown in years 4 & 5 with volumes being discussed in detail later in the EJP but at summary level some key points to note regarding assets where there is a step change in the volume to be achieved are:

2.1.15 Pipework Coating – In years 1 to 3 NGT have delivered [redacted] volumes of AGI pipework painting with this number steadily rising across Financial year FY22' to 24' year on year. As we have picked up momentum in delivery we have stabilised to a point where the work is known, scoped and detailed and this sees us completing RIIO T2 with an additional [redacted] volumes with [redacted] in both years 4 and 5 respectively.

2.1.16 Insulation Joints (IJs) – It is noted that in the first 3 years of RIIO T2 NGT have delivered [redacted] volume interventions and then in the remainder of the Regulatory this ramped up considerably to a total of [redacted] in the remaining 2 years. Whilst this may look like a challenging ramp up this is because during the production of the year 4 and 5 plan, the approach taken has been to optimise outage windows and techniques making sure that as much work as possible to drive efficiencies and maximise the opportunity.

2.1.17 CM4 Corrosion defects – similar to the work associated with IJs works have been scheduled to maximise access to complete more volumes within an efficient window which is driving a step change between years 1 to 3 and 4/5. This is also shown in terms of a list of defects that would need to be addressed and worked on within the regulatory period.

2.1.18 In summary, the RIIO T2 overall workload request for this re-opener (£114.305m) submission is approximately ~27% lower than what was initially requested in RIIO T2 overall [redacted] lower than the original [redacted] request. This is the product of the stress test to ensure only work that can be delivered is taken forward in the remaining time for RIIO 2. A reduced overall delivery compared to RIIO T2 Business plan submission also supports that where NGT have taken more time to develop a final solution, in some cases for example pressure reduction and cathodic protection works this has allowed NGT to land on a bundle of work that can be liquidated and achieved in the remaining RIIO T2 period with items that can't be achieved and moved to delivery in the early part of RIIO-T3.

3 Equipment Summary

3.1 Overall Plant and Equipment Summary

3.1.1 The investment case for Plant and Equipment is organised into three groups:

- **Above Ground Pipework, Cladding and Cathodic Protection (CP)** – these assets comprise pipework and associated assets on NGT sites. **Pipework** enables the flow of gas onto, around and away from the site. Pipework is protected by a coating which provides the primary protection against corrosion. **Pipe Cladding** is installed on pipework to mitigate noise and to provide thermal insulation to maintain the temperature of the gas in the pipework. It is also used to protect NG staff from coming into contact with hot pipeline surfaces. **Cathodic Protection** provides corrosion protection for any buried pipework or other buried steel structural site elements where the primary barrier coating has failed.
- **Pressure Reduction, Flow Control and Slamshut Systems** – these assets control the pressure and flow of gas and provide protection for over pressurisation. **Pressure Reduction** assets reduce the pressure of the gas from full NTS pressure to that required for use by customers, actuation of valves or to provide fuel gas to compressors. Flow Control Valves allow Gas Network Control Centre (GNCC) to remotely control the flow of gas and pressure between two or more sections of pipeline. Slamshuts are automatic devices which protect the pipe work and other assets from over pressure failure.
- **Filters, Scrubbers and Preheaters** – these assets condition the gas ready for use by NGT, customers and transmission on the NTS**. Filters, Scrubbers and Strainers** are placed within the gas flow at points on the site to remove dust, debris and liquid from the high-pressure gas flow and protect key items of operational plant. **Preheaters** preheat the gas prior to pressure reduction to prevent condensation and the subsequent liquids entering items of plant or being transmitted through the NTS.

3.2 Above Ground Pipework, Cladding and Cathodic Protection (CP) Systems – Equipment Summary

3.2.1 The purpose of above ground pipe is to contain natural gas flow and conduct it under pressure between process, flow-control, pressure control, gas quality, compression, metering, scrubbers and Pipework inspection equipment.

3.2.2 Above ground pipework consists of:

- General Pipework.
- Risers.
- Flanges.
- Insulation Joints.
- Pipe Supports (Corrosion at interface with pipeline and under the pipe support). Pipe Supports Asset Health Interventions are primarily funded through the interventions within the Civil theme, not within scope of the reopener.

- Pit Wall Transitions (Corrosion at interface with pipeline/pipework and the Pit Wall Transitions).
- Cladding.
- Vent and Sealant (Funding was provided in RIIO2 for this area under the valve theme).

3.2.3 Pipework coating provides a barrier between the parent pipework and its environment to prevent corrosion from occurring. Corrosion has been highlighted as being the single biggest life limiting mechanism affecting the NTS.

3.2.4 Pipework is also designed to allow access to associated assets (e.g., valves), for operation and maintenance.

Above Ground Pipework, Cladding and CP Systems – Location and Volume

3.2.5 Above ground pipework is present on a total of [redacted] sites, [redacted] Compressor Stations, [redacted] Multi-Junctions, [redacted] Entry Points, [redacted] Exit Points and [redacted] Block Valves. The majority are at diameters ranging from 50 mm to 1,200 mm. Of the total number of locations within this subtheme, that NG operates, circa [redacted] sites have identified as needing intervention in RIIO-2 representing roughly [redacted] of total locations.

Above Ground Pipework, Cladding and CP Systems – Pressure Ratings

3.2.6 The above ground pipework operates at a range of pressures up to and including the full pressure of the NTS, which is 70 to 94 bar. Within AGIs and Compressors there is some further breakdown of pressures for other site equipment operations. CP systems protection is for all buried metallic assets and includes assets such as, but not limited to, fuel gas lines and fire water mains. CP systems include insulation joints, transformer rectifiers, test posts and ground beds.

Above Ground Pipework, Cladding and CP Systems – Redundancy

3.2.7 Where an area of cladding is removed or becomes damaged or compromised e.g., acoustic cladding becoming wet it ceases to be able to be able to fulfil its primary purpose. As a result of this there is no inbuilt redundancy within the system.

3.2.8 Redundancy depends on the specific process equipment that is conveying gas to e.g., multi stream regulators, filters, scrubbers, modular boilers etc and where any defect is situated in relation to a valves to be able to achieve an effective gas tight isolation. The range of pipework can vary from <50mm to 1220mm>.

3.2.9 Depending on the configuration of pipework on site it may be possible to isolate pipework with little or no impact on the operational capability of the site or a specific process. Some pipework configurations are designed for 100% redundancy to allow access to associated assets (e.g., valves), whilst ensuring effective operation of the site can continue during maintenance. Across AGIs redundancy varies based on design function, Multijunction and compressors site have inbuilt redundancy through the ability to manage flows whereas single purpose sites such as pig traps and minimum connection offtakes have little to no redundancy.

3.2.10 Above ground pipework coating does not in itself have any inherent/inbuilt redundancy; however, where the coating becomes compromised it will not result in an immediate failure. Once the coating has failed, corrosion will occur and without repair this will continue until there is a loss of containment. Where the coated pipework is routed below ground the effective application of cathodic protection will continue to provide protection until the extent of the defect surface area in contact with the electrolyte eventually becomes too large to protect (see paragraph 3.2.11 Cathodic Protection).

3.2.11 Cathodic Protection systems are designed with an assumed current density requirement to protect an assumed initial starting point for coating system breakdown and allowance for the gradual degradation of the external coating system over time, the initiation of further defects and an increase in current loads, as a result of changes occurring during the operation of the asset over a given time period (typically 40 years) is also factored into the system design. This will see the CP system designed with a 100% allowance/redundancy from the starting current density; however, this is predicated on the assumption that the breakdown in coating and increase in current density is linear over the design life meaning that were large coating defects or current drains are introduced locally the distribution of current may not provide effective protection.

3.2.12 The purpose of insultation joints is to create an electrical discontinuity so that CP can be applied to discrete pipeline or pipework ensuring the manageable application of CP current. IJs are discrete assets and are not designed or installed with any redundancy.

3.3 Filters, Scrubbers and Preheaters – Equipment Summary

3.3.1 The purpose of filters and scrubbers is to remove dust, debris and liquids from the gas flow. They provide protection to pressure reduction, flow control equipment or compression plant. Asset types include:

- Coalescing filters and filter vessels
- Scrubbers and the associated condensate tank
- Strainers.

3.3.2 The purpose of the preheater assets is to regulate temperature of gas during the pressure reduction process. Natural gas when it is reduced in pressure expands and cools. This temperature cooling is known as the Joules Thomson effect. Depending on the level of pressure reduction there may be a requirement to pre-heat the gas to avoid unacceptable low temperatures that could affect the integrity of the pipework, plant & equipment downstream of the Pressure Reduction Installation (PRI). Preheating operates in predominantly in the following key areas:

- Offtakes (in conjunction with Regulators)
- Compressor Unit fuel gas heating.

Filters, Scrubbers and Preheaters – Location and Volume

3.3.3 There are [redacted] Filters, [redacted] Scrubbers and [redacted] Strainers installed at [redacted] sites on the NTS. Of the total number of locations within this subtheme that NG operates, circa [redacted] locations have been identified as needing interventions in RIIO-2 representing roughly [redacted] of total locations.

Filters, Scrubbers and Preheaters – Pressure Ratings

3.3.4 The assets operate at the following maximum pressures:

- Coalescing filters and filter vessels - 94 bar.
- Scrubbers and the associated condensate tank - 94 bar.
- Strainers - 94 bar.

3.3.5 All the assets normally operate in the range 39 to 94 bar.

Filters, Scrubbers and Preheaters – Redundancy

3.3.6 Coalescing filter and filter vessels are designed to function with the full design flow allowing for one unit out of service. Where filters are used to protect downstream processes; supplementary equipment filters may also be installed.

3.3.7 Scrubbers are instrumented with liquid level detection devices, which will close the scrubber inlet valve to prevent liquid carry over. Where there is no valid flow path due to tripped offline scrubbers, partial or full compression capacity cannot be reinstated until a valid gas path is re-established. Reinstating Scrubbers require the liquids to be drained away, condensation tanks are designed to store the liquids prior to disposal.

3.3.8 Modular Boiler Systems with Heat Exchangers or systems with waterbath heaters are installed in an N+1 configuration. Where “N” equals the number of boiler modules or waterbath heaters required giving the system redundancy and to facilitate maintenance.

3.4 Pressure Reduction, Flow Control and Slamshut Systems – Equipment Summary

3.4.1 The purpose of flow or pressure regulation is to allow control of gas pressure/flow characteristics from the NTS pressure to that required for use by customers, actuation of valves or to provide fuel gas to compressors.

3.4.2 A Flow Control Valve allows GNCC to remotely control the flow of gas and pressure between two or more sections of pipeline. In some circumstances this equipment is situated on a pressure boundary and depending on the pressure differential between the sections of pipeline there could also be a pressure control valve installed.

3.4.3 Pressure reduction streams are pneumatically operated installations and control the pressure between two different pressure tiers and their prime purpose is to control and regulate the pressure into the downstream pipeline or pipework.

3.4.4 Flow or Pressure Regulators can be divided as follows:

- Pressure or Flow Control Valves
- Pressure Regulator Stream
- Compressor Station pressure reduction.

3.4.5 Slamshuts are protective devices which automatically operate if the downstream pressure increases above the maximum operating pressure, to protect the downstream pipe work from over pressure failure. All Slamshuts operating in above 7 bar systems are covered by PSSR legislation. Slamshuts typically consist of:

- Associated valve vent and sealant pipework and fittings.
- Valve stem extension
- Valve operator (actuator) and associated fittings and actuating medium storage vessels.
- Actuating medium up to the point of isolation, including impulse pipework
- Controls cabinet inclusive of all contents e.g., Regulators, relief valves, pressure switches, solenoid valves etc.
- Instrumentations inherent with the actuations systems e.g., pressure transmitter, flow measurement, PLC, valve position switch etc.

Pressure Reduction, Flow Control and Slamshut Systems – Location and Volume

3.4.6 There are [redacted] flow control valves, [redacted] pressure control valves, [redacted] pressure Regulator streams on AGIs and [redacted] pressure Regulators on compressor stations. Of the circa [redacted] total number of locations within this subtheme that NGT operates, circa [redacted] locations have been identified as needing interventions in RIIO-2 representing roughly 10% of total locations.

Pressure Reduction, Flow Control and Slamshut Systems – Pressure Ratings

3.4.7 Pressure reduction and flow control assets operate predominantly NTS pressure, 70 to 94 bar but also have pressure Regulators that reduce pressure to low pressure.

3.4.8 Slamshuts operate in the range of approximately 10 mbar up to the full NTS pressure of 94 bar.

Pressure Reduction, Flow Control and Slamshut Systems – Redundancy

3.4.9 Pressure and control valves are configured as single streams. Where these have two or three streams in parallel this provides redundancy in the event of equipment failure.

3.4.10 Pressure reduction streams at industrial offtakes consist of paired streams with a working and standby stream configuration. In event of failure of the working stream the standby maintains supply.

4 Problem Statement

4.1 Problem Statement Overview

Above Ground Pipework, Cladding and CP Systems

4.1.1 Coating provides the corrosion protection for all above ground pipework. Various protections such as Fusion bonded epoxy, coal tar wrap, two-part epoxy and traditional paint systems are all commonly referred to as coating. Above ground coating has varying design life dependant on environmental conditions. For example, existing paint systems typically have an effective design life of 10 to 15 years. This can vary depending upon the environment that it is subjected to. Throughout the life of the coating, it will start to break down. As any coating system breaks down the resulting defects require inspection and localised repair. This may include remediation of the corrosion of the underlying pipework. The coating needs to be reapplied every 10 to 15 years (varied by local environment) to re-life it and ensure its continued effectiveness to protect the pipework asset.

4.1.2 Where coating systems break down, carbon steel pipework will corrode, and this is the predominant life limiting factor for the buried site pipework across the NTS as a whole. Coating provides primary corrosion prevention for all buried pipework with CP providing secondary protection where the coating is imperfect or has failed.

