Scottish & Southern Electricity Networks

RIIO-T2 Business Plan: T2BP-EJP-0019-Rev1.1

Broadford Substation Works

Engineering Justification Paper

1 Executive Summary

Our paper A Risk Based Approach to Asset Management[1] sets out our approach to network risk and how, we subsequently identify assets that require intervention; to limit the rise of the risk over the RIIO-T2 period.

Following Ofgem's draft determination, the need and scope of this project has been reviewed. This paper outlines and demonstrates the key intervention requirements for asset replacement works at Broadford 132kV substation. The primary driver for the works are asset condition and the exceptionally poor performance of the same type of circuit breaker on our and other networks.

In addition to this, there are several significant issues present which are considered to be secondary drivers. These relate to network security and reliability for the wider Skye network and connected customers.

Following a process of optioneering and detailed analysis, as set out in this paper, the proposed scope of works is:

- Replacement of circuit breaker 305, disconnector 113, Grid Transformer (GT) 1 NER, and associated feeder and GT1 protection systems
- Provision of a GT1 circuit breaker 115, to enhance network security and reliability

This scheme delivers the following outputs and benefits:

- Improved operational flexibility and resilience, in line with our goal of 100% network reliability
- A reduction in the risk of failure in the electricity supply to Skye and Western Isles from the main transmission system and the associated cost [redacted] and environmental impacts of extensive use of diesel generation.
- Use of innovative non SF_6 solutions (for the Circuit Breakers)
- Contribution to our goal of one third reduction in greenhouse gas emissions
- Brings aspects of the existing infrastructure in line with current standards and practices, increasing network security and reducing operational risks.

This scheme will deliver an immediate reduction of total network risk [redacted] for a cost of [redacted] and the works are planned to be completed within the RIIO-T2 period. The Long-Term Monetised Risk Benefit is calculated as [redacted].

The Broadford scheme is not flagged as eligible for early or late competition due to it being under Ofgem's £50m and £100m thresholds respectively.

[1] A Risk Based Approach to Asset Management

Name of Scheme/Programme	Broadford Substation Works
Primary Investment Driver	Asset Health (Non-Load)
Scheme reference/ mechanism or category	SHNLT2012 Switchgear (replacement)
Output references/type	NLRT2SH2012 Switchgear (replacement)
Cost	[redacted]
Delivery Year	Within the RIIO T2 period
Reporting Table	C.07 Non-Load Master Data
Outputs included in RIIO T1 Business Plan	NO

2 Introduction

This Engineering Justification Paper sets out our plans to undertake network condition work during the RIIO-T2 period (April 2021 to March 2026). The planned works are at Broadford Substation; as shown on the map below.

The Engineering Justification Paper is structured as follows:

Section 3: Need

This section provides an explanation of the need for the planned works. It provides evidence of the primary and, where applicable, secondary drivers for undertaking the planned works. Where appropriate it provides background information and/or process outputs that generate or support the need.

Section 4: Optioneering

This section presents all the options considered to address the need that is described in Section 3. Each option considered here is either discounted at this Optioneering stage with supporting reasoning provided or is taken forward for Detailed Analysis in Section 5.

Section 5: Detailed Analysis

This section considers in more detail each of the options taken forward from the Optioneering section. Where appropriate the results of Cost Benefit Analysis are discussed and together with supporting objective and engineering judgement contribute toward the identification of a selected option. The section continues by setting out the costs for the selected option.

Section 6: Conclusion

This section provides summary detail of the selected option. It sets out the scope and outputs, costs and timing of investment and where applicable other key supporting information.

Section 7: Price Control Deliverables and Ring Fencing

This section provides a view of whether the proposed scheme should be ring-fenced or subject to other funding mechanisms.

Section 8: Outputs included in RIIO-T1 Business Plan

This section identifies if some or all the outputs were included in the RIIO-T1 Business Plan and provides explanation and justification as to why such outputs are planned to be undertaken in the RIIO-T2 period.

2.1 Post Draft Determination Update

Since the receipt of feedback from Ofgem as part of their draft determination, this paper has been revised to emphasise the critical nature of Broadford Substation and to provide further information on options considered.

Further detailed information on the type of circuit breaker – Brush DB145 – has been added. This includes information obtained from other owners of this type of circuit breaker. This continues to show a problem inherent with this type of circuit breaker, with the breaker at Broadford an exceptional case as the only breaker of this type that has not to date exhibited substantial leaks.

The proposed scope has been modified to include a circuit breaker on the transformer, in line with current engineering specifications and greenhouse gas emission targets. The costing information has been modified to account for the cost associated with running generation during the outage required for the works at Broadford.