4.1.3 Coatings deteriorate with age and as this occurs, buried steel is exposed to its environment providing a situation where corrosion processes can occur. Unlike NTS pipelines, which can be internally inspected, presently there is no reliable method to provide the same level of integrity information for buried AGI pipework. Where coating defects occur, we are fully reliant on the CP system as the primary protection for buried steel pipework.

4.1.4 In parallel with the below ground pipelines the AGI CP systems are deteriorating. Many have reached the limits of their original life and design capacity and can no longer effectively protect the buried site pipework from the effects of coating degradation and the volume of defects present and occurring. In some instances, this could dictate that fixing several known defects within a system may provide immediate resolution to those issues, but still result in a system that is deficient to the need from that system.

Filters, Scrubbers and Preheaters

4.1.5 Filters, Strainers & Scrubbers (including Condensate Tanks) are installed on the NTS to remove debris, dust and liquids from the gas flow ensuring gas quality is to the required specification. These assets provide protection to both our assets and our customers downstream assets and equipment such as pressure regulators and flow control valves.

4.1.6 Filters and Scrubbers are subject to Pressure Systems Safety Regulations 2000 which are in place to prevent serious injury from the hazard of stored energy. Failure to comply with these regulations could lead to serious injury and/or prosecution.

4.1.7 Waterbath heaters are an aging asset, with increasing corrosion defects and they are very inefficient in operation. Localised control systems for burner and ignition control are obsolete and there have been instances of corrosion and loss of wall thickness on the gas coils. This internal degradation is only found during 12-yearly revalidations. There are operating issues due to the age of equipment. Waterbath heaters are often prone to reliability issues especially when normal operation is required usually during the winter period. Often at compressor stations the distance the pre-heated gas from the Waterbath heater must travel is too far, leading to excessive cooling of the gas.

4.1.8 Modular Boiler Systems and associated controls range from new installations to older ones in some cases containing obsolete parts. Some systems are towards the end of their expected life (15-20 years) and will start to encounter Programmable Logic Controller (PLC) issues along with material degradation of internal components. Numerous issues encountered throughout RIIO-1 were due to boilers coming to end of their life. Failures were associated with breakdown of boilers and inability to repair due to obsolescence, once one boiler in the package fails the others tend to follow shortly afterwards.

4.1.9 The assets deteriorate over time and with use which leads to their inability to perform their required function. This can also result in them no longer complying with other legislative requirements.

4.1.10 Heat Exchangers are an aging asset prone to corrosion related failure. There have been numerous heat exchanger failures that have led to further degradation of the heating system and other assets and defects that have only been identified during the PSSR Inspections such as loss of wall thickness on gas tubes.

Pressure Reduction, Flow Control and Slamshut Systems assets

4.1.11 Most pressure Regulators on the NTS used to reduce pressure to end users are the Engineering Research Station (ERS) High Pressure (HP) Regulator. These regulators were developed in the late 1980s/early 1990s specifically to suit the requirements of gas fired power station. Over the years the power station requirements have changed (increase or decrease in flow, increased ramp rates, noncontinuous running) and now in some instances the regulators suffer from performance issues including those related to mechanical vibration.

4.1.12 The ERS pressure regulation streams were originally designed by British [redacted] which sold the rights to [redacted] who have since ceased to support the Regulators. As such these Regulators are obsolete and only supported by a single engineering company, [redacted]. The obsolescence of these assets results in an increased restoration time, due to the challenge of implementing an effective spares strategy for obsolete assets. This can affect the ability to supply individual customers as well as the longer outage times impacting the overall resilience of the NTS.

4.1.13 The main issues NGT have experienced with the Flow Control Valves are associated with the failure of the dedicated localised 3-15 psi control systems. Also, NGT are experiencing pressure differentials across these valves which indicate that overhauls are required.

4.1.14 By the end of RIIO-3, circa [redacted] of the slam shut assets will be over 35 years old. The number of defects is rising and are predicted to continue to do so at an increasing rate. Some of the slam shuts do not operate when required to do so, others do not provide an effective seal.

4.1.15 In some cases, the time taken for the slam shuts to operate is insufficient to safely, and effectively, protect the downstream assets. This is either due to original design or degradation in performance. Some Slamshuts are an actuated ball valve which have a risk of downstream over pressurisation due to slow closure times. These assets are critical to safety under the IGEM/TD/13 standard and require replacing with fast acting slam shut valves to prevent downstream over pressurisation.

4.2 Asset Management Issues

Above Ground Pipework, Cladding and CP Systems

4.2.1 Along with fatigue, due to thermal and pressure cycling, corrosion is the single biggest life limiting factor for above ground pipework.

4.2.2 By the end of RIIO-3 over 77% of the above ground pipework will be over 50 years old with coatings being between 15 and 20 years old. NGT are experiencing and will continue to experience pipework corrosion including other related defects that need investment to remediate and prevent the associated consequences.

4.2.3 Coating on above ground pipework is managed through the asset life through CM/4 visual inspections with recoating of the pipework within a site occurring when the breaking down of this coating is observed. The other mitigation for corrosion on buried pipework is through ensuring our CP systems are operating effectively. The CP system is in place to prevent the corrosion at locations on the pipework where the coating has been compromised. To be effective, the CP system needs to maintain a defined polarised potential at the location which it needs to protect. As the coating ages and degrades the current requirement for effective CP protection increases.

4.2.4 AGI CP Systems are by their nature significantly more complex than pipeline systems making it very difficult to resolve discrete P1 and P2 features without affecting or influencing other areas of the site, or vice versa. AGIs are by their very nature considered to be complex CP environments and will include:

- Other buried metallic structures and steelwork on the site
- Shielding of the pipework by surrounding soft fill materials installed to allow the pipework to 'move' to reduce physical stresses placed on it.
- Shorting of the isolation joints that are in place to electrically separate the individual Pipeline CP systems from the site Pipework CP system where feeders enter a site.
- Degradation of specific elements of the CP system such as ground beds.

4.2.5 In the design process it is necessary to consider the performance of the AGI CP system as a whole to prevent the resolution of one defect resulting in non-compliance elsewhere.

4.2.6 As with the CP systems on pipelines, the protection of AGI CP system can, within limits, be balanced to compensate for some of these factors and in doing so maintain its protective capability. This is acceptable but has three limitations:

- Each CP system has a maximum capacity and range of influence in which it is effective based on the location of the anodes.
- Increasing the CP output excessively results in damage to the coating systems increasing their rate of degradation and reducing their effectiveness.

- Increasing CP output can lead to interaction with other buried metallic services and structures which can lead to accelerated corrosion events rather than reducing corrosion.

4.2.7 Most of the CP systems have been balanced as far as it is possible within their operating parameters. These systems need investment to ensure that they can continue to provide effective protection without presenting a further risk to coating integrity and buried site pipework corrosion. There remain additional complexities in protecting an arrangement of buried pipework rather than buried site linear pipeline.

4.2.8 As with other electrical assets elements of the CP system will deteriorate over time and through operation. As part of the overall CP system other elements are sacrificial, such as the ground beds; their deterioration is dependent upon the duty performed since installation. These issues are specifically prevalent on impressed current CP systems but still apply to some extent on the sacrificial systems.

4.2.9 As such the solutions being put forward in the submission is aligned to delivering a full CP system replacement which would create sufficient flexibility to minimise the risk of defects remaining after remediation and the application of localised current to discrete CP defects causing interaction, interference or over polarisation risks to other structures and pipework resulting in accelerated corrosion risks or coating damage.

4.2.10 Such an approach will ensure that a longer term and more robust management of risk can be maintained by creating the baseline CP design for the next 40-year operation from which to manage from.

Filters, Scrubbers and Preheaters

4.2.11 Asset health is normally determined during detailed examination when required under the Pressure Systems Safety Regulations (PSSR).

4.2.12 Filters require periodic cleaning or replacement to remove dust; which is classed as Hazardous Waste.

4.2.13 Life of the Process heat exchanger on a modular boiler package is in the 20–40-year bracket, the boilers themselves are more like 10-15 years, with some internal components (e.g., internal heat exchangers) having a life of up to 10 years.

4.2.14 Obsolete boilers, with limited spares available, remain in use.

4.2.15 Some of the equipment in gas pre-heating systems are subject to statutory inspection in accordance with the PSSR.

4.2.16 There is an element of uncertainty regarding the life expectancy of legacy offtake points. This uncertainty impacts on the choice of asset health interventions. Legacy offtakes are those where NGT provides pressure reduction and have all the associated equipment to do that process. Our annual engagement with our customers is used to gather this information however customers do not need to disclose this. Therefore, NGT needs to ensure assets are available to meet its contractual obligations with its customers.

Pressure Reduction, Flow Control and Slamshut Systems assets

4.2.17 This type of equipment generally has a mechanical asset life of between 20 to 40 years but may also be affected by obsolescence due to lack of OEM support and availability of spares and consumables.

4.2.18 Asset health issues, e.g., valves failing to seat correctly due to wear and contamination, are generally identified during condition assessments and through gas leak detection surveys.

4.3 The different drivers for intervention

4.3.1 The key drivers for investment in **Above Ground Pipework, Cladding and CP Systems** assets are:

- **Asset Deterioration** - pipework and its coating are subject to several deterioration mechanisms such as coating failure, reduction of wall thickness and internal corrosion. The pipeline asset deteriorates due to several mechanisms: (i) deterioration of the cladding followed by deterioration of the protective coating system; (ii) corrosion of the metal of the asset; (iii)accelerated corrosion in the form of Corrosion Under Corrosion.
- **Defects** - material, manufacturing or installation defects impacting the integrity of the pipework or its coating.
- **External Interference** - the pipework is subject to damage by external parties which reduces the structural integrity of the pipework resulting primarily from dents and metal loss. Ground movement on site can also lead to unacceptable stresses within the pipework potentially compromising the structural integrity.
- **Legislation -** inspection, maintenance and associated remediation is essential to enable their management as a pressure vessel thereby maintaining compliance with PSSR and PSR.
- **Operational** – such as pressure and temperature cycling fatigue, vibration, erosion, and abrasion all affect the integrity of pipework and coating.

4.3.2 The key drivers for investment in **Filters, Scrubbers and Preheaters** assets are:

- **Legislation – PSSR -** Except for strainers these assets are captured under the Pressure System Safety Regulations 2000 (PSSR) and the aim of these regulations is to prevent serious injury from the hazards of stored energy. Compliance with PSSR drives inspection and validation of the assets and associated remediation of any defects found. Heat Exchangers are captured under the Pressure System Safety Regulations 2000 (PSSR) and the aim of these regulations is to prevent serious injury from the hazards of stored energy. Compliance with PSSR drives inspection and

validation of the assets and associated remediation of any defects found. Waterbath Heaters and the modular boilers are not subject to PSSR.

- **Asset Deterioration -** The assets deteriorate over time and with use which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements. The elements of deterioration are: (i) deterioration of the coating; (ii) corrosion of the metal of the asset – both internal and external; (iii)fatigue due to pressure cycling or vibration.
- **Asset Performance -** Several pre-heating systems used for compressor fuel gas provide inadequate pre-heat to ensure that the gas quality entering the turbine on start-up is above the require hydrocarbon dew point. These pre-heating systems located too far away from the gas turbine, resulting in significant heat losses in the fuel gas supply.
- **Obsolescence -** there are several manufacturers/models of equipment that are approaching or exceeding their original design life and are now becoming obsolete. Some manufacturers are no longer trading others are no longer supporting or providing spares for some of the assets. Elements of some of the assets are obsolete and no longer supported by the manufacturers. The obsolescence of some of the assets can mean, despite a comprehensive spares' strategy, a risk of increased impact when they fail.
- **Customer Obligations -** At several offtakes managed by NG there is a contractual agreement to supply gas at a specific temperature to the end user.

4.3.3 The key drivers for investment in **Pressure Reduction, Flow Control and Slamshut Systems assets** are:

- **Legislation – PSSR -** These assets are included under the Pressure System Safety Regulations 2000 (PSSR) and the aim of these regulations is to prevent serious injury from the hazards of stored energy. Compliance with PSSR drives inspection and validation of the assets and associated remediation of any defects found.
- **Asset Deterioration -** The assets deteriorate over time and with use which leads to their inability to perform their required function. This can also result in them no longer complying with direct legislative requirements. The elements of deterioration are: (i) deterioration of the coating; (ii) corrosion of the metal of the asset – both internal and external; (iii) wear due to the duty in terms of number of on/off cycles; (iv)wear and tear; (v) age related failure of the control elements.
- **Obsolescence -** elements of some of the assets are obsolete and no longer supported by the manufacturers. The obsolescence of some of the assets can mean, despite a comprehensive spares' strategy, a risk of increased impact when they fail.

4.3.4 Lack of investment in remediating the defects on the above ground pipework coating will result in an increasing number of corrosion defects. The existing defects will continue to get worse and new defects will arise. Lack of investment in coating will further increase the amount of corrosion and the associated defects. Defects identified as having appreciable metal loss triggers a P11 process resulting in pressure restrictions and isolations in order to resolve the defects.

4.3.5 Unmanaged corrosion and unresolved defects will ultimately lead to loss of integrity of the above ground pipework, loss of containment of high-pressure gas, unacceptable safety risks, and therefore limit the availability or performance of the NTS as a whole.

4.3.6 Lack of investment in remediating the defects on the cladding will result in increased corrosion. The existing defects will continue to get worse and new defects will arise. As the cladding continues to deteriorate there is a potential increase in corrosion on the associated pipework.

4.3.7 While cladding itself does degrade over time, a significant concern is with the pipework associated with the cladding. Where the cladding is damaged water ingress occurs and increases corrosion risks for pipework while also concealing the visual evidence of potential corrosion damage.

4.3.8 Failure of the cladding could result in:

- Reduced noise mitigation leading to complaints, failure of environmental permits, and where installed, to regulate heat could lead to personal injury.
- Reduced gas temperature leading to reduced efficiency and/or corrosion of downstream equipment.

4.3.9 Lack of investment in the remediation of failures found during inspections will result in a rise in the number of cladding defects and associated pipe corrosion issues.

4.3.10 The performance of the CP system deteriorates over time which in turn leads to increasing corrosion of the buried site pipework. The integrity of the pipework must be maintained to enable continued use and compliance with PSSR and PSR.