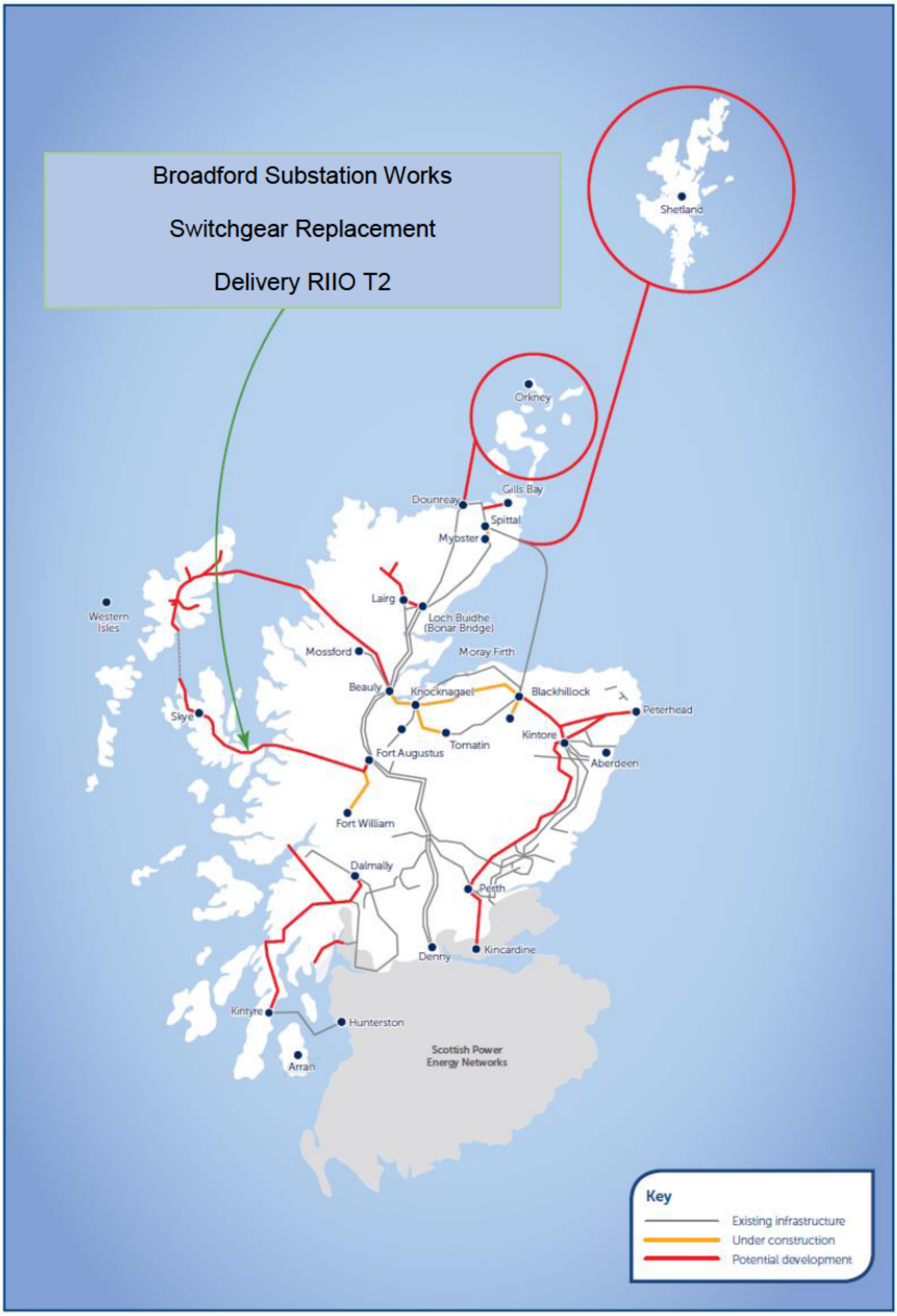

Figure 1 - Geographical Representation

3 Need

This section provides an explanation of the need for the planned works. It provides evidence of the primary and, where applicable, secondary drivers for undertaking the planned works. Where appropriate it provides background information and/or process outputs that generate or support the need.

3.1 Background

Broadford substation is located on the Isle of Skye, nine miles to the west of Kyle of Lochalsh. The site forms a critical part of the Main Interconnected Transmission System (MITS) as the part of the single circuit 132 kV line supplying the Western Isles.

The site is a shared location with Scottish Hydro Electric Transmission (SHE Transmission) and Scottish Hydro Electric Power Distribution (SHEPD) plant, equipment and common shared services. Transmission primary assets and all secondary systems are located within a single shared compound with SHEPD assets.

3.2 Asset Need

The original substation at Broadford was constructed in the 1950's. The site has undergone periods of refurbishment, notably GT1 installation in 1978 and the 132kV CB replacement in 1989.

Broadford GSP is a single point of failure in our network, as can be seen in Figure 2. Any fault at Broadford would result in loss of grid connection to the entirety of the Western Isles. The same level of risk exists for system protection; any loss of protection at Broadford would incur a loss for the complete Western Isles line.