4.3.11 Not remediating the current poor performance of the CP will result in corrosion of the buried pipework at locations where the coating has deteriorated. It is currently impossible to understand the full extent of any coating defects without exposing this pipework, some of which are up to 7m deep.

4.3.12 Unmanaged corrosion and unresolved defects will ultimately lead to loss of integrity of the buried pipework, loss of containment of high-pressure gas, unacceptable safety risks, and therefore require shutdown of parts of our site limiting the availability of the NTS and service to our customers.

Filters, Scrubbers and Preheaters - Why are we doing this work and what happens if we do nothing?

4.3.13 Continued use of these assets without investing in inspections, revalidation and remediation will breach legal obligations of PSSR and PSR. Lack of investment in the inspections and revalidation will mean that assets are non-compliant with PSSR legislation.

4.3.14 Lack of investment in the remediation of faults found during inspections will also render the assets unable to be used to convey gas. Isolation of items of plant and equipment would reduce the resilience of the NTS, ultimately it may lead to the inability of NG to meet the service requirements of our customers. It is predicted that with no investment there will be assets with outstanding PSSR failures or significant defects by the end of the period.

4.3.15 The function of filters, scrubbers and strainers is to remove contamination from the gas flow that could damage plant equipment downstream which could result in a loss of gas supply or reduction in the capacity of the network. Failure to invest adequately will lead to a loss of performance will allow liquids and other contaminants to flow with the gas and potentially damage our or our customers' downstream equipment.

4.3.16 Failure or reduction in performance of filter and scrubber assets will lead to contamination of critical downstream equipment i.e., failure of a filter on a Pressure Reduction AGI could lead to damage of a pressure Regulator which can lead to security of supply issues.

4.3.17 For the NGT gas turbine fuel gas supply, pre-heating is required to ensure the gas quality entering the turbine is a minimum of 20°C above the hydrocarbon dew point of 0°C. Failure to provide the correct gas quality could lead to liquid drop out resulting in reduced life expectancy and therefore increased overhauls of the gas turbine. Low temperature fuel gas can also prevent the starting and operation of the compressor power train. Inability to run the compressors due to incorrect gas temperatures may result in network constraints.

4.3.18 Lack of investment leading to a loss of performance will allow condensate to flow with the gas and potentially corrode and damage other downstream equipment.

4.3.19 Lack of investment in the assets may also lead to loss of containment of high-pressure gas, safety related issues and environmental damage.

4.3.20 For preheating assets there is a contractual obligation to meet site outlet temperatures as at sites supplying 3rd parties per Network Exit Agreement [NEXA]. Failure to meet contracted temperatures may result in a Power Station suffering damage to their equipment or being unable to run their plant.

Pressure Reduction, Flow Control and Slamshut Systems assets - Why are we doing this work and what happens if we do nothing?

4.3.21 Continued use of these assets without investing in inspections, revalidation and remediation will breach legal obligations of PSSR. Lack of investment in the inspections and revalidation will mean that assets are non-compliant with PSSR legislation.

4.3.22 Lack of investment in the remediation of failures found during inspections will also render the assets unable to be used in a pressurised environment. In some cases, they will not be able to be used at all. It is predicted that with no investment there will be assets with outstanding PSSR failures or significant defects by the end of the period.

4.3.23 Pressure/Flow Control Valves have a significant effect on the flow and pressures in the NTS. Their performance is critical to managing the flexibility, operation and line-pack of the NTS. Loss of main line pressure/flow control can lead to failure to meet network demand.

4.3.24 Loss of offtake pressure regulation streams could lead to loss of customer supply or gas supplied at the incorrect pressure. Loss of compressor station (fuel gas) pressure Regulators would lead to compressor unit unavailability. Incorrect pressures can also lead to damage to the integrity of any downstream equipment.

4.3.25 Loss of appropriate Slamshut functionality can lead to damage to the integrity of any downstream equipment. Failure to isolate a pipeline section following an incident has the potential to result in non-compliance with legislative requirements, reputational and commercial damages. The failure mode of a slam shut valve should be fail closed as their duty is to protect the downstream pipeline/pipework from over-pressurisation.

4.3.26 Several Slamshut valves also act as the main inlet isolation valve for Regulator streams and reduced isolation integrity by non-sealing valves, presents increases the isolation size and the associated amount of gas that is vented.

What is the outcome that we want to achieve?

4.3.27 Across the three subthemes of Above Ground Pipework, Cladding and CP Systems; Filters, Scrubbers and Preheaters; and Pressure Reduction, Flow Control and Slamshut Systems, the desired outcome of all the identified investments is to:

- Stabilise, and where required remediate the asset deterioration and specific corrosion issues to ensure that they do not result in a loss of containment of high-pressure gas, present a safety risk, and are not a limiting factor on availability or performance of the NTS.

- Maintain medium- and long-term integrity of the buried pipework asset through the effective management of the coating and cathodic protection of the buried pipework.
- Ensure continued compliance with PSSR and PSR and other legislative requirements.

4.3.28 The investment plans will be considered to be successful when the outcomes summarised above are met.

5 Narrative Real-Life Example of Problem

5.1 Data Collection

5.1.1 NGT's intervention Plan for years 4 &5 has been developed utilising maintenance and defect data supplemented through the completion of individual asset condition assessment surveys at each site included for funding in this submission. NGT's approach to data collection, options assessment and option selection process comprised the following process: Survey of the asset, Campaign Decision Panel (CDP) comprising experts from across the business to undertake option selection to reach to the proposal for Years 4 & 5.

5.2 Year 4 and 5 Identified Problems

5.2.1 This section details, by key themes, samples of defects identified from the condition assessments, summary nature of issues and example sites. This information was used in informing NGT's Plant and Equipment funding request for years 4 and 5 of RIIO-2.

5.2.2 Summary of issues across all sites surveyed covering the three separate subthemes are summarised in Table 1, Table 2 and Table 3. These site surveys have been included in appendix A (Please note option paper include some non-Plant and Equipment UM related UID's as the sites were surveyed to identify all defects).

Table 1: Summary of defects across the above ground pipework, cladding and CP Systems sites

Above Ground Pipework, Cladding and CP Systems		
Defect Category	**Sample Sites**	**Defect description summary**
Above Ground Pipe and Coating	[redacted]	• Grade 4-6 patch Corrosion and Algae build up on pipes. • Coating breakdown evident at locations requiring full grit blast and repaint across areas. • Degradation of paint system across site - site requires full site paint. • Failed (or failing) Wind/water line wrappings on all assets.
Below Ground Pipe and Coating	[redacted]	• Severe paint/coating/ wrapping breakdown/loss at flanges - Full site grit blast/rewrap/recoat required. • Severe corrosion present on flanges. • Filler material has moved and is exposing the internals of the IJ to water ingress and possible corrosion.
Civil assets - pipe supports	[redacted]	• Significant corrosion and damage to pipe supports
Cladding	[redacted]	• Cladding is damaged in some areas and will allow water ingress. This could be causing corrosion to the mainline pipework beneath.
Cathodic Protection	[redacted]	• Insulation Joints onsite have exceeding design life. Installed mostly early 1970s. • Surveys identified evidence of deterioration due to age of the assets
Consequence of no action		

Above Ground Pipework, Cladding and CP Systems		
Defect Category	**Sample Sites**	**Defect description summary**
Continued use of assets that are not inspected and revalidated will result in them becoming non-compliant with PSSR legislation and breach legal obligations.		

Table 2: Summary of defects across filters, scrubbers and preheaters

Filters, Scrubbers and Preheaters		
Defect Category	**Sample Sites**	**Defect description summary**
Preheater AGI Boiler Replacement	[redacted]	• Boiler package at the site is obsolete with limited spares availability. It requires replacement to ensure that NGT meets its contractual obligation to supply preheated gas to the end user. • One of the existing boilers has suffered an internal Boiler Heat Exchanger Failure and is off-line. • Redundancy has been lost due to failed boilers.
Pressure Reduction - Flow Control Valve Upgrade	[redacted]	• Capacity and Velocity issues identified at locations. • Obsolescence of the existing assets with spares and OEM support unavailable therefore reliability and availability cannot be assured
Consequence of no action		
Continued use of assets that are not inspected and revalidated will result in them becoming non-compliant with PSSR legislation and breach legal obligations. Failure to deal with preheater defects risks inability to meet contracted temperature requirements.		

Table 3: Summary of defects from pressure reduction, flow control and slamshut

Pressure Reduction, Flow Control and Slamshut		
Defect Category	**Sample Sites**	**Defect description summary**
Pressure Reduction Offtakes - Regulator Replacement	[redacted]	• Existing pilot operated ERS HP Regulators are obsolete with limited access to spares. • The ERS regulators tend not to form a tight shut off, when fully closed, this lack of tight shut off causes the regulator to pass or flow gas at times of no demand. Tight Shut off valves [TSOV] are in place
Pressure Reduction Offtakes - Regulator Replacement	[redacted]	• Existing arrangements do not meet current isolation standards as defined in T/PM/TR/17 • Obsolete and/or unsupported equipment, general age-related asset condition issues • Site requirement issues have changed
Consequence of no action		
Continued use of assets that are not inspected and revalidated will result in them becoming non-compliant with PSSR legislation and breach legal obligations. Lack of remediation of failures found during inspection will render assets unusable for pressurised environments or completely unusable. Equipment operating incorrectly can cause reduced efficiency or damage to downstream equipment including 3rd party assets. Network demand will be impacted by loss of main line pressure; loss of fuel gas regulators leading to compressor outage.		

5.3 King's Lynn Multi Junction

5.3.1 Subsidence at Kings Lynn MJ was first identified in 2011 and funding was requested through NGT's RIIO-2 submission to deliver the Front-End Engineering design and submit a subsequent a reopener to seek funding to address the subsidence at the site. Ofgem agreed with this proposal. Through a number of external assessments, it was concluded that the subsidence needs case driver for the project was no longer valid and the agreement between Ofgem and NGT was that the Price Control Deliverable (PCD) be brought to conclusion and closed out. However, it was recognised that there were still outstanding asset health issues that needed to be addressed [4].

5.3.2 As a result of this, a survey of the Multi junction, see appendix C, was undertaken to ascertain the nature and quantity of asset health issues that needed to be resolved. The main finding was that there are ongoing multiple issues of corrosion, including:

- Almost no flange protection on any of the site, any protection in place is [redacted] fitted as a last resort.
- Almost all Flanges and studs have corrosion present.
- Wind and water lines are not delineated.

[4] On 31 March 2022 NGT submitted a close-out report to Ofgem for this licence condition rather than a full Reopener requesting further allowances. As part of the Basic PCD report submitted to Ofgem on 31 July 2022 NGT proposed to return unused Baseline funding of [redacted] in 2018/19 prices. This is currently being reviewed by Ofgem.

6 Spend Boundaries

6.1 Description of spend boundary – in scope

6.1.1 The spend boundaries of this EJP encompasses baseline funded works (years 1 to 3) and proposed investments (years 4 and 5) covering the following themes:

- Above Ground Pipework, Cladding and Cathodic Protection (CP);
- Pressure Reduction, Flow Control and Slamshut Systems; and
- Filters, Scrubbers and Preheaters.

6.1.2 The UIDs associated with this spend boundary are primarily those in the [redacted], [redacted], and [redacted] range, but also including additional UID's for St Fergus UID's as highlighted in the **Summary** in section 3.

6.1.3 Investments completed across [redacted] sites in years 1 to 3 and those planned across the [redacted] sites in years 4 & 5 in the Plant and Equipment theme.

6.1.4 Any foundation and civil works associated with interventions on the Plant and Equipment assets are included within the scope.

6.1.5 Included within this spend boundary are investments at King's Lynn MJ which are required to remediate identified asset health issues at the multi junction.

6.2 Out of scope

6.2.1 Funding adjustment for most Plant and Equipment asset health investments at St Fergus and Bacton have not been included in this EJP. For some St Fergus investment funding has been requested as part of the January and June 23 Asset Health Re-opener submission. The investments proposed at Bacton and originally included within the Plant and Equipment Asset health theme will be included within the Bacton FOS Reopener. For further detail see the Asset Health Overarching Document (NGT_AH3_01).

6.2.2 Investment associated with compressor related Plant and Equipment assets for new compressor units is excluded as this is included in the separate compressor investment business plan.

6.2.3 Investment to decommission assets that have already been funded through the Redundant Assets PCD are excluded from this request.

7 Probability of Failure

7.1 Probability of Failure Overview

7.1.1 NGT's ongoing asset health assessment programme and the surveys conducted on the 605 year 4 and 5 sites identified a range of defects, some of which if not addressed would result in loss of asset capability. NGT's intervention programme on Plant and Equipment assets seeks to intervene prior to the failure of the asset, following identification of asset deterioration, due to the consequence that this failure has on NGT's operation.

7.1.2 Most Plant and Equipment assets do not immediately fail but rather deteriorate resulting in poor performance which leads to further deterioration and eventually failure. Many of the Plant and Equipment assets are 15 to 45 years old with some being over 50 years old. The age and frequency of the usage of the Plant and Equipment assets has implications on the rate of deterioration. Failures can happen even with regular maintenance due to age and usage frequency drivers.

7.1.3 Corrosion is the main failure mode, and this is applicable to all Plant and Equipment sub. Other failure modes include faults, pipework rupture and pressure variations.

7.1.4 As part of the UM all the sites for which funding is being requested have been assessed and surveyed, defects identified, and known issues affecting performance are being addressed. An engineering assessment has been undertaken by SMEs on the ongoing risk that not rectifying the defects would have on the operation of the Plant and Equipment assets.

7.1.5 Other defects have been identified that, either do not require immediate remediation or can be resolved by operational staff and so are not included in this funding request.

7.1.6 Plant and Equipment assets failing and resulting in NTS capability being compromised and could lead to network constraints, particularly in low resilience areas of the network.