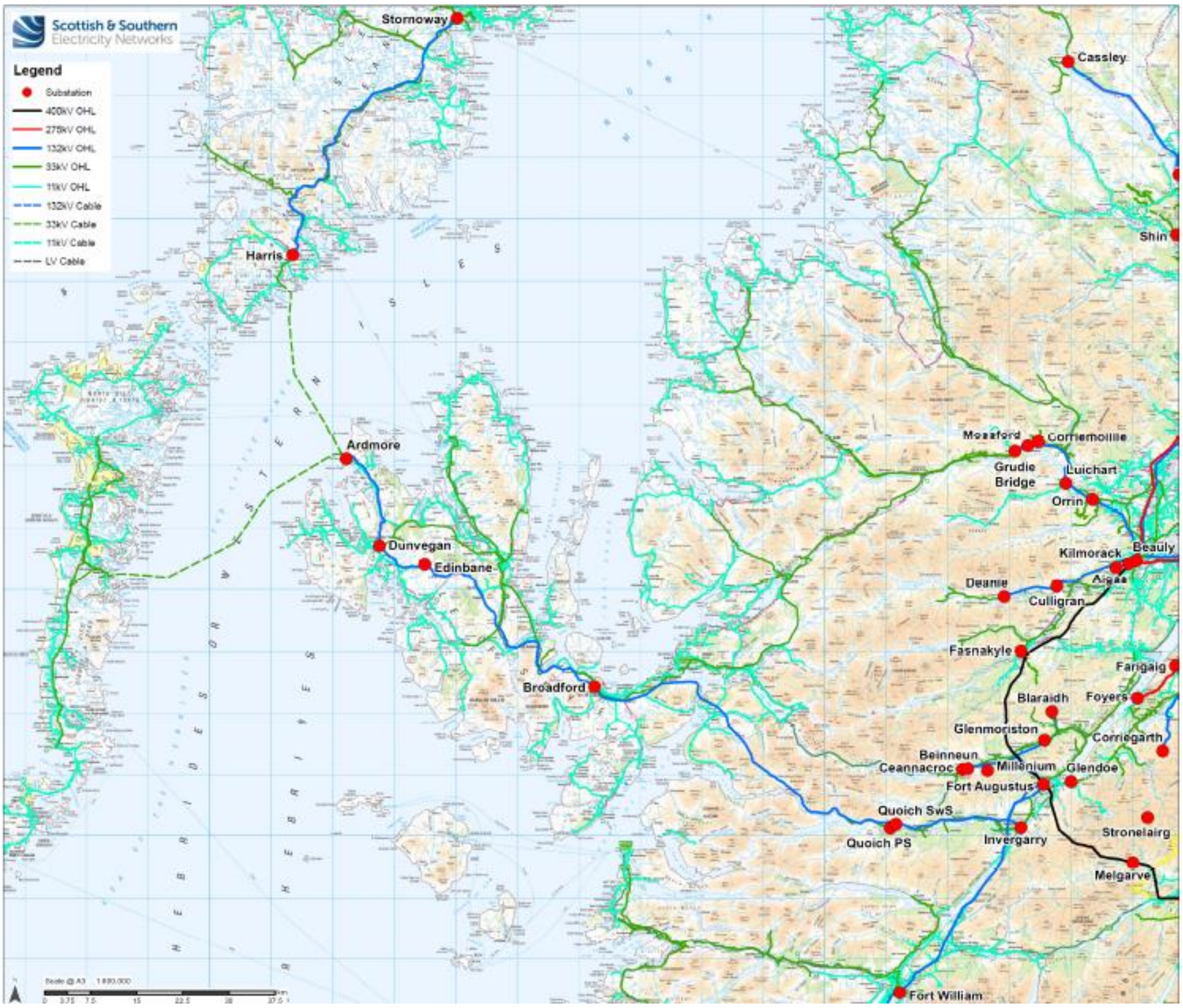

Figure 2 – Single Circuit Overhead Line from Broadford to Stornoway

Loss of the Broadford Grid would result in loss of supply to some 27,000 domestic and industrial consumers on the Western Isles. Whilst restoration times are minimum, consumers' supplies can only be restored through the running of diesel generation, which can only be run [redacted] days. The costs of running this diesel generation is high – in excess [redacted] – it is also carbon intensive and requires staff to be diverted from other duties. These staff are then not available to respond to other disturbances on the network. Additionally, the ability to restore all customer supplies from the power stations in the Western Isles is becoming limited due to load increases, largely in Skye; this means that any network failure may result in extended customer interruptions and the requirement to install mobile diesel generators. These additional costs have not been factored into this paper.

In RIIO-T1, the Fort Augustus to Stornoway line was on outage for [redacted], with power station costs of [redacted]. Broadford Grid has been on outage for maintenance or repair for a total [redacted] days. At [redacted] Note these costs do not include any maintenance or repair costs, but are purely related to the running of the power station.

In the event of a failure to the circuit breaker at Broadford this diesel generation would have to operate until such point as the circuit breaker was replaced and commissioned. If a spare circuit breaker was available the outage would be approximately ten days, costing in excess of [redacted] emergency generation only and causing undesirable carbon emissions. In addition, the prime capital and installation cost would add to this.

The circuit breaker at Broadford is of a type which exhibits poor performance within SHE Transmission and other Network Operators. The Asset Condition Report[2] (ACR) details the condition and performance issues.

In summary, there are a number of areas which need to be addressed at Broadford GSP.

1. Plant and System Protection

    - The plant and system protection at Broadford Grid are of unusual arrangements with significant deficiencies both in age and configuration and the check sync performs poorly. As a result, there is a higher chance of an uncleared fault and cascade failure.

    - Any cascade protection failure would cause damage on the network beyond the original fault.

    - The existing configuration at Broadford does not allow for the grid transformer to be isolated for maintenance or repair without isolating the entire Western Isles, with the resultant need for diesel generation to provide a consumer supply.

2. Transformer and auxiliaries

    - Whilst GT1 itself is in satisfactory condition, the transformer bund is non-compliant and there are no oil handling/containment facilities.

    - GT1 NER is fluid filled and the design is obsolete

3. Circuit Breaker 305

    - The existing breaker 305 is a Brush DB145 circuit breaker. Breakers of the same make and model have performed very poorly in the past, both in SHE Transmission and on other transmission and distribution networks.

[2] Broadford Asset Condition Report

- Spares for this breaker type are no longer supported by the manufacturer, and experience elsewhere on the network has demonstrated the challenges in sourcing alternative spares.

- In the last financial year, six of these breakers were in service on the SHE Transmission network, across three substations: Broadford, Errochty and Keith.

- SHE Transmission's experience of this type of breaker is not positive, and we believe them to be inherently unreliable as evidenced by removal of seven more breakers of this type during RIIO-T1. The data below shows all remaining instances of this breaker type, with the exception of Broadford 305, have displayed annualised leakage across RIIO-T1 in excess of that stated as natural leakage by the manufacturer. The table below summarises this:

Substation	**ID**	**Year**	**SF6 Weight (kg)**	**Natural Leakage Rate (%)**	**Number of pumping records**	**Number of pumping records in RIIO-T1**	**Total Weight pumped in lifetime (kg)**	**Total Weight pumped in RIIO-T1**	**Annualised Leakage Rate (% installed kg/ year) (RIIO-T1)**
Broadford	305	1989	10.5	1	2	1	1.7	0.3	0.40%
Errochty	705	1991	10.5	1	3	2	2.66	1.56	2.09%
Keith	405	1990	10.5	1	26	20	23.69	16.19	21.67%
Keith	505	1990	10.5	1	7	4	4.55	2.25	3.01%
Keith	605*	1990	10.5	1	16	16	8.7	8.7	11.65%
Keith	705	1990	10.5	1	6	2	4.55	1.25	1.67%

Table 1 - Brush DB 145 Breaker Leakage

- At Keith, circuit breaker 605 was removed and replaced as emergency works in September 2019 due to excessive leakage. Similarly, 405 requires replacement and will also be removed from the network as part of an ongoing project. The remaining Brush DB145 breakers at Keith should be replaced as part of another core non-load scheme during RIIO-T2.

- The next two charts show the Brush DB 145 is comparison to other circuit breakers on the SHE Transmission network[3].

[3] Keith 605 is not shown in these figures as it has been removed from the network; hence five DB145s

- Figure 3 shows the total number of pumping records against the total amount of gas pumped for different circuit breaker types. The size of the bubbles is relative to the number of circuit breakers. The data labels contain details of the number of operating circuit breakers that have experienced a leak. It can be seen that five out of five operating DB145 circuit breakers have experienced a leak, and the quantity of gas and number of pumping operations is large compared to circuit breakers that are many times more numerous on our network.

- Figure 4 is a scatter plot of the same thing but for 132 kV and the values have been averaged using the number of circuit of breakers of each type to have experienced a leak. It shows the DB145 to be the worst performing 132 kV circuit breaker type on our network.

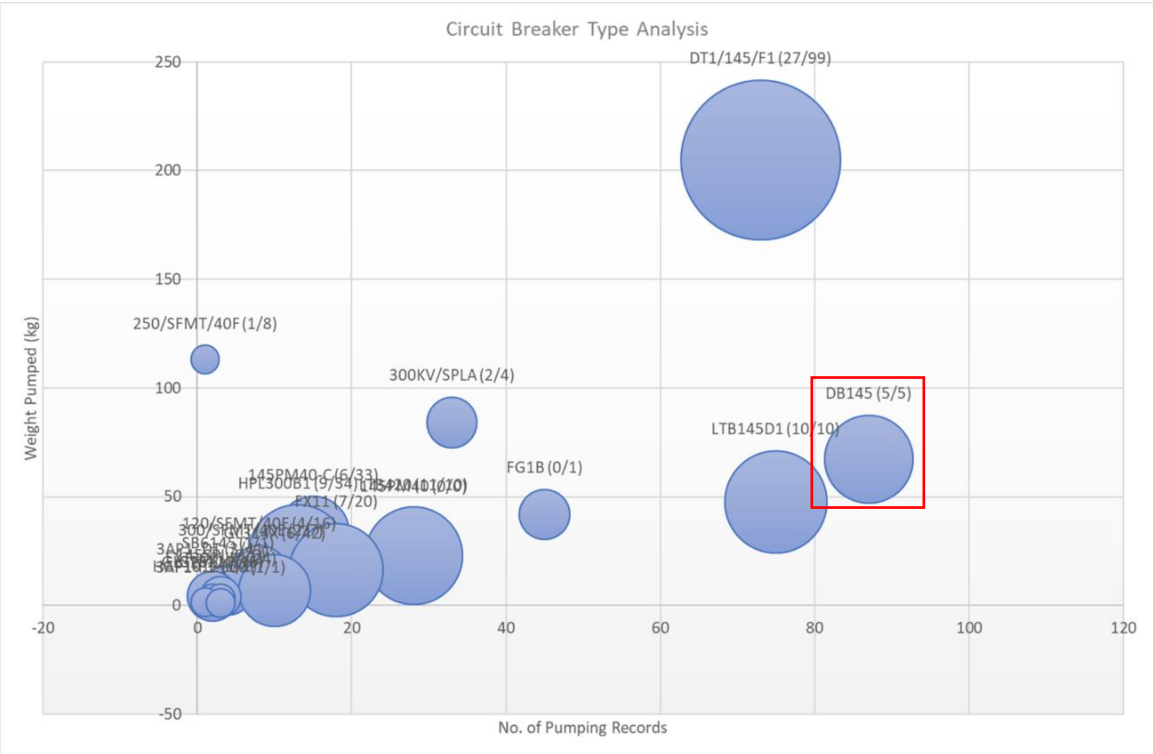

Figure 3 - Circuit Breaker Type Analysis (all voltages)

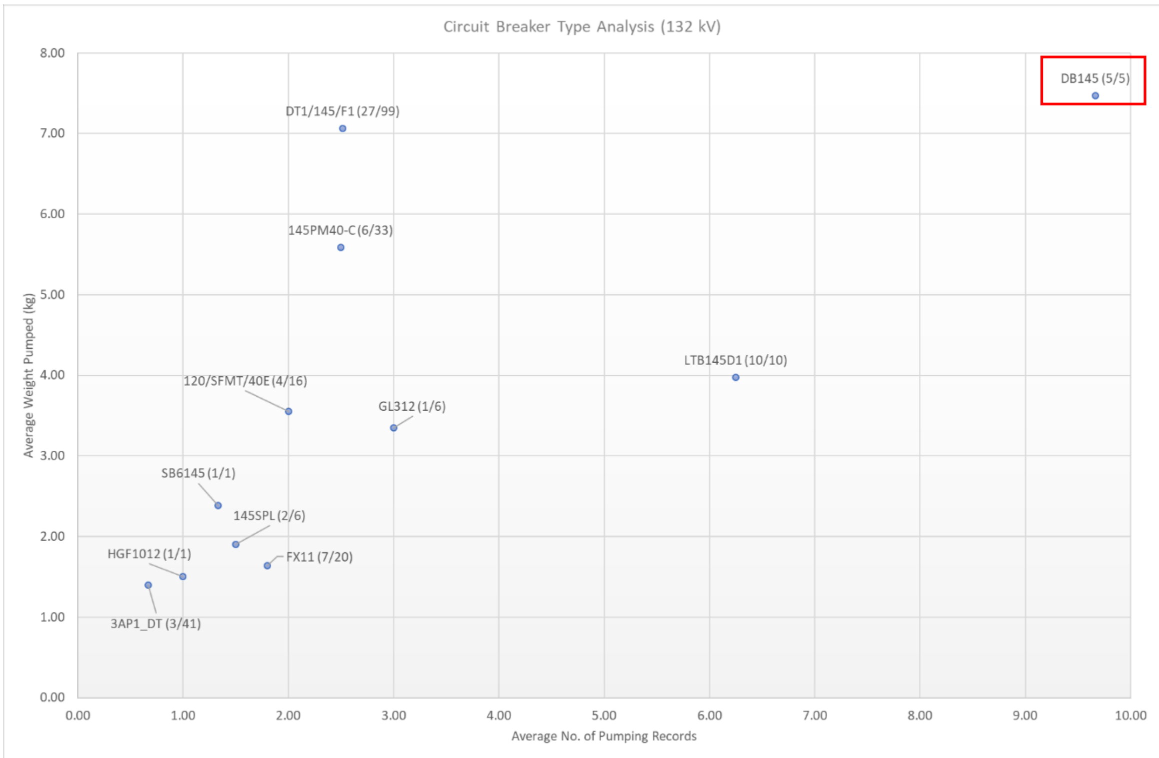

Figure 4 - Circuit Breaker Type Analysis (132 kV circuit breakers)[4]