7.2 Above Ground Pipework, Cladding and CP Systems – Probability of Failure

7.2.1 For Above Ground Pipework, Cladding and CP Systems assets, the failure modes that contribute mostly to the probability of failure are:

- Corrosion with no leak.
- Defect leading to minor leak.
- Fault leading to trip.
- Rupture of pipework caused by external interference.

7.3 Filters, Scrubbers and Preheaters– Probability of Failure

7.3.1 For Filters, Scrubbers and Preheaters assets, the failure modes that contribute most to the probability of failure are:

- Corrosion with no leak
- Fault leading to compressor trip.
- Fault leading to trip.
- Oil Leak or Spill.
- Failure leading to low outlet temperature.

7.4 Pressure Reduction, Flow Control and Slamshut Systems – Probability of Failure

7.4.1 For Pressure Reduction, Flow Control and Slamshut Systems assets, the failure modes that contribute most to the probability of failure are:

- Corrosion no leak.
- Fault leading to trip.
- Low or no pressure downstream.
- High pressure downstream.
- Loss of pressure/flow control.
- Loss of downstream supply.
- Loss of Regulator stream redundancy.
- Over-pressure of downstream system.
- Mechanical damage resulting from vibration.
- Obsolescence.

7.5 Probability of Failure Data Assurance

7.5.1 Only defects, proven to have deteriorated sufficiently that they are adversely affecting performance or are in an unsuitable state of deterioration, identified through NGT's Plant and Equipment rolling asset health plan, and bolstered by asset condition survey reports, are proposed to be addressed in this UM reopener submission.

8 Consequence of Failure

8.1 Overview

8.1.1 Assets within the Plant and Equipment theme have historically failed. There are instances of where ancillary equipment, which is component of an asset, has failed such as at [redacted] or insulation joints which are part of Cathodic Protection systems. Another example is where a two-inch transition failed at [redacted] due to corrosion shutting two compressors down. Generally, the consequence of failure of Plant & Equipment assets could lead to inefficient network and site operation, resulting from utilisation of sub-optimum compressors, and loss of gas through corrosion and joint leaks. All consequence of failure can be assessed against our consequence of Supply model within our NARMS framework. For each sub asset we have summarised the impact/consequence of failure in the table below (Table 4).

Table 4: Consequence of Failure Summary

Sub Asset	Impact / Consequence				
	Availability	**Environment**	**Financial**	**Safety**	**Other**
Above Ground Pipework, Cladding and CP Systems	Corrosion failures related to above or below ground pipework could lead to outages, pressure restriction, isolation of downstream customers and network constraints. Failure of cladding systems will typically have negligible effects on availability. Potential to affect temperature regulation in isolated cases. There is a minor risk that where it is required to maintain the temperature of the gas for metering that it	Loss of gas through corrosion and joint leaks including loss from pipework protected by cladding and from mechanically failed IJs. Noise nuisance caused by poor acoustic cladding. Loss of gas arising from a leak or rupture of the pipework caused by external interference, corrosion or other failure modes.	***This is the risk with the highest expected stakeholder impact.*** This is associated with the costs of operating and maintaining the network at the current level of risk including resolving existing defects. Significant financial impact of a large-scale failure or loss of service event, due to loss of revenue, impact on reputation, fines and compensation.	The potential for corrosion failure, mechanical failure, ground movement or damage, causing a pipework to leak or rupture. The failure of cladding associated with personal protection could result in injury to site personnel.	Corrosion related failure does not typically result in a catastrophic failure event e.g., rupture but instead results in a leak event. Gas losses resulting from corrosion will generally vent to air. Self-ignition due to static energy is possible. Where leaking gas does not ignite this potentially increases the risk of explosion. The directional nature of a leak poses additional risk to personnel in instances where ignition occurs. Poor insulation of the cladding on pre-heater pipework would potentially cause a failure of the pressure reduction system, but this risk is low.

Sub Asset	Impact / Consequence				
	Availability	Environment	Financial	Safety	Other
	could result in the loss of a stream for GSMR				
Filters, Scrubbers and Preheaters	Potential outages associated with failure of the pressure reduction system and subsequent isolation of downstream customers. This includes trips due to out-of-range temperatures and pressures. Failure of scrubbers have potential to reduce capacity or impact site availability. This risk is partially mitigated through the presence of built-in redundancy for equipment of this type at many sites	***This is the risk with the highest expected stakeholder impact.*** Filters, Scrubbers and Strainers – is the largest proportion of overall service risk and is associated with the loss of gas from leaks and carbon emissions associated with asset maintenance. There is also environmental risk associated with leaks from fuel/oil systems on compressor sites. The environmental costs of running the preheating system (e.g., gas/electricity supplies) are not included.	This is mostly associated with the costs of operating and maintaining the assets at the current level of risk. This includes routine inspection and repairs. Minor PSSR inspection costs (heat exchangers) are included, but major PSSR surveys are considered as proactive costs.	The possible risk of ignition and fires and explosions following a loss of gas event. This risk is small due to the low probability a of fire/explosion event and the low chance of employees or staff being nearby at the time.	**Societal risk** - disruption associated with potential fires and explosions.
Pressure Reduction, Flow Control and Slamshut Systems	***This is the risk with the highest expected stakeholder impact.*** This is associated with the failure of pressure	This is associated with the loss of gas from leaks and carbon emissions associated	Mostly associated with the costs of operating and maintaining the assets at the current level of risk. Including	This is associated with the possible risk of ignition and fires/explosions following a loss of gas event. This risk is small due to	**Societal risk** - is associated with disruption to transport associated with potential fires and explosions. The possibility of the Slamshut valve failing open or closed, which

Sub Asset	Impact / Consequence				
	Availability	**Environment**	**Financial**	**Safety**	**Other**
	reduction which has potential to affect the availability of 3rd party customers including power stations. Failure of flow control valves has potential to result in NTS network constraint. Failure of slamshut to close on demand could lead to downstream over pressurisation leading to loss of containment or over stressing of pipework.	with asset maintenance.	routine inspection and repairs.	the low probability a of fire/explosion event and the low chance of employees or staff being near the asset at the time of failure.	might potentially cause supply outages are generally mitigated by the presence of effective fail-safe systems.

9 RIIO-2 Baseline Interventions (yrs. 1-3)

9.1 Summary of Interventions

9.1.1 The total number of volumes and their associated sites intervened on in years 1 to 3 is summarised in *Table 5*. These interventions have been completed or are nearing completion at [redacted] sites. Some sites have had multiple Plant and Equipment subtheme interventions, across years 1 to 3.

Table 5: Summary of works completed so far in RIIO-2 across years 1 to 3

Year	Theme	Comments
FY22	Above Ground Pipework, Cladding and CP Systems ([redacted] series of UIDs)	[redacted] volumes comprising pipework protection, valve & flanges major refurbishment and CP insulation joint replacement at [redacted] sites.
	Filters, Scrubbers and Preheaters ([redacted] series of UIDs)	[redacted] volumes comprising major refurbishment on filters at [redacted] sites.
	Pressure Reduction, Flow Control and Slamshut Systems [redacted] series of UIDs)	[redacted] volumes were delivered under this subtheme in this financial year.
FY23	Above Ground Pipework, Cladding and CP Systems ([redacted] series of UIDs)	[redacted] volumes comprising pipework protection, valve & flanges major refurbishment and CP insulation joint replacement at [redacted] sites.
	Filters, Scrubbers and Preheaters ([redacted] series of UIDs)	[redacted] volumes comprising major refurbishment on filters and heaters & boilers at [redacted] sites.
	Pressure Reduction, Flow Control and Slamshut Systems [redacted] series of UIDs)	[redacted] volumes were delivered under this subtheme in this financial year.
FY24	Above Ground Pipework, Cladding and CP Systems ([redacted] series of UIDs)	[redacted] volumes of pipework protection, valve & flanges major refurbishment and cladding minor refurbishment at [redacted] sites.
	Filters, Scrubbers and Preheaters ([redacted] series of UIDs)	[redacted] volumes of major refurbishment on filters and heaters & boilers at [redacted] sites.
	Pressure Reduction, Flow Control and Slamshut Systems [redacted] series of UIDs)	[redacted] volumes comprising regulator replacement, new valves, control logic replacement and regulator minor refurbishment at [redacted] sites.

9.1.2 Table 6 summarises the Plant and Equipment baseline interventions volumes for years 1 to 3 of RIIO-2.

Table 6 Summary of RIIO-2 baseline (Yrs. 1-3) intervention volumes

Subtheme	UID	Intervention	RIIO-2 UID Volumes			Total Volumes
			Delivery 2021/22	Delivery 2022/23	Delivery 2023/24	
Above Ground Pipework, Cladding and CP Systems	[redacted]	Pipework Modifications Compressor surge issues	[redacted]			
		Pipework Modifications Minor Capex				
		AGI Pipework Painting (Full, Partial or Patch)				
		CM/4 Corrosion Defects Resolution				
		Replace Cladding on AGIs				
		Replacement of Failed IJs on AGIs				
		Resolve Existing AGI CP Priority 1 Defects				
		Resolve Existing AGI CP Priority 2 Defects				

Subtheme	UID	Intervention	RIIO-2 UID Volumes			Total Volumes
			Delivery 2021/22	Delivery 2022/23	Delivery 2023/24	
Filters, Scrubbers and Preheaters	[redacted]	Filters PSSR Inspection & Major Overhauls	[redacted]			
		Replace Strainers with Filters/Separators				
		Scrubber & Condensate Tank Internal Inspections & Estimated Major Refurbs				
		Preheater AGI Boiler Replacement				
		Preheater Minor Refurb				
		Preheater PSSR Revalidation, WBH Inspection & Major Refurbs				
		Preheater Upgrade - Compressor Fuel Gas @ Wooler				
Pressure Reduction, Flow Control and Slamshut Systems		Pressure Reduction - Flow Control Valve Upgrade				
		Pressure Reduction Offtakes - Regulator Replacement				
		Pressure Reduction Skid Replacement - Compressor Stations				
		Pressure Reduction Streams - Major Overhauls				
		Pressure Reduction - Flow Control Valve Upgrade				
		Pressure Reduction Offtakes - Regulator Replacement				
		Pressure Reduction Skid Replacement - Compressor Stations				
		Pressure Reduction Streams - Minor Overhauls				
Totals (£m)			[redacted]	[redacted]	[redacted]	460

9.2 Baseline Funded Costs

9.2.1 Total costs incurred for Plant and Equipment baseline interventions across years 1 to 3 of RIIO-2 are summarised in Table 7.

Table 7: Baseline funded (yrs. 1-3) actual spend (£m in 18/19 price base)

Subtheme	UID	Intervention	RIIO-2 UID Costs			Total
			Delivery 2021/22	Delivery 2022/23	Delivery 2023/24	
Above Ground Pipework, Cladding and CP Systems	[redacted]	Pipework Modifications Compressor surge issues	[redacted]			
		Pipework Modifications Minor Capex				
		AGI Pipework Painting (Full, Partial or Patch)				
		CM/4 Corrosion Defects Resolution				
		Replace Cladding on AGIs				
		Replacement of Failed IJs on AGIs				
		Resolve Existing AGI CP Priority 1 Defects				
		Resolve Existing AGI CP Priority 2 Defects				

Subtheme	UID	Intervention	RIIO-2 UID Costs			Total
			Delivery 2021/22	Delivery 2022/23	Delivery 2023/24	
Filters, Scrubbers and Preheaters	[redacted]	Filters PSSR Inspection & Major Overhauls	[redacted]			
		Replace Strainers with Filters/Separators				
		Scrubber & Condensate Tank Internal Inspections & Estimated Major Refurbs				
		Preheater AGI Boiler Replacement				
		Preheater Minor Refurb				
		Preheater PSSR Revalidation, WBH Inspection & Major Refurbs				
		Preheater Upgrade - Compressor Fuel Gas @ Wooler				
		Pressure Reduction - Flow Control Valve Upgrade				
		Pressure Reduction Offtakes - Regulator Replacement				
Pressure Reduction, Flow Control and Slamshut Systems		Pressure Reduction Skid Replacement - Compressor Stations				
		Pressure Reduction Streams - Major Overhauls				
		Pressure Reduction - Flow Control Valve Upgrade				
		Pressure Reduction Offtakes - Regulator Replacement				
		Pressure Reduction Skid Replacement - Compressor Stations				
		Pressure Reduction Streams - Minor Overhauls				
Totals (£m)						

9.2.2 Table 8 provides a summary of awarded baseline spend against actual spend. The table also contains the volumes associated with this spend. Completed and inflight baseline interventions have been used to provide the necessary evidence in relation to unit costs across RIIO-2.

Table 8: Awarded baseline spend vs actual volume and spend

Category	Volumes (no.)	Spend (£m)
Actual baseline delivery (yrs. 1 -3)	460	[redacted]
Awarded baseline (yrs. 1 -3)	[redacted]	68.527
(Actual – Awarded)	[redacted]	[redacted]

9.2.3 Unit costs based on Ofgem's Final Determination, in December 2020, were used as target costs for years 1-3 works. Through delivery, a range of tendered and outturn costs have been collected. Costs variances between unit costs used to establish the baseline allowance and actual unit costs to complete the works have been found and reasons for these variances are summarised as:

- **Scope specificity:** Intervention specific scopes for each Plant and Equipment defect as opposed to generic scopes used to generic unit costs establish used to establish baseline allowances.

- **Scope increase:** Increase in scope for works on the Plant and Equipment assets (e.g., for fire suppression the number of cylinders and nozzles increased following cab specific condition assessment). Additional testing, resulting from Plant and Equipment specific condition assessment, requiring to be done (i.e., for nozzles).
- **Workforce:** a number of issues including workforce constraints, material delays and cost increases.
- **Covid 19:** Due to the pandemic the construction industry has had to catchup for lost time and in doing so the demand for materials has increased leading to both shortages and increased cost.
- **Cost to Employ:** National Insurance costs increased since the beginning of RIIO-2. Costs to purchase vehicles have also increased due to microchip shortages.
- **Energy costs:** gas and electricity costs have increased since the beginning of RIIO-2.
- **Fuel costs:** Petrol and diesel costs have increased significantly since the beginning of RIIO-2.
- **Red diesel:** This cheaper diesel is no longer allowed to be used on construction sites. White diesel, which is now being used on construction sites, is considerably more expensive resulting in an increase in site mobilisation and plant fuel costs by an estimated factor of [redacted]
- **Overall Inflation:** Comparison [redacted]

10 Options Considered for Years 2024/25 and 2025/26

10.1 Options Overview

10.1.1 Defects, identified through NGT's Plant and Equipment rolling asset health plan, and bolstered by external Plant and Equipment condition survey reports included in Appendix A, were assessed for intervention options. This assessment was completed through a series of Campaign Decision Panels (CDPs) comprising, Subject Matter Experts (SMEs), Delivery and Project Managers, portfolio planning teams, as well as site operations staff. In addition to other identified stakeholders accordingly to assess all credible options for each identified defect and ascertain the optimum asset management intervention to balance cost risk and performance and deliver on NGT's consumer outcome. This was to ensure the level of investment to progress and complete the interventions was appropriate for the predicted life of the asset.

10.1.2 Options considered for Cathodic Protection (CP) is summarised in Section 10.4.

10.1.3 Table 9 summarises, and provides an overview of, the various options assessed, and examples of the various interventions considered following defect assessment and surveys, and maps these to the RIIO-2 baseline interventions of 'minor refurbishment', 'major refurbishment' and 'replacement'. Please note that this is not an exhaustive list – it merely provides an example of the typical types of interventions associated with each sub asset.

Table 9: Options considered and examples of interventions

Business Plan	Real Intervention Example
Do nothing (all sub assets in the table)	• The impact of no investment in Plant and Equipment assets generates a compounding increase in service failure risk every year, across all service risk categories. • Lack of investment in Plant and Equipment assets will result in an unsustainable situation where the volume of corrosion defects will grow to a level where the performance on the NTS cannot be maintained, and any level of remediation would not keep pace with degradation. This would place the NTS in a state where only significant asset replacement would counter the corrosion issues, at significant cost to customers and consumers. • This option includes the reactive only investment across all Plant and Equipment assets and is the option against which all the other options are compared. For some assets which have redundancy and are easy to replace then reactive investment (fix on fail) is an acceptable strategy. • This option is discounted as it does not result in in any tangible benefit to the asset and increases the risk of failure and safety related incidents. • For some assets, this option is the most suitable intervention at the present time, this is where specific maintenance proposals will be most appropriate considering the assets in the WLC plan.
Decommission (all sub asses in the table)	• This is the option of permanently removing, through dismantling and disposal, of assets from service. • This option is largely discounted as the assets identified for intervention are still required on the NTS. However, there are some exceptions, such as cladding where removal and decommissioning is the first option

Business Plan		Real Intervention Example			
		always considered. Investments such as pipe-throughs where pits and valves are decommissioned fall into this category. • All Plant and Equipment assets identified for intervention are in line with NGT's Needs Case and future strategy of keeping gas flowing in the interests of consumers. Hence the requirement for Plant and Equipment investment to ensure continued and safe operation of the NTS.			
Above Ground Pipework, Cladding and CP Systems	Decommission	Removal of cladding if no longer required.	Removal of CP drain by excavation.	-	-
	Refurbishment (component re-life)	AGI Pipework Coating (Full, Partial or Patch of asset or site)	Clean corrosion, OR Grit blast and Coating	Refurbish elements of CP system, OR partial CP system replacement	-
	Replace	New CP system	Replace Cladding on AGIs	Replacement of Failed IJs on AGIs	-
Filters, Scrubbers and Preheaters	Refurbishment (component re-life)	Filters PSSR Inspection & Major Overhauls	Scrubber & Condensate Tank Internal Inspections & Estimated Major Refurbs	Preheater Minor Refurb	Preheater PSSR Revalidation, WBH Inspection & Major Refurbs
	Replace	Replace Strainers with Filters/Separators	Preheater AGI Boiler Replacement	Preheater Upgrade - Compressor Fuel Gas at Wooler	-
Pressure Reduction, Flow Control and Slamshut Systems	Minor refurbishment (component re-life)	Component replacement, repair OR	Clean corrosion	-	-
	Replace	Pressure Reduction Offtakes - Regulator Replacement	-	-	-

10.2 Options Summary

10.2.1 The following section provides a description of the options assessed for each defect type. **Do nothing** and **Decommission**, which apply to all sub assets, are also assessed if considered reasonable.

10.2.2 Some Plant and Equipment assets do not fail but deteriorate resulting in poor performance which leads to further deterioration. There are assets that haven't failed but are in various states of deterioration and should be intervened upon before adversely affecting performance. At the same time there are assets that have failed, e.g., above ground pipework corrosion which results in loss of containment.

10.2.3 Considering the above, the options being taken forward are identified as refurbishment or replacement and summarised in Table 10.

Table 10: Option Summary Conclusion

Option	Narrative
Pre-emptive Refurbishment	This is **an option being taken forward** as the outputs of the surveys of some assets highlight deterioration that would result in failure. As a prudent Asset Management Company NGT should be planning interventions that prevent asset failure. The current volume of defects dictates that this is a position NGT will be in once it is out of the current largely reactive position.
Refurbishment on Failure	This is **an option being taken forward** as there are instances of where components of assets have failed rendering them unusable of ineffective.
Pre-emptive Replacement	This is **an option being taken forward** as the outputs of the survey highlight deterioration that would result in failure and/or assets that need replacement as they do not meet current design standards. As a prudent Asset Management Company NGT should be planning interventions that prevent asset failure.
Replacement on Failure	This is **an option being taken forward** as there are instances of where components of assets have failed rendering them unusable of ineffective.

10.3 Years 4 and 5 Options Details and Selection Summary

10.3.1 Options and identified interventions are based on condition-based assessments reviewed as part of NGT's Plant and Equipment rolling asset health plan and bolstered by external Plant and Equipment condition survey reports. The options selected provide the most optimum asset management intervention to balance cost risk and performance and deliver on our consumer outcome.

10.3.2 Each site is being treated as a separate project but aligned to respective UIDs to provide a holistic view of identified interventions.

Option Summary

10.3.3 [redacted] sites have been identified for asset health interventions in Years 4 and 5. A representative sample from each subtheme comprising complex, standard and simple interventions sites is summarised in the following sections. Definition of complex, standard and simple intervention sites. Please note that these are not exhaustive definitions:

- **Complex intervention sites** include those with numerous assets, such as compressor stations and complex AGIs, requiring outages and associated with many interventions including high value interventions.
- **Standard intervention sites** include those sites such as AGIs with only a few assets that require remediation and may or may not require outages.

- **Simple intervention sites** include those at sites with only a few assets that require remediation and may not require outages including low value interventions.

10.3.4 The sites are summarised in Table 11, Table 12, Table 13,Table 14 , Table 15, Table 16, Table 17, Table 18, and Table 19. Representative sample sites highlighted in Table 1, Table 2 and Table 3 and subsequent options, identified for years 4 and 5 are contained in Appendix B.

Table 11: Above Ground Pipework, Cladding and CP Systems Outline and Discussion – [redacted]

[redacted] - Above Ground Pipework, Cladding and CP Systems [COMPLEX SITE] Deterioration of paint topcoat on all assets, heavy algae build up on Pig Trap [redacted] Wind/water line wrappings on all assets have failed or are failing and inadequate for task on Feeders [redacted] assets. Defective Cathodic Protection system.	
Option	**Narrative**
Refurbishment	Surface preparation and partial site paint of corroded areas of Feeder [redacted] assets. Excavate, rewrap/refurb w/w lines on all risers and stems, remediate all sandboxes and install new anti-burrowing mesh; Replace flange protection. Minor refurbishment of some Cathodic Protection assets.
Replacement	Grit blast and full site paint of all Feeder [redacted] assets including Pig Trap [redacted]; excavate, rewrap/refurb w/w lines on all risers and stems, remediate all sandboxes and install new anti-burrowing mesh; Replace flange protection as necessary. Replacement of existing Cathodic Protection system with a new one.
Selected Option	Funding request through UID [redacted]

Table 12: *Above Ground Pipework, Cladding and CP Systems Outline and Discussion* – [redacted]

[redacted] - Above Ground Pipework, Cladding and CP Systems [STANDARD SITE] Full site is heavily coated in algae/moss resulting in areas of corrosions or failed/peeled paint.	
Option	**Narrative**
Refurbishment	Biocide wash of all above ground assets. Site specific patch paint of pipework as necessary after Biocide treatment. P/11 Inspection of specific pipework section. Resolving the issues now would significantly slow the onset of corrosion and prolong the life of the asset, this would also save future operational & maintenance costs.
Replacement	Replacement is not considered to be appropriate for this range of defects as the assets can be restored via refurbishment.
Selected Option	Funding request for refurbishment through UIDs [redacted]

Table 13: *Above Ground Pipework, Cladding and CP Systems Outline and Discussion* – [redacted]

[redacted] - Above Ground Pipework, Cladding and CP Systems [SIMPLE SITE] Large Patch of Grade 5 Corrosion on Bypass pipework of 'H' Arrangement comprising pipework, coatings and wrappings.	
Option	**Narrative**
Refurbishment	Full site grit blast and paint following completion of P/11 & P/20 Inspections to resolve CM/4 corrosion defects.
Replacement	Replacement is not considered to be appropriate for this range of defects as the assets can be restored via refurbishment.
Selected Option	Funding request for refurbishment through UIDs [redacted]

Table 14: Filters, Scrubbers and Preheaters Outline and Discussion – [redacted]

[redacted] - Filters, Scrubbers and Preheaters [COMPLEX] Boiler package at the site is obsolete with limited spares availability. One of the existing boilers has suffered an internal Boiler Heat Exchanger Failure and is off-line.	
Option	**Narrative**
Refurbishment	Refurbishment of an internal Boiler Heat Exchanger.
Replacement	Replacement of the boiler package at the site to ensure that NGT meets its contractual obligation to supply preheated gas to the end user.
Selected Option	Funding request for refurbishment through UID [redacted] and replacement through UID [redacted]

Table 15: Filters, Scrubbers and Preheaters Outline and Discussion – [redacted]

[redacted] - Filters, Scrubbers and Preheaters [STANDARD] The boiler package at the site is obsolete with limited spares availability.	
Option	**Narrative**
Refurbishment	Refurbishment is not appropriate as the range of defects cannot be restored using this option.
Replacement	To ensure continued availability and reliability of [redacted] the preheat package requires replacement.
Selected Option	Funding request for replacement through UID [redacted] - Preheater Upgrade - Compressor Fuel Gas at [redacted]

Table 16: Filters, Scrubbers and Preheaters Outline and Discussion - [redacted]

[redacted] - Filters, Scrubbers and Preheaters [SIMPLE SITE] One auxiliary boiler has failed at Tirley and cannot be repaired meaning that standby capability has been lost. It is known from the results of routine servicing by our approved service vendor that the performance of these boilers is deteriorating thus the remaining boiler is at risk of failure.	
Option	**Narrative**
Refurbishment	This is the most appropriate action as only a component of the preheat system needs replacing and not the whole preheat package.
Replacement	Whole system replacement is not considered to be appropriate for this range of defects as the preheat package can be restored via component replacement.
Selected Option	Funding request for refurbishment through UIDs [redacted] (Filters PSSR Inspection & Major Overhauls) and [redacted] (Preheater PSSR Revalidation, WBH Inspection & Major Refurbs)

Table 17: Pressure Reduction, Flow Control and Slamshut Systems Outline and Discussion – [redacted]

[redacted] - Pressure Reduction, Flow Control and Slamshut Systems [COMPLEX] Existing pilot operated Engineering Research Station (ERS) High Pressure (HP) Regulators obsolescence with limited access to spares. The ERS regulators tend not to form a tight shut off, when fully closed, this lack of tight shut off causes the regulator to pass or flow gas at times of no demand. Tight Shut off valves [TSOV] in place	
Option	**Narrative**
Refurbishment	This is not an appropriate intervention due to the nature of regulator defects.
Replacement	Replace complete streams containing obsolete / unsupported pressure let-down equipment [Slamshuts, Regulators, relief valves] with modern equivalent equipment. Replace the regulator streams with a combination of Pilot Operated and Direct Electric Regulator and rationalise the pipework within the regulator building by removing the existing manual valve and spool arrangement downstream of the regulators.
Selected Option	Funding request for regulator replacement through UID [redacted] and valve replacement through UID [redacted].

Table 18: Pressure Reduction, Flow Control and Slamshut Systems Outline and Discussion - [redacted]

[redacted] - Pressure Reduction, Flow Control and Slamshut Systems [STANDARD SITE] Existing arrangements do not meet current isolation standards as defined in T/PM/TR/17 Obsolete and/or unsupported equipment, general age-related asset condition issues Site requirement issues have changed.	
Option	**Narrative**
Refurbishment	Refurbishment is not an option due to the level of valve deterioration.
Replacement	Install a new pressure reduction system, fully compliant with IGEM/TD/13, T/SP/TR/18 and T/SP/COMP/33. This will include installing in each stream: Slam shut valve (2nd Safety Device), Monitor Regulator (1st Safety Device), Active Regulator, Creep Relief, NRV.
Selected Option	Funding request through UID [redacted] Valves replacement.

Table 19: Pressure Reduction, Flow Control and Slamshut Systems Outline and Discussion - [redacted]

[redacted] - Pressure Reduction, Flow Control and Slamshut Systems [SIMPLE SITE] Existing pilot operated Engineering Research Station (ERS) High Pressure (HP) Regulators obsolescence with limited access to spares. The ERS regulators tend not to form a tight shut off, when fully closed, this lack of tight shut off causes the regulator to pass or flow gas at times of no demand. Tight Shut off valves [TSOV] in place	
Option	**Narrative**
Refurbishment	This is not an appropriate intervention due to the nature of regulator defects.