- SHE Transmission have consulted with other network operators regarding their experience of the Brush DB145 – this also shows a problem inherent with this type of circuit breaker:
  - UK Power Networks have also experienced high gas leakage from Brush DB145 circuit breakers, stating the following in their 2017/18 Environment Report[5]:

    "In 2017/18, in our EPN region, we successfully completed an expedited programme of works to replace two 132kV Brush DB145 SF_6 filled circuit breakers at Colchester Grid which were leaking heavily and substantially contributed to the poor EPN performance alluded to earlier. (21.85 kilograms of SF_6 were emitted, accounting for 30% of SF_6 leaks in EPN during the 2017 calendar year.)"
  - A transmission network operator stated they have removed all bar one of this type of breaker and plan to replace the remaining one by 2026 due to gas leakage. This remaining breaker has lost approximately 12 kg of gas in three years.

[4] A single outlining circuit breaker type, with a higher numbering of pumping records, of which we have only one remaining in service, is not shown in this graph as it is to be removed by a current in progress works.
[5] https://www.ukpowernetworks.co.uk/internet/en/about-us/documents/Annual_Environment_Report_2017-18v1.0.pdf

  - A different transmission network operator told us they removed all hydraulically operated circuit breakers, due in part to reliability and difficulties in sourcing spare parts. (The Brush DB 145 is hydraulically operated; SHE Transmission have also experienced difficulty obtaining parts as noted above.)

- A review of publicly available literature has also been performed; CIGRE TB 510[6] provides information about the failure of circuit breakers up to 2007 (the end of the survey). For live tank circuit breakers, it states that major failure frequency per 100 circuit breaker years is 0.42 for breakers manufactured 1989-1993 but only 0.18 for those manufactured 2004-2007. This is part of a downward trend in failure rates as manufacturing year approaches the present. In summary CIGRE TB 510 states "the newer circuit breakers, the lower the associated MaF [major failure] frequencies".

In addition to condition experience, the criticality of Broadford 305 must be taken into consideration.

Should the condition of 305 deteriorate, as we and others have experienced with this breaker type elsewhere, regular top-up filling would be required. Offline SF6 filling (i.e. with circuit dead), which is standard practice from a safety perspective, requires planned outages necessitating widespread switching to supply Skye and the Western Isles by backfeeds, in addition to the use of diesel generation at a cost in excess [redacted], and constraint of renewable generation in the Western Isles. This is labour intensive in a remote part of the network, environmentally undesirable, and places the network and customers at a greater risk. The risk of this occurring with any increasing frequency is unacceptable.

An unplanned outage through fault or failure of Broadford 305 circuit breaker would result in the loss of supplies to all customers on Skye and the Western Isles until switching could be undertaken, and backfeeds and diesel generation put in place. It should be noted that diesel generation can only be run for a maximum of 14 consecutive days. Sourcing of spare parts coupled with the relative remoteness of the site make failure investigation and corrective action, or unplanned breaker replacement, challenging to achieve in this time period.

Given the history of poor performance of DB145, and network and customer impact of failure, it is deemed appropriate to ensure a proactive rather than reactive approach is taken, and that Broadford 305 is replaced with a reliable alternative in a controlled and planned manner, during RIIO T2.

[6] CIGRE Technical Brochure (TB) 510 – Final Report of the 2004 – 2007 International Enquiry on Reliability of High Voltage Equipment – Part 2 - Reliability of High Voltage SF_6 Circuit Breakers

3.3 Growth Need

Within the scope of this paper, demand is not projected to significantly rise in the medium term thus there is no growth need to be considered for the site.

4 Optioneering

This section presents all the options considered to address the "need" that is described in Section 3. Each option considered here is either discounted at this Optioneering stage with supporting reasoning provided or, is taken forward to Detailed Analysis in Section 5.

The Asset Condition Report[2], together with our and others experience with the Brush DB145, does not support "do nothing" scenario(s). Leaving the installed circuit breaker is not an option due to poor experience with this type of circuit breaker and presents increasing risk of failure; and/or presents risks to operational personnel which are unacceptable.

In addition, an unplanned outage on this breaker will necessitate the running of diesel generation on Battery Point, Arnish, Loch Carnan and Barra to supply domestic and industrial consumers, for approximately two weeks. This would consume [redacted], and is the equivalent [redacted]f carbon dioxide.

It is considered that the asset replacement works must occur within the RIIO-T2 period (April 2021 to March 2026). Four options including minimal asset replacement and focused intervention is made within this EJP as follows. All the costs in the below table include an allowance for the running of diesel generation, to maintain supplies to Skye and the Western Isles, for the duration of outage works. The outage is expected to last ten days. The costs associated with this diesel generation were not included in the previous submission; they constitute a significant portion of the cost for every option and cannot be avoided.