Replacement	Replace complete streams containing obsolete / unsupported pressure let-down equipment [Slamshuts, Regulators, relief valves] with modern equivalent equipment. Replace the regulator streams with a combination of Pilot Operated and Direct Electric Regulator and rationalise the pipework within the regulator building by removing the existing manual valve and spool arrangement downstream of the regulators.
Selected Option	Funding request through UID [redacted] – Regulators Replacement

10.4 Cathodic Protection Systems Options selection

10.4.1 During the survey and design stage of the project, delivery teams identified that a number of the sites where Category 1 highest priority (P1) and 2 (P2) defects , summarised in Table 20 were present, the interaction of these defects with the existing site CP system was deemed complex and the system finely balanced. It was evaluated that by just remediating the defects noted, this would still give rise to CP issues manifesting itself later due to:

- Location of the defects on the site and in relation to other CP and NGT buried assets.
- Each CP system has a maximum capacity and range of influence in which it is effective based on the location of the anodes. If capacity is reached and the system is still deficient
- Increasing the CP output excessively results in damage to the coating systems increasing their rate of degradation and reducing their effectiveness.
- Increasing CP output can lead to interaction with other buried metallic services and structures which can lead to an accelerated corrosion events rather than reducing corrosion.

10.4.2 The definition of P1, P2 and P3 features is summarised in Table 20.

Table 20: Definition of P1 and P2 Features

Category	Description	Comment
Category P1 Defect	Both the 'ON' and instant 'OFF' potentials are more positive than – 850mV. There is little or no IR factor.	The pipe to soil potentials is unsatisfactory and the locations are not cathodically protected.
Category P2 Defect	The 'OFF' potential is more positive than –850mV, the 'ON' potential more negative. (This may also occur with a reduction in IR factor).	Cathodic protection levels are unsatisfactory.
Category P3 Defect	Positive change in the 'ON' and instant 'OFF' potential plot although both remain more negative than –850mV.	Indicates location of increased current demand, cathodic protection levels are satisfactory.

10.4.3 In order to mitigate a number of know defects and future risks and due to the complexity of the issues noted above the number of options available to remediate CP systems is limited. Refurbishment of the existing systems could involve extensive replacement of CP system componentry and potential excavations to uncover these components. Even with these interventions the performance of the CP system may not be suitable to mitigate against the degradation rates and necessitate further investment, prolonging the project duration, and increasing costs due to the complexity of the projects.

10.4.4 In undertaking this review primary option being presented is aligned to a full CP system replacement at the [redacted] x sites that are proposed to be delivered in RIIO T2. Following is an overview of the P1 and P2 defects:

- [redacted] **e** – this location was found to have [redacted] x P1 and [redacted] x P2 defect features. The groundbeds are expecting to be reaching the end of their service life. Energisation of the high voltage pulsed DC system for the ISS fencing can have a significant detrimental effect on the measured pipe-soil-potentials with positive potential swings of 60mV noted. the location of an earth mat, believed to be situated directly above the pipeline near the scrubber pipework, presents some specific problems. Connection between the ISS fence earth and site earth will have increased the CP current requirement for protection. There are no voltage surge devices fitted across insulation joints, despite the perceived risk of lightning strikes at this location. Termination of Pipe and AGI cables in a single post presents two earth systems and the opportunity for a touch potential risk.
- [redacted] – this location was found to have [redacted] x P1 and [redacted] x P2 defect features. The drain point test post is not wired to best practice standard. Due to proximity with the fence, the CR5 installation is connected to the fence and therefore does not receive the benefit of CP.
- [redacted] – [redacted] is a relatively small site where FM11 and FM12 pipelines' pass through the site and are in close proximity to buried AGI pipework. The AGI is situated on rock with a shallow overlying soil layer which prevents deep installation of earth rods for fence earthing. The high soil resistivity also presents difficulties for CP groundbed design to avoid CP interaction between AGI and pipeline CP systems. However, historically, before installation of the ISS fence, the CP system is known to have been effective. Two groundbeds are installed, but the ISS fence was constructed on top of the horizontal groundbed located in the northeast corner of the site, which was destroyed, and the second bed has failed. The ISS fence earth system consists of a substantial network of earth rods which also present a drain of CP current. The CP system has not been effective since ISS fence construction.
- [redacted] – this location was found to have [redacted] x P1 and [redacted] x P2 defect features. The existing transformer rectifier is no longer serviceable and requires replacement, complete with groundbed control system, facility for measurement of individual groundbed current and timer. Where P1 and P2 features occur, at pit wall transitions, new test facilities should be fitted adjacent to pit walls.
- [redacted] – this location was found to have [redacted] x P1 and [redacted] x P2 defect features. The groundbeds are likely to be reaching the end of their design life and should be replaced. To deliver more current in problematic areas and reduce any over polarisation, the re-design will require additional groundbeds which should include facilities for current measurement and individual adjustment which will allow finer control of CP current attenuation around the site. It is also considered that anode strings will be required near the large pit outside compressor K102. Appendix B contains an example report that supports the optioneering work concluding that a new CP system is the preferred option at this site.
- [redacted] – this location was found to have [redacted] x P1 and [redacted] x P2 defect features. It is considered that the entire CP system is not fit for purpose. Currently the buried pipework at this installation is at risk of corrosion. To deliver effective cathodic protection, a re-design and replacement of the entire CP system.

10.4.5 Noting that these projects would be the most appropriate solution to remedy the CP defects and scale of the works involved overall deliverability was reviewed to ensure that works started could complete within the RIIO T2 period. As such the execution strategy was modified to focus on the [redacted] sites listed with the remaining sites being planned for delivery in RIIO T3. The RIIO T3 program of works would include an additional [redacted] x sites that underwent survey and development in RIIO T2 using baseline funding (alongside the 6 being taken to delivery) and the remaining [redacted] sites which will undertake survey work in RIIO 3, that would not be deliverable in RIIO -2 based on the anticipated works.

10.4.6 Additionally, and in support of new CP System option, not all verified records and original design intent for the existing CP systems are available which makes it harder to ensure that a repair is in keeping with this rationale. There is a risk that enhancing only part of the system can lead to issues such as current drains or other interaction issues that then lead to onset of more defects earlier. There is also a risk that a repair will not offer a guaranteed design life extension whereas a new design and installed system would guarantee a 40-year design life starting from a clean defect free position.

10.4.7 Options considered for CP related interventions are summarised in Table 21.

Table 21: Cathodic Protection Optioneering Summary

Option	Summary
Do nothing	To ensure effective corrosion control, and deliver compliance, in accordance with the standards and specifications, it is essential that CP systems are effective and can be validated at all locations. Compressor Stations and AGIs generally present significant corrosion risks. This is due to the following circumstances: - • Presence of bi-metallic coupling with large "foreign" cathodes, such as concrete rebar, presenting unfavourable anode/cathode area ratios which can result in high corrosion rates. • Pipework experiencing higher temperatures is subject to increased corrosion rates. Above 25 degrees Celsius corrosion rate doubles with each 10 degree increase in temperature. • Soil resistivity measurements indicate that site conditions are aggressive to carbon steel. • The existing CP monitoring facilities do not enable pipe-to-soil potential measurements to be made in critical locations, therefore the CP system cannot be validated in these areas. • Site pipework is not suitable for a PIG.
Decommission the CP system	Not applicable as effective corrosion control measures are essential for as long as the installation is operational.
Component replacement	Some components requiring replacement and/or optimised relocation to ensure satisfactory service over the next 25 years
Component update/repair	Low-cost component repair and update to improve CP monitoring and attenuation, such that CP compliance can be validated. Also presents an opportunity to update the site CP records which is essential for effective control and management of the CP system.
Whole system replacement	Buried pipework at risk of corrosion. To deliver effective cathodic protection, a re-design and replacement of the entire CP system is urgently required.

10.5 Pressure Reduction Skids (PRS) Scope

10.5.1 Pressure Reduction Skids are one of the most complex assets within the Plant and Equipment category theme as the work type can cut across all engineering disciplines with interaction at both design, installation, and operational stages. In RIIO T2 NGT initially targeted delivery of PRS interventions and initial review of the scoping detail required to remedy the known issues as planned revealed that in many cases a simple upgrade is not always the optimal solution to fix a deficiency and as such in many cases a full replacement is required to ensure that the longevity of the asset is maintained. Rationale for full replacement is driven by:

- Differing customer requirements from the original design intent – for example Power stations – flow rates and demands have changed over time which has resulted in the whole stream diameter requiring a change (to combat noise, flow rate, velocity restrictions), and regulator sizes may have changed with differing flow rate demands too, to meet customer demands.
- Obsolete equipment across the entire skids because they've never been upgraded or replaced since installation.
- TD/13 compliance – some skids are not compliant with the Gas Industry standards and with the work being undertaken there is no alternative other than to install equipment that complies with the standards.
- Remedying noise, velocity, and vibration restrictions for PRS skids

10.5.2 In progressing PRS works it transpired that the allocated UIDs were not fully aligned to the actual interventions being implemented. Noting that achieving multiple scopes of work on one site then became a complex activity to map these items back to the existing UID's, a process was undertaken to ensure there was a sensible alignment to respective UIDs. Therefore, the scope for each site has been matched to the existing UIDs based on best endeavours.

10.5.3 High level scope for sites to be executed in Year 4:

- [redacted] - replacement of [redacted] 18" pressure reduction streams including complex control package upgrades, replacement of two slam shut valve control systems.
- [redacted] - replacement of [redacted] flow control valve and pneumatic control system, removal of one flow control valve and control system, modifications to existing pipework
- [redacted] – replacement of [redacted] 8" pressure reduction stream.
- [redacted] – replacement of [redacted] 1" domestic pressure reduction stream

10.6 Options Summary

10.6.1 Selected options for all Plant and Equipment assets identified for 2024/25 and 2025/26 interventions are summarised in Table 22. The table summarises the preferred options for each site identified for works in 2024/25 and 2025/26. It highlights the individual and combined range of interventions per site related to specific and unique UIDs. There are a total of 605 interventions identified to be undertaken across 2024/25 and 2025/26.

Table 22: Years 4 and 5 Option Summary

Subtheme	UID	Intervention	RIIO-2 UID Volumes		Total
			Delivery 2024/25	Delivery 2025/26	
Above Ground Pipework, Cladding and CP Systems	[redacted]	Pipework Modifications Compressor surge issues	[redacted]		
		Pipework Modifications Minor Capex			
		AGI Pipework Painting (Full, Partial or Patch)			
		CM/4 Corrosion Defects Resolution			
		Replace Cladding on AGIs			
		Replacement of Failed IJs on AGIs			
		Resolve Existing AGI CP Priority 1 Defects			
		Resolve Existing AGI CP Priority 2 Defects			
Filters, Scrubbers and Preheaters		Filters PSSR Inspection & Major Overhauls			
		Replace Strainers with Filters/Separators			
		Scrubber & Condensate Tank Internal Inspections & Estimated Major Refurbs			
		Preheater AGI Boiler Replacement			
		Preheater Minor Refurb			
		Preheater PSSR Revalidation, WBH Inspection & Major Refurbs			
		Preheater Upgrade - Compressor Fuel Gas @ Wooler			
Pressure Reduction, Flow Control and Slamshut Systems		Pressure Reduction - Flow Control Valve Upgrade			
		Pressure Reduction Offtakes - Regulator Replacement			
		Pressure Reduction Skid Replacement - Compressor Stations			
		Pressure Reduction Streams - Major Overhauls			
		Pressure Reduction - Flow Control Valve Upgrade			
		Pressure Reduction Offtakes - Regulator Replacement			
		Pressure Reduction Skid Replacement - Compressor Stations			
		Pressure Reduction Streams - Minor Overhauls			
Totals (£m)			[redacted]	[redacted]	605

11 Years 4 and 5 Options Cost Estimate Details

11.1 Cost Estimation Approach

11.1.1 NGT's aim in estimating the asset health UM activities, is to provide cost estimates with the appropriate level of confidence and consistency, based on the available data. NGT have used three methodologies to estimate the Unit costs which to be used in calculating the value for the works in years 4 and 5.

11.1.2 Outturn costs:

- The preferred estimating methodology is where possible, use the outturn actual and forecast cost data for works completed in RIIO-2 so far. To ensure the accuracy of the cost estimate, only the outturn costs for activities completed with similar scope to the years 4 and 5 interventions were used to derive the cost estimates.
- The scope and complexities of years 1 to 3 interventions and years 4 and 5 interventions were compared and normalised, by considering the costs associated with factors such as volume/size, engineering difficulties, location, access, and asset condition. Variations in scope were estimated and then added to, or deducted from, the out-turn cost or to reflect future works accurately.
- To provide granularity and transparency we collated historical cost data against a lower level to the UIDs, for example, for UID [redacted] AGI Pipework painting, was subdivided into equipment categories such as Pipe, AGIs, Block Valves, Multijunction and Offtakes. The outturn costs were collated and analysed for each category resulting in an average unit cost for each of the equipment categories. Where possible to subcategorise the UID future volumes for Years 4 and 5 the average unit cost for the UID subcategories are used, otherwise the weighted average is used for the total UID future volumes. Also, the UIDs weighted average excluding contingency are used to calculate the spend against the volumes in years 1 to 3.

11.1.3 Tendered or contracted prices:

- If relevant historical outturn cost data was not available, tendered or contracted prices were used where appropriate and available. The same level of rigour with regards to scope variation and other factors were followed to ensure consistency and accuracy.

11.1.4 Bottom up estimating methodology:

- If neither historical out-turn cost data nor relevant tendered prices were available, the cost estimates would be developed by internal bottom up estimating methodology, using NGT's unit cost library (for the rates components labour, plant and materials) combined with some price elements extracted from supplier prices of other works. NGT's internal unit cost library is a compilation of labour, plant and materials unit costs collated from frameworks, tenders and contracts.

11.1.5 Since the start of RIIO-2, new ways of working have been implemented and refined, which facilitated this structured approach to estimating years 4 and 5 costs. One of the benefits of this way of working is the ability to capture actual cost to the appropriate level of granularity at asset and intervention levels. For this purpose, the Unit Cost Schedule (UCS) was introduced in all our contracts and became a contractual requirement for all NGT suppliers to populate the UCS. The UCS is an Excel template embedded in the supplier activity schedule, enabling the mapping of actual cost from how they are collated on site into asset intervenable units with associated cost differentiators. This allows the interrogation of cost and understanding the differences in cost for similar UIDs on different sites or assets.

11.1.6 The UCS is kept up to date during the execution of the works, ensuring alignment with NGT's core financial system (SAP) and the Work Breakdown Structure (WBS), to ensure the correct split between direct and indirect costs.

11.1.7 All elements of the cost estimate, whether from historical outturn costs and current prices are in the same base year and then converted to 18/19 prices. Indirect costs are set at [redacted] which is the relationship between total project cost and indirect cost set in accordance with Special Condition 3.18 Opex Escalator. For the purposes of collecting historical costs, the costs are collected as gross costs in our SAP system, inclusive of both direct and indirect costs. Due to the complexity of splitting out gross costs into direct/indirect consistently across all projects and UIDs, the Opex Escalator relationship prescribes a useful definition of the expected split of these costs.

11.1.8 The UIDs unit costs that are calculated from historical outturn cost data, includes for the incurred costs associated with materialised risks and cost savings as a result, of realised opportunities. However, there is a contingency associated with the risks related to the investment proposed in years 4 and 5. This contingency is calculated based on a populated portfolio risk register, that includes delivery risks and risks associated with incomplete designs and surveys. The resulting contingency percentage only included in the unit costs used with years 4 and 5 works and not years 1 to 3 works.

11.1.9 The unit costs calculated from historical data does include the materialised risks and opportunities.

General Estimating Approach Process

11.1.10 The general estimating methodology is shown as a visual process map in Figure 1 and UID specific costing commentary is summarised in Table 25. Appendix 7 of the Asset Health Overarching document contains more detail on the cost estimating methodology.

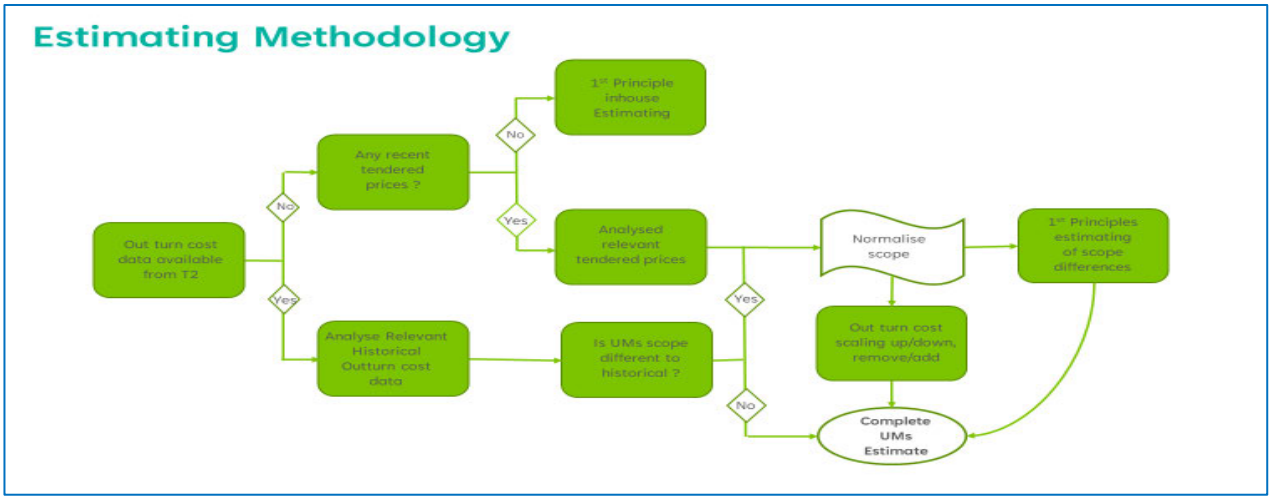

Figure 1: Estimating Methodology

11.1.11 Regarding the data points used to determine year 1 to 3 Unit Cost this can vary to the volumes described for delivery in year 1 to 3 as per *Table 23*. Data Points pulled from UCS are at more granular level than the volumes delivered and forecasted as part of this submission. Hence there will be a discrepancy between data points and volumes which is described in the UID specific commentary in the *Table 23*. It should be noted that claiming of outputs such as LTRB can lag behind work delivery as project closure activities are often undertaken in the following year. There is an active focus on streamlining our project closure process to claim outputs in the year of delivery where possible.

Table 23: UID Specific commentary

UID	Description	Estimating Narrative
[redacted]		

UID	Description	Estimating Narrative
[redacted]		

UID	Description	Estimating Narrative
[redacted]		

UID	Description	Estimating Narrative
[redacted]		

UID	Description	Estimating Narrative
[redacted]		

Figure 2: One of several valves at [redacted] requiring patch painting associated with UID [redacted]

Figure 3 [redacted] - painting habitat associated with UID [redacted]

Figure 4 Drone picture of [redacted]

Figure 5 [redacted] following NARC 23 works

Figure 6 [redacted] - coating replaced on the pipework

Figure 7 [redacted] excavation to replace damaged pipework

11.2 UID Cost Estimates

11.2.1 Cost estimate details for each intervention in 2024 and 2025 are summarised in Table 24. The submitted cost book (appendix 7 of the Asset Health Overarching document) provides more detail on cost granularity.

11.2.2 NGT's application of the derived Unit Costs has been balanced and split in terms a year 1 to 3 and years 4 and 5 methodology. This has been done based on the fact that volumes delivered in years 1 and 2 as well as in flight works due to complete in year 3 are actualised/out turned figures that have fed into the Unit Cost development and as such no risk provision has been added. Forward volumes in years 4 and 5, have included the risk contingency devised via the Quantified Risk Assessment (QRA) method as these aspects have yet to hit site and execute the. The QRA is included in appendix 7 of the Asset Health Overarching document.

Table 24: 2024/25 and 2025/26 year by year cost split(£m)

Subtheme	UID	Intervention	RIIO-2 UID Costs		Total (£m)
			Delivery 2024/25	Delivery 2025/26	
Above Ground Pipework, Cladding and CP Systems	[redacted]	Pipework Modifications Compressor surge issues		[redacted]	
		Pipework Modifications Minor Capex			
		AGI Pipework Painting (Full, Partial or Patch)			
		CM/4 Corrosion Defects Resolution			
		Replace Cladding on AGIs			
		Replacement of Failed IJs on AGIs			
		Resolve Existing AGI CP Priority 1 Defects			
		Resolve Existing AGI CP Priority 2 Defects			
Filters, Scrubbers and Preheaters		Filters PSSR Inspection & Major Overhauls			
		Replace Strainers with Filters/Separators			
		Scrubber & Condensate Tank Internal Inspections & Estimated Major Refurbs			
		Preheater AGI Boiler Replacement			
		Preheater Minor Refurb			
		Preheater PSSR Revalidation, WBH Inspection & Major Refurbs			
		Preheater Upgrade - Compressor Fuel Gas @ Wooler			
Pressure Reduction, Flow Control and Slamshut Systems		Pressure Reduction - Flow Control Valve Upgrade			
		Pressure Reduction Offtakes - Regulator Replacement			
		Pressure Reduction Skid Replacement - Compressor Stations			
		Pressure Reduction Streams - Major Overhauls			

Subtheme	UID	Intervention	RIIO-2 UID Costs		Total (£m)
			Delivery 2024/25	Delivery 2025/26	
	[redacted]	Pressure Reduction - Flow Control Valve Upgrade	[redacted]		
		Pressure Reduction Offtakes - Regulator Replacement			
		Pressure Reduction Skid Replacement - Compressor Stations			
		Pressure Reduction Streams - Minor Overhauls			
Totals (£m)			[redacted]	[redacted]	[redacted]

12 Business Case Outline and Discussion

12.1 Business Case Outline Overview

12.1.1 This section sets out the proposed investment plan for Plant and Equipment assets for years 4 and 5 of RIIO-2 (2024 and 2025). It demonstrates why the proposed investment levels and options for the identified Plant and Equipment assets are at the right level to ensure the health and reliability of these assets for the investment period and beyond.

12.1.2 The operating conditions seen across the NTS means that Plant and Equipment assets deteriorate with time and use which leads to their inability to perform their required function.

12.1.3 Any failure or significant deterioration causes the associated asset to be unavailable and hence does directly affect the availability of the network and compression assets There is potential for inefficient operation of the NTS, increased operational cost and accelerated asset degradation due to Plant and Equipment assets operating in sub-optimal conditions.

12.2 Key Business Case Drivers Description

12.2.1 The key drivers for investment in the Above Ground Pipework, Cladding and CP Systems assets, as stated in Section 4.3, are:

- Asset Deterioration
- Defects
- External Interference
- Operational
- Legislation.

12.2.2 The key drivers for investment in the Filters, Scrubbers and Preheaters assets, as stated in Section 4.3, are:

- PSSR Legislation
- Asset Deterioration
- Asset Performance
- Obsolescence
- Customer Obligations

12.2.3 The key drivers for investment in the Pressure Reduction, Flow Control and Slamshut Systems assets, as stated in Section 4.3, are:

- PSSR Legislation
- Asset Deterioration
- Obsolescence
- Customer Obligations

12.3 Business Case Summary

12.3.1 Options and identified interventions are based on condition-based assessments reviewed as part of NGT's Plant and Equipment rolling asset health plan and bolstered by external Plant and Equipment condition survey reports, and CDPs. The specific interventions selected are driven by the specific defect/level of deterioration and specific identified means of resolving that defect/level of intervention. The costed option is therefore the one that has been selected to provide the most optimum asset management intervention to balance cost risk and performance and deliver on our consumer outcome.

12.3.2 In appraising asset health investment, NGT has considered how the Plant and Equipment related assets can impact on a number of outcomes:

- Availability & Reliability risk.
- Environmental risk.
- Safety risk.
- Societal risk.

12.3.3 On failure, the Plant and Equipment asset elements have an impact on the afore-mentioned outcomes; this is shown in the consequences of failure in sections 7 and 8. However, failure of the full asset can particularly impact the network operational capability.

12.3.4 Maintaining the health of these assets is important in ensuring they continue to deliver the required network capability. Specific outcomes associated with this investment are:

- Maintaining the integrity of the assets now and in the long term efficiently and effectively through the management and remediation of defects.
- Maintaining legal compliance of all the assets, most notably with PSR and PSSR.
- Managing and remediating asset deterioration and specific corrosion issues to ensure that they do not result in a loss of containment of high-pressure gas, present a safety risk, are not a limiting factor on availability or performance of the NTS.
- Ensure as far as possible all buried pipework on sites are protected by effectively cathodic protection systems.
- Maintaining compliance with PSSR.

12.3.5 NGT's proposed investment in the Plant and Equipment assets will ensure that the required assets meet the needs of its customers.

12.3.6 In order to deliver the outcomes for the investment period the Plant and Equipment assets require a mixture of the intervention types defined in Section 10. The decision on the volume of each of the interventions required has been determined using the following methodology:

- Where an asset is required, there is a need for that asset for the foreseeable future to facilitate the safe running of the NTS.

- The chosen approach is to be proactive in resolving issues ahead of further deterioration and failure while developing asset strategy based on learning from ongoing condition analysis. There needs to be a minimum level of pro-active asset intervention planned ahead of significant asset condition and risk. Risks and mitigations reviewed through the RIIO-2 period around gas turbine enclosures in line with HSE guidance and this approach will be continued through the investment period as these assets deteriorate with age and use.
- To manage asset obsolescence in a planned manner.
- A forecast of the number of repairs based on the historical information combined with the knowledge of the proposed replacement and refurbishment work.

12.3.7 A risk-based approach has been used to develop an asset-by-asset list of the appropriate type of intervention to be undertaken. This risk-based approach included:

- Deliverability in terms of internal and external cost and resource
- Issues and defects currently identified, through surveys, and those forecast to arise through the period.
- Asset age, condition and impacts of deterioration and no investment.
- Future need of the Plant and Equipment asset.
- Remaining Life of the Plant and Equipment asset.
- Site Outages where staggering of work on and across sites is required to ensure gas supply is available to meet demand scenarios.

12.3.8 The investment proposed is to maintain, and where possible reduce, the current risk profile across the network by remediating the highest risk currently identified defects together with those which are forecast to be identified during scheduled routine inspection and maintenance activities.

12.3.9 The proposed mix of interventions and programme of work will have been set to maximise delivery efficiency. The intervention programme will be continually reassessed and reprioritised to mitigate the risk of not being able to deliver all the work planned for years 4 and 5 of RIIO-2.

12.3.10 There are currently 605 separate interventions identified for years 4 and 5 of RIIO-2, across the NTS.

12.3.11 In developing interventions and plans and making decisions NGT has been fully cognisant of the need to develop plans that are value for money, acceptable, affordable and deliverable.

12.3.12 No Cost Benefit Analysis has been completed as the technical option based on engineering judgement has been utilised. Investment in Plant and Equipment assets is essential to the safe and efficient running of NGT's NTS. The investment provides life extensions for those Plant and Equipment assets in line with the NGT's overall Asset Strategy. It is vital for the supply of gas to our customers that NGT Plant and Equipment assets remain available and resilient to the demands and changes on the NTS as a whole and investment in our Plant and Equipment infrastructure is essential to ensuring this availability is not compromised.

12.3.13 The level of investment outlined in this paper will ensure NGT successfully manages asset deterioration and obsolescence, whilst meeting legal obligations and expected customer outcomes.

12.4 Network Risk Analysis Based on Proposed Work

12.4.1 99% of the Plant & Equipment Asset Health proposals deliver NARMs outputs with 74% of the proposal driven by Legislation/Safety Case requirements.

12.4.2 LTRB for the proposed interventions will be reported in FY24's NARMs RRP as part of the forecast position, as the interventions are yet to happen. As expressed in the Asset Health Overarching Document, the target adjustment for NGT is proposed to happen after final Ofgem determinations following submission of all three Asset Health re-opener windows.

12.5 Summary of Options Considered for each Sub-theme

12.5.1 A range of options has been considered for each sub-theme of the Plant & Equipment interventions as summarised in Table 25.