Option	Option Detail	Cost (£m)	Taken forward to Detailed Analysis?
0	Do Nothing	0	No
1	Replacement of CB 305	[redacted]	Yes
2	Replacement of CB 305 and DS 113	[redacted]	Yes
3	As option two plus associated Asset Replacement and Protection Modifications	[redacted]	Yes
4	As option two plus associated Asset Replacement, Protection Modifications and Bund Remedial Works	[redacted]	Yes

Table 2 – Options Summary

Option 0 – Do Nothing

As has been detailed in this report, our and others poor experience with the Brush DB145 circuit breaker show a problem inherent with this type of circuit breaker. Therefore, leaving the current circuit breaker in place is not an option as it presents an unacceptable risk of failure on a critical part of the SHE Transmission network.

NOT PROGRESSED TO DETAILED ANALYSIS

Option 1 – Replacement of CB305

This option is for minimal asset replacement based on the findings of the ACR.

Benefits:

- Replacement of CB305 improves security of supply and Network reliability, reduces environmental risk.
- More recently manufactured circuit breakers have a lower probability of failure compared to those manufactured at the time of the current circuit breaker.

It should be noted that replacement of the existing DC battery, LVAC systems and the site diesel generator, will be covered under a separate non-core, non-load scheme paper.

Risks and Concerns:

- This does not address concerns regarding the deficient protection systems or consequences of a fault at Broadford.
- Bypassing of the 132kV OHL is not achievable, which limits options for the replacement and refurbishment works.
- This does not address the environmental concerns raised by the non-compliant GT1 bund and the lack of oil containment facilities.

PROGRESSED TO DETAILED ANALYSIS

Option 2 – Replacement of CB305 and DC113

- Replacement of:
    - Feeder CB305
    - GT1 DC113 with a circuit breaker CB115

Benefits are as Option 1, plus:

- CB115 allows for the isolation of Broadford Grid transformer from the network without the need for de-energisation of the incoming circuit and the associated requirement for diesel generation-driven backfeeds for the Western Isles.

Risks and Concerns:

- This does not address concerns regarding the deficient protection systems or consequences of a fault at Broadford.
- This does not address the environmental concerns raised by the non-compliant GT1 bund and the lack of oil containment facilities.

PROGRESSED TO DETAILED ANALYSIS

Option 3 – As Option 2 plus Associated Asset Replacement and Protection Modifications

- Replacement of:
  - Feeder CB305
  - GT1 DC113 with a circuit breaker CB115
  - GT1 NER with a dry type unit
  - GT1 protection system
- Modification of Feeder protections to incorporate backup protection functions, interface to new CS115, removal of fault thrower;
- Removal of Power Line Carrier (PLC) and replacement with triangulated digital Intertripping;

Benefits are as option 2, plus:

- The addition of an HV circuit breaker (115) allows for modification of Protection Systems, and the installation of triangulated digital Intertripping to improve Network reliability and security

Risks and Concerns:

- This does not address the environmental concerns raised by the non-compliant GT1 bund and the lack of oil containment facilities.

PROGRESSED TO DETAILED ANALYSIS

Option 4 – As Option 2 plus Associated Asset Replacement, Protection Modifications and Bund Remedial Works

- Replacement of:
    - Feeder CB305
    - GT1 DC113 with a circuit breaker CB115
    - GT1 NER with a dry type unit
    - GT1 protection system
- Modification of Feeder protections to incorporate backup protection functions, interface to new CB115, removal of fault thrower;
- Removal of Power Line Carrier (PLC) and replacement with triangulated digital Intertripping
- GT1 bund remedial works.

Benefits are as Option 3, plus:

- Environmental concerns are addressed.

PROGRESSED TO DETAILED ANALYSIS

5 Detailed Analysis

This section considers in more detail the option taken forward from the Optioneering section. Where appropriate the results of Cost Benefit Analysis are discussed and together with supporting objective and engineering judgement contribute toward the identification of a selected option. The section continues by setting out the costs for the selected option.

5.1 Cost Benefit Analysis

All four options have been included in the Cost Benefit Analysis (CBA). The CBA is being undertaken to help inform which of the options is preferred from a cost benefit perspective.

NPVs for the two options were calculated and compared against each other. The output from the CBA is shown in Table 3.

CBA Reference	Total Forecast Expenditure *(£m)*	Total NPV	Delta *(Option to baseline)*	Total NPV *(Incl. Monetised Risk)*
Option 1 (Baseline)	[redacted]	[redacted]		[redacted]
Option 2	[redacted]	[redacted]	[redacted]	[redacted]
Option 3	[redacted]	[redacted]	[redacted]	[redacted]
Option 4	[redacted]	[redacted]	[redacted]	[redacted]

Table 3 - CBA results for the Broadford Substation Works.

Option Selection

The CBA has shown that in the analysis of the four options. The CBA shows that basic NPV for options one, two and four are relatively close, however, once monetised risk is included, option two and four are significantly better. The delta between Options two and four is minimal ([redacted]). Considering the added benefit to customer security of supply, and the relatively close ranking between these two options, option four is the preferred solution.

Proposed Solution

The scope of the selected solution is to replace assets within the existing substation in situ whilst undertaking all necessary improvements. A copy of the existing Single Line Diagram (SLD) is shown in Appendix A. The project will be energised within the RIIO-T2 period. The table below details the outputs:

Plant	New plant	Replacement for
Replacement of Primary and Secondary Assets	1x 132kV circuit breaker (305) 1x 132kV circuit breaker (115) 1 x GT1 NER GT1 Protection Feeder Backup Protection Feeder Digital Intertripping	CB 305 DC 113 GT1 NER GT1 Protection
Transformer Bund Improvement	New GT1 Bund Oil Containment Unit	Existing GT1 Bund

Table 4 - Outputs from preferred option

5.2 Risk Benefit

A Risk Benefit Analysis has been carried out in order to compare "no intervention" against the selected "with intervention" options. Please note that while monetised risk is denoted as a financial figure, it is important to note that it is not "real" money and does not correspond to the cost that SHE Transmission would incur if an asset was to fail and these values are thus identified with R£ prefix (for more details please refer to A Network For Net Zero – A Risk Based Approach to Asset Management[7]).

The immediate monetised risk benefit which would be realised through the completion of this project is [redacted].