Table 25: Summary of options considered for each sub-theme

Option	Narrative
Pre-emptive Refurbishment	This is **an option being taken forward** as the outputs of the surveys of some assets highlight deterioration that would result in failure. As a prudent Asset Management Company NGT should be planning interventions that prevent asset failure. The current volume of defects dictates that this is a position NGT will be in once it is out of the current largely reactive position.
Refurbishment on Failure	This is **an option being taken forward** as there are instances of where components of assets have failed rendering them unusable of ineffective.
Pre-emptive Replacement	This is **an option being taken forward** as the outputs of the survey highlight deterioration that would result in failure and/or assets that need replacement as they do not meet current design standards. As a prudent Asset Management Company NGT should be planning interventions that prevent asset failure.
Replacement on Failure	This is **an option being taken forward** as there are instances of where components of assets have failed rendering them unusable of ineffective.

13 Preferred Option Scope and Project Plan

13.1 Preferred option

13.1.1 The preferred options for each of the **Plant and Equipment** assets, covering the RIIO-2 period, is presented in Table 26. The key benefit of all the selected interventions is that the customer is at lower risk of not receiving energy as and when they need it. The interventions are balanced between refurbishment and replacement resulting from robust condition-based assessment. 460 UID interventions are in scope (completed and inflight) for years 1 to 3 and 605 UID interventions have been identified for years 4 and 5.

Table 26: Preferred P&E Options across RIIO-2

Funding	Subtheme	Above Ground Pipework, Cladding and CP Systems	Filters, Scrubbers and Preheaters	Pressure Reduction, Flow Control and Slamshut Systems	Total UID Volumes
	UID	[redacted]			
Baseline Funded (1 to 3)	Year 1				[redacted]
	Year 2				
	Year 3				
	Yrs.1-3 UID Vols.				*460*
Uncertainty Mechanism Funded (Yrs. 4&5)	Year 4	[redacted]			[redacted]
	Year 5				
	Yrs. 4&5 UID Vols.				*605*
RIIO-2 UID VOLS.					1065

13.2 Plant and Equipment Asset Health Spend Profile

13.2.1 For Plant and Equipment related interventions Detailed Design and Build (DD&B) are completed in the same year. Table 27 summarises the spend profile detailing when the interventions for each selected set of options, has been completed or is expected to take place. This cost includes the survey and options assessment activities conducted in determining interventions and costs. There are some preparatory activities, such as survey and feasibility leading up to actual interventions that have resulted in costs incurred to date and this is summarised in Table 27. Included in the table are the costs incurred and forecast for activities completed and forecast to be complete in years 1 to 3.

Table 27: Overall P&E Estimated Spend Profile for RIIO-2 (£m) - 18/19 price base

Description	FY22	FY23	FY24	FY25	FY26	Totals (£m)
Yr 1-3 interventions de ivered through Base ine a owances	[redacted]					
Yr 4 interventions de ivered through Base ine a owances						
Yr 4-5 interventions de ivered through additiona a owances requested (UM)						45.778
Totals						114.305

13.3 Efficient Cost

13.3.1 NGT costs are based on current assumptions made as a result of its experience of completing similar asset health interventions in the first three years of RIIO-2. The identified asset health interventions will adopt learning from ongoing intervention projects covering items such as contracting strategy, surveys, bundling etc.

13.3.2 The following key points have guided NGT's cost efficiency:

- Defect data, surveys outputs and CDPs driving a range of site and asset specific Plant and Equipment specific scopes that reduce scope creep resulting in a reduction in compensation events and enable efficient procurement and cost control during delivery. It must be noted that based on an assessment of years 1 to 3 interventions the scope within a single UID can vary and this has an impact on costs.
- Option selection being guided by relevant specific drivers such as legislation, environment, HSE guidance, safety, asset condition, etc.
- A consistent cost estimation approach following a strict hierarchy cascading in order of confidence from outturn costs, through competitive tendered prices to in-house 1^{s} principles cost estimation. This approach ensures consistency and enables the team to focus efforts on high-cost activities, during procurement and negotiation stages.
- Efficiencies due to bundling and contracting strategies, have already been realised and are embedded in the out-turn cost data of completed activities in RIIO 2 used to estimate the activities within the UMs.
- Structured approach to estimating costs by capturing actual cost to the appropriate level of granularity at asset and intervention levels through contractual Unit Cost Schedules populated by all external contractors.
- Use of external contractors to provide independent scopes and costs for validation by NGT.
- Negotiating volume discounts and additional 'value add' services, such as free training or call-out support.
- Bundling works into different packages of work therefore creating lessons learned and best practise for how to maximise efficiencies at tender and what to include in a package contract to aid smooth delivery.
- Consideration of in-house delivery of works where appropriate.
- The project delivery approach to bundle and ramp up FY24 interventions is has been reviewed to adapt it to the FY25 and FY26 interventions.

13.4 Project Plan

13.4.1 The milestones are based on NGT's current view of when each site will be intervened on. NGT has also considered wider works planned across the NTS. Internal stakeholder engagement has identified the best time to undertake these interventions, so the milestones are based on this timescale. *Table 28* is NGT's summary plan and provisional internal sanction milestones identified to deliver the Plant and Equipment interventions within RIIO-2. The table provides the current view of the range of dates covering the different work packages across the Plant and Equipment theme over 2024/25 and 2025/26.

13.4.2 The project plan has been aligned to currently planned system outages.

Table 28 Summary Project Plan and Provisional Sanction Dates

Network Development Stage Gates	Sanction Dates
T0	N/A
T1	Sept20 to Aug21
F1 (Scope Establishment)	Sept20 to Aug21
T2	Apr21 to Sept22
F2 (Option Selection)	Apr21 to Sept22
T3	Aug21 to May23
F3 (Conceptual Design Dev/Long Lead Items)	Aug21 to May23
T4	Mar23 to Nov23
F4 (Execute Project)	Apr23 to Feb24
T5	Oct22 to TBC
ACL (Available for Commercial Load)	Completion by the end of RIIO-2.
T6	Completion by the end of RIIO-2.
F5 (Reconcile and Closure)	Completion by the end of RIIO-2.

13.5 Key Business Risks and Opportunities

13.5.1 All Plant and Equipment assets identified for intervention are in line with NGT's Needs Case and future strategy of keeping gas flowing in the interests of consumers. Key risks and currently identified mitigations are summarised in Table 29. These risks have been extracted from the costed risk register in the cost book contained in Appendix 7 of the Asset Health Overarching document.

Table 29: Plant and Equipment key risks and identified mitigations (extracted from costed risk register)

No.	Risk	Mitigation (based on current view)
1	There is an **opportunity** of bundling the works together on each site	Going to look at exploring different bundling options for delivery, including programming of works, depending on best efficiencies available.
2	There is an **opportunity** of long lead procurement efficiencies through early bulk purchasing or utilising spares	Identify and categorise all Long Lead Items.
3	There is a risk of buried services being identified	Check data banks and internal desktop review but ensure GPR & underground surveys are completed in areas of the works as assurance to de-risk
4	There is a risk of additional site surveys	Try to minimise number of surveys by getting multiple contractors to site for each aspect of works
5	There is a risk of increase to materials prices impacting project launch	Project team to work with 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
6	There is a risk of diluted operational resource support due to a number of concurrent projects running on site	Close engagement with Operations and frequent meetings to ascertain resource requirements.
7	There is a risk of additional scope requirements (including mechanical, design & civil) leading to scope change / scope creep	Close engagement with contractor and site operations. Detailed surveys to ensure no additional works required
8	There is a risk of outage issues (prior, during or post mobilisation)	Communication with Portfolio Planning team to understand projects scheduled during this period.
9	There is a risk of weekend working / additional resource required	Regular Programme Reviews required with Operations and Contractor.
10	There is a risk of policy changes impacting upon project requirements	Close engagement with Safety Engineering to any upcoming specification updates.
11	There is a risk of unavailability / delayed delivery of long lead items	Frequent communication with Contractor to ensure that Long Lead Items are ordered, and FAT Test dates are reserved on Programme.
12	There is a risk of development of additional Operational Drawings (Engineering Drawing) and associated appraisal for the modification implemented	Identify all drawings that require updating at FEED stage.
13	There is a risk of increase to exchange rates affecting project costs	Project team to work with MWC to monitoring exchange rates, ensuring materials are procured in a timely manner.
14	There is a risk of adverse weather conditions affecting the works	Liaise with contractor to avoid interdependent activity i.e., Heavy Lifting where possible.
15	There is a risk of resource unavailability (internal & external)	Regular meetings to review resource requirements with early recruitment and appointment of resource to the project
16	There is a risk of additional works after condition testing relating to unresolved defects	Known concern due to nature of the discipline. Project to produce a commissioning plan and report, and investigation methodologies to minimise impact of identification and rectification processes
17	There is a risk of increase to fuel prices impacting upon project launch	Project team to work with MWC to monitoring prices and obtain at the most suitable time

No.	Risk	Mitigation (based on current view)
18	There is a risk of delays due to nesting birds, pests and additional environmental considerations.	Intrusive surveys required where necessary.
19	There is a risk of unsuitable ground conditions for excavation	Ground investigations and bore holes to be completed to assess ground conditions, weather monitoring around ground related activities. Unforeseen residual risk will always remain
20	There is a risk of lack of contractor availability	Engagement with the market as early as possible and ensure resource is ringfenced and booked to the project as early as possible

13.5.2 In developing unit costs to progress and complete identified interventions, NGT has considered the following, as key opportunities, to ensure efficiencies:

- Detailed scoping of works to ensure intervention specific works are costed and completed.
- Aligning intervention activities with NTS outage programmes.
- Resource scheduling to ensure efficient and timely delivery.
- Bundling works together on each site where multiple Plant and Equipment interventions are required.
- Bundling of works with other Plant and Equipment Asset Health impacted sites, bringing contracting efficiencies.
- Assessed procurement efficiencies through early bulk purchasing.

14 Conclusion

14.1.1 This report is submitted in accordance with the National Transmission System Gas Transporter Licence Condition 3.14 Asset Health Re-opener, Price Control Deliverable Reporting Requirements and Methodology Document and RIIO-2 Re-opener Guidance and Application Requirements Document.

14.1.2 This paper has explained the Needs Case, options considered and presented NGT's preferred options and associated requested funding to ensure NGT's Plant and Equipment assets operate to meet customer requirements. Ofgem are invited to assess and approve this funding request.

14.1.3 NGT proposes that the allowances in accordance with Special Condition 3.14 are adjusted to reflect the year 1 to 5 funding request of **£114.305m**, within this EJP as shown in Table *30*.

Table 30: P&E RIIO-2 Asset Health -Non-Lead Assets PCD Tables (all in scope of the Asset Health UM)

Subtheme	UID	Intervention	RIIO-2 UID Volumes			Cost (£m)		
			Yrs. 1-3	Yrs. 4&5	Total	Yrs. 1-3	Yrs. 4&5	Total
Above Ground Pipework, Cladding and CP Systems	[redacted]	Pipework Modifications Compressor surge issues	[redacted]					
		Pipework Modifications Minor Capex						
		AGI Pipework Painting (Full, Partial or Patch)						
		CM/4 Corrosion Defects Resolution						
		Replace Cladding on AGIs						
		Replacement of Failed IJs on AGIs						
		Resolve Existing AGI CP Priority 1 Defects						
		Resolve Existing AGI CP Priority 2 Defects						
Filters, Scrubbers and Preheaters		Filters PSSR Inspection & Major Overhauls						
		Replace Strainers with Filters/Separators						
		Scrubber & Condensate Tank Internal Inspections & Estimated Major Refurbs						
		Preheater AGI Boiler Replacement						
		Preheater Minor Refurb						
		Preheater PSSR Revalidation, WBH Inspection & Major Refurbs						
		Preheater Upgrade - Compressor Fuel Gas @ Wooler						
		Pressure Reduction - Flow Control Valve Upgrade						

Subtheme	UID	Intervention	RIIO-2 UID Volumes			Cost (£m)		
			Yrs. 1-3	Yrs. 4&5	Total	Yrs. 1-3	Yrs. 4&5	Total
	[redacted]	Pressure Reduction Offtakes - Regulator Replacement	[redacted]					
Pressure Reduction, Flow Control and Slamshut Systems		Pressure Reduction Skid Replacement - Compressor Stations						
		Pressure Reduction Streams - Major Overhauls						
		Pressure Reduction - Flow Control Valve Upgrade						
		Pressure Reduction Offtakes - Regulator Replacement						
		Pressure Reduction Skid Replacement - Compressor Stations						
		Pressure Reduction Streams - Minor Overhauls						
Totals (£m)			**460**	**605**	**1,065**	[redacted]	[redacted]	**114.305**

14.1.4 The total RIIO-2 forecasted spend is **£114.305m** as summarised in Table *31*. Baseline funding of **£68.527m**[5] was awarded. Therefore, though the total RIIO-2 spend is **£114.305m** the total funding request being made through this paper is **£45.778m.**

Table 31: Summary funding request

Description		**Totals (£m)**
Baseline Interventions (yrs. 1-3)	***Baseline Breakdown (£m)***	
	Actual spend	[redacted]
	Awarded FD spend	*68.527*
	Actual - Awarded	[redacted]
Years 4&5interventions		[redacted]
Total RIIO-2 spend		114.305
Awarded baseline spend		**68.527**
Funding request being made through this paper		**45.778**

14.1.5 All works proposed under this submission have been reviewed and assessed with NGT delivery vehicles to ensure stable delivery within the remainder of the RIIO-T2 price control period.

[5] This includes Baseline allowances for two St Fergus UIDs, other Baseline allowances for Bacton and St Fergus under the Plant and Equipment theme are excluded. The treatment of those UIDs is described in section 6 of the Overarching Document (NGT_AH3_01).

Appendices

Appendix A: Sample Option Papers

(Please note option paper include some non-Plant and Equipment UM related UID's as the sites were surveyed to identify all defects)

Appendix B: Cathodic Protection Optioneering Reports

Appendix C: King's Lynn Multi Junction Subsidence Submission