In addition to assessing the immediate risk reduction achieved, a long-term benefit has also been determined. The long-term benefit is derived by consideration of the risk of the asset experiencing a catastrophic failure weighted by the probability that the asset will survive for the Options and "no intervention" scenarios. The long-term benefit is an aggregation of the risk of all assets being considered within the option. The risk of each Option is then compared with the "no intervention" scenario. The "no intervention" scenario assumes that when the asset experiences a catastrophic failure the asset is replaced.

In most cases, the addition of a new lead asset to a site would introduce new risk and, therefore, produce a low, or even negative, long-term benefit. However, in the case of Broadford, the risk reduction (including a significant reduction in system risk) delivered by the replacement of CB305 far outweighs the risk introduced by new CB115. The long-term benefit of this project is [redacted]

[7] A Network For Net Zero – A Risk Based Approach to Asset Management

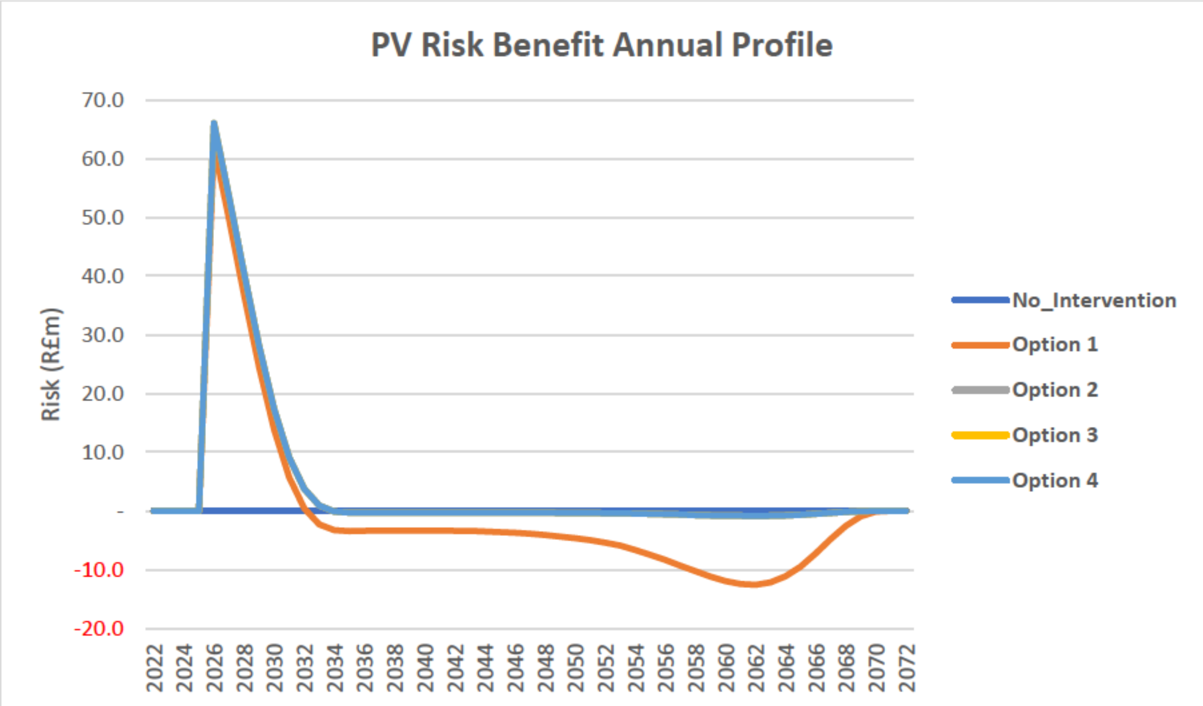

Figure 5 - Long Term Benefit of Proposed Intervention

5.3 Project Sensitivity

As outlined in our core RIIO-T2 business plan document, “A Network for Net Zero”, we believe we have a critical role to play in delivering Net Zero ambitions in both the UK and Scotland. Therefore, our plan has been carefully designed with the flexibility to deliver pathways to Net Zero. Our policy paper “A Risk-Based Approach to Asset Management” outlines our approach to monitoring and assessing the condition of our assets to maintain the reliable and resilient network that is expected by our stakeholders. Where asset condition deteriorates, we undertake a programme of cost-effective, risk-based interventions to maintain the longevity and performance of the transmission network. Each of our non-load related projects for T2 is underpinned by Asset Condition Reports which clearly outline that the works are necessary and driven for reliability.

Sensitivity	Test and impact observed – switching inputs
Asset Performance / deterioration rates	Switching deterioration assumption: The asset performance / deterioration rates can only improve or deteriorate. As the need for this project is driven by an asset condition report (as outlined in Section 3), the asset condition will not improve in the intervening period. The second option is for the asset performance to deteriorate and therefore the need remains, and the project would be considered for advancement within available outages.
Ongoing efficiency assumptions	Switching efficiency assumption: increased or decreased. Test would have no impact on (feasible) option selection, only one option was taken forward to detailed analysis and therefore there is no impact on the preferred solution.
Demand variations	No significant demand forecast
Energy scenarios	Sensitivity considered in Section 3 (Need) already. As this is a non-load project and the need is driven by the asset condition, the work would be required regardless of any changes to the energy scenarios.
Asset utilisation	Our policy paper “A Risk-Based Approach to Asset Management” outlines our approach to monitoring and assessing the condition of our assets to maintain the reliable and resilient network that is expected by our stakeholders. Where asset condition deteriorates, we undertake a programme of cost-effective, risk-based interventions to maintain the longevity and performance of the transmission network. Each of our non-load related projects for T2 is underpinned by Asset Condition Reports which clearly outline that the works are necessary and driven for reliability.
Timing / delivery	We have considered timing of investments as part of our CBAs.
Consenting / stakeholders	Where applicable we have considered consenting and stakeholder engagement as part of section 5 (Detailed Analysis) and the impact which this has had on the selection of the preferred solution.
Public policy / Government legislation	We have considered the impact of public policy, government legislation and regulations as part of the need (section 3), optioneering (section 4) and detailed analysis (section 5) and the impacts this has on the selection of the preferred solution. For example, the projects have considered the impact of the UK Governments’ Net Zero emission by 2050 target, SQSS and ESQCR.

Table 5: Sensitivity Analysis table

5.4 Innovation & Sustainability

Also considered is the use of alternatives to mitigate the use of the greenhouse gas sulphur hexafluoride (SF_6) on SHE Transmission's network. The installation of new CBs at Broadford will employ a non-SF_6 filled solution. At 132kV there are non-SF_6 alternatives market ready, one of which is being deployed at Dunbeath during RIIO-T1. During the RIIO-T2 period, and in support of our Sustainability and Environmental policies, all 132kV CB replacements will consider the use of non-SF_6 filled technology.

5.5 Carbon Modelling

We are committed to managing resources over the whole asset lifecycle – i.e. including the manufacturing of assets, construction, operations and decommissioning activities – to reduce our greenhouse gas emissions in line with climate science and become a climate resilient business. It is our aspiration that the carbon lifecycle cost of investment options plays a key role within our project development (between gates 1 and 2) and is considered in the selection of a preferred solution. We have therefore developed an internal carbon pricing model that estimates a carbon cost for each option considered in our CBA through deriving values for:

- Embodied carbon, which relates to the carbon emissions associated with the manufacturing and production of the materials use in production of the lead assets (transformer, reactors, underground cables and Overhead lines. Overhead line is made up of tower/wood pole/composite pole, conductor and fittings) procured and installed as part of the project.
- The carbon emissions associated with the main stages of the project lifecycle (construction, operations and decommissioning).

It is our vision to embed carbon considerations within our strategic optioneering and project development processes, which will require us to determine a way of flagging high carbon options within our CBA outputs. We will continue to develop our thinking in this space, which will involve our model being validated by a third party, so the results included in this EJP are indicative and subject to change.

The results of analysis for this project are captured in the carbon footprint results table.

Project Information		1	2	3	4
Project info	Project Name/number	0	0	0	0
	Construction Start Year	2026	2026	2026	2026
	Construction End Year	2026	2026	2026	2026
Cost estimate £GBP	Embodied carbon	£4,434	£8,868	£8,868	£8,868
	Construction	£5,688	£11,376	£11,376	£11,376
	Operations	£20,950	£41,901	£41,901	£41,901
	Decommissioning	£2,625	£5,249	£5,249	£5,249
	Total Project Carbon Cost Estimate	£33,697	£67,394	£67,394	£67,394
Carbon footprint tCO2e	Embodied carbon	59	118	118	118
	Construction	76	152	152	152
	Operations	97	193	193	193
	Decommissioning	8	15	15	15
	Total Project Carbon (tCO2e)	239	479	479	479
Project Carbon Footprint by Emission Category	Total Scope 1 (tCO2e)	43	86	86	86
	Total Scope 2 (tCO2e)	54	107	107	107
	Total Scope 3 (tCO2e)	143	286	286	286
SF6 Emissions	Total SF6 Emissions 3 (tCO2e)	34	68	68	68

Table 6: Carbon Calculation Summary

5.6. Cost Estimate

The cost of the preferred option for works at Broadford has been developed using rates from existing substation framework contracts and benchmarks from delivered RIIO-T1 projects. These have been applied to indicative quantities obtained from layout drawings. The total cost for delivering the scope of works for the proposed solution [redacted]

6 Conclusion

This paper identifies the need for intervention on existing assets at Broadford substation. The primary driver for the scheme is the widespread poor performance of the Brush DB145 circuit breaker type. There are several secondary drivers present, relating to condition or design of other assets, network security and reliability.

Both minimal and more substantial refurbishment and replacement works were identified and considered for detailed analysis.

The proposed scope of work selected is:

- Replacement of CB305 to reduce the of requiring extend use of diesel generation to avoid supply interruption caused by failure of this circuit breaker
- Replacement of DC113, GT1 NER, associated feeder and GT1 protection systems
- Provision of circuit breaker on GT1 CB115 to enhance network security and reliability

This scheme will deliver an immediate reduction of total network risk of R£157.4m for a cost of [redacted] the works are planned to be completed within the RIIO-T2 period. The Long-Term Monetised Risk Benefit is [redacted].

The Broadford scheme is not flagged as eligible for early or late competition due to it being under Ofgem’s £50m and £100m thresholds respectively.

7 Price Control Deliverables and Ring Fencing

As set out in our Regulatory Framework paper (section 1.12 and Appendix 3) we support a key principle from Citizens Advice – one that guarantees delivery of outcomes equivalent to the funding received - to ensure that RIIO-T2 really deliver for consumers.

For our core non-load projects this means that we commit to delivering our overarching NARMs target. If we do not deliver the NARMS target, or a materially equivalent target, then we should be subject to a penalty. Equally, if we over-deliver against our target and are able to justify that the over-delivery is in the consumers interests and could not have been reasonably factored into our business plan at the time of target setting then we should be made cost neutral for this work.

Core non load projects should not be ring fenced. This is to allow for substitution of projects in order to meet that NARMs target. We need flexibility to respond to up to date asset data information or external influences on our network during the price control; this information might drive us to substitute one project for another in order to ensure a reliable and resilient network. Ring fencing projects may result in sub-optimal decisions, having adverse consequences for the health of our network, which will ultimately be reflected in the NARMs target.

8 Outputs included in RIIO T1 Business Plan

Although part of this scheme was originally included in our baseline for delivery during the RIIO-T1 period, changes in asset condition and prioritisation across our portfolio means that our asset program is under continual review. Our decision to defer this scheme means that we were able to substitute and deliver other schemes to meet our required absolute output target in line with our license obligation. An assessment will be undertaken at the end of the RIIO-T1 period to validate our performance against our license target and associated Rewards and Penalties guidelines.

Appendix A Existing Site Single Line Diagram