



Network Output Measures

Rebasing Submission

July 2017

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1 Introduction

As part of the RII0-GD1 Framework, Northern Gas Networks (NGN), along with the other Gas Distribution Networks (GDNs), submitted Network Asset Workbooks (NAWs) which reported asset health, criticality and risk index targets at the following points:

- Position as at 1 April 2013
- Position as at 31 March 2021 without intervention
- Position as at 31 March 2021 with intervention

Ofgem rejected the workbooks approach, having identified that the indices, as they stood, did not allow a comparison between asset groups, since each index was unique to an individual asset group. Consequently, Ofgem instructed the GDNs to develop a new methodology, which expressed health as a form of reliability (failures per annum), criticality as a form of monetary consequence and risk in the form of monetised risk. They enacted this through Special Condition 4G which requires the licensees to work together to develop and submit a Network Output Measures (NOMs) Methodology for Health, Criticality and Risk. The Safety and Reliability Working Group (SRWG), which is comprised of gas technical experts and managers representing each GDN, was established to develop the new methodology.

The GDNs submitted the first NOMs Methodology in September 2015. In its letter dated 15 December 2015, Ofgem specified that it was minded to support the submission of the NOMs methodology if aspects of the document were updated and re-submitted in March 2016. Ofgem also issued direct modifications to the NOMs Methodology under Special Condition 4G. The modifications were listed in Annex 1 to that letter. Item 4 in Annex 1 specified:

“Tracking is completed by July 2017 to establish targets using the new NOMs Methodology to ensure the new targets have an equivalent impact as the original targets.”

Additionally, NGN (along with the other GDNs) were directed to restate their NAW in Ofgem Guidance received 2 June 2017 in-line with Special condition 4H (part E).

This document presents NGNs methodology for Rebasing its initial Asset Health, Criticality and risk index targets using the new NOMs methodology. Using the approach outlined in this document, NGN has applied the new NOMs methodology to derive monetised risk targets for the following points.

- Position as at 1 April 2013
- Position as at 31 March 2021 without intervention
- Position as at 31 March 2021 with intervention (based on GD1 Regulatory Contract Workloads).

NGN has also tested its approach to ensure the new targets have an equivalent impact as the original targets. The approach NGN has applied for rebasing and also application of tests is consistent with those proposed within the *“Rebasing Methodologies”* document prepared by SRWG (July 2017), a final version of which, has been submitted jointly by GDNs alongside this submission.

2 Scope

This document outlines NGN's rebasing of the Network Asset Workbook (NAW) as directed by Ofgem to be carried out by 31 July 2017.

The Scope covered is:

- The methodology NGN has applied to restate its NAW.
- Results of the Rebased Risk positions by asset class, and at Network Level, including confidence interval testing of the associated outputs, at 2013, 2021 (without investment) and 2021 (with investment).
- Results of the application of tests to "ensure that the new targets have equivalent impact as the original targets". The tests applied by NGN include:

Test 1 – Asset base test. To ensure that the asset base used in the Monetised Risk (MR) models reflect the asset base.

Test 2 – Volumes of investment test. To ensure the volume of the specific intervention driver is the same volume as was stated in the original FP Business Plan (Regulatory Contract).

Test 3 – Asset Condition/ performance test. To ensure that the modelled asset condition/ performance is the same as the 2013 asset base.

Test 4 – Consequence test. To identify if any investment is made in condition grades where it would not be expected.

3 Process

The proposed Rebasing Methodology, which was prepared by the Safety and Reliability Working Group (SRWG), and initially submitted to Ofgem in March 2017, identified four approaches that could be applied to rebase the risk targets using the NOMs Methodology. These approaches are outlined in Table 1 below:

Method	Strengths	Restrictions	Suitable Application Where:
1 Actual 2013 asset base and performance	Uses actual 2013 asset base and levels of performance	Requires GDNs to have asset and performance data preserved from 2013	<ul style="list-style-type: none"> The 2013 asset base is known The 2013 performance is known
2 Unpick Investments to Reset the Asset Base	<p>Asset base resembles 2013's asset base</p> <p>Deterioration rates reflect the mix of assets in the asset base in 2013</p>	<p>Assumptions required to unpick interventions</p> <p>The condition of an asset before renewal may not always be known</p>	<ul style="list-style-type: none"> The 2013 asset base is unknown The 2013 performance is known The rate of deterioration changes on intervention
3 Run the Model in Reverse to Reset the Asset Base	<p>Asset base resembles 2013's asset base</p> <p>Deterioration rates reflect the mix of assets in the asset base in 2013</p>	Performance of the 2013 assets inferred from today's performance	<ul style="list-style-type: none"> The 2013 asset base is unknown The 2013 performance is unknown The rate of deterioration changes on intervention
4 Extrapolation / back-casting	<p>Simple to implement as it does not require asset base restoration</p> <p><i>Statistically more accurate to back-cast and forecast 4 years from 2017 than forecast 8 years from 2013</i></p>	Will lead to over / understatement <i>in long term risk</i> if applied where deterioration rates change <i>rapidly</i> through time	<ul style="list-style-type: none"> The 2013 asset base is unknown The 2013 performance is unknown The rate of deterioration doesn't change on intervention

		<p><i>Uses a known current risk position, where forecasting from 2013 may give discrepancies.</i></p>		
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Table 1: Approaches for rebasing Risk Targets

NGN have applied Method 4: Extrapolation/ back-casting for all asset classes. The reason for selecting this method is because NGN does not have sufficiently robust 2013 datasets to input into the NOMs models and run directly. This is a result of the granular level of data needed by the NOMs models and it being incomplete or, there is a low level of confidence in the data at 2013. Specifically:

- 2013 datasets to run the MRS risk models are not available weather in entirety or to a level of completeness to be confident in the outputs for pipeline and services models;
- There is uncertainty in the 2013 datasets for AGI models. However, condition surveys have recently been undertaken on the assets in these systems, giving NGN confidence about the condition and risk at a known point (at 2017).

In assessing options for rebasing NGN have concluded that it is more accurate to back-cast and forecast through the known point at the mid-point of RIIO-GD1 than to make subjective assumption across incomplete data (see Section 4). This also means that we would not be expecting a discontinuity at the GD1/GD2 interface.

NGN also considers that its approach provides a consistent and repeatable rebasing methodology that works at both the asset class and network level.

NGN Extrapolation/ Back-Casting Method

Figure 1 outlines the process map that NGN has followed in developing and testing its rebased GD1 risk targets and restated NAW.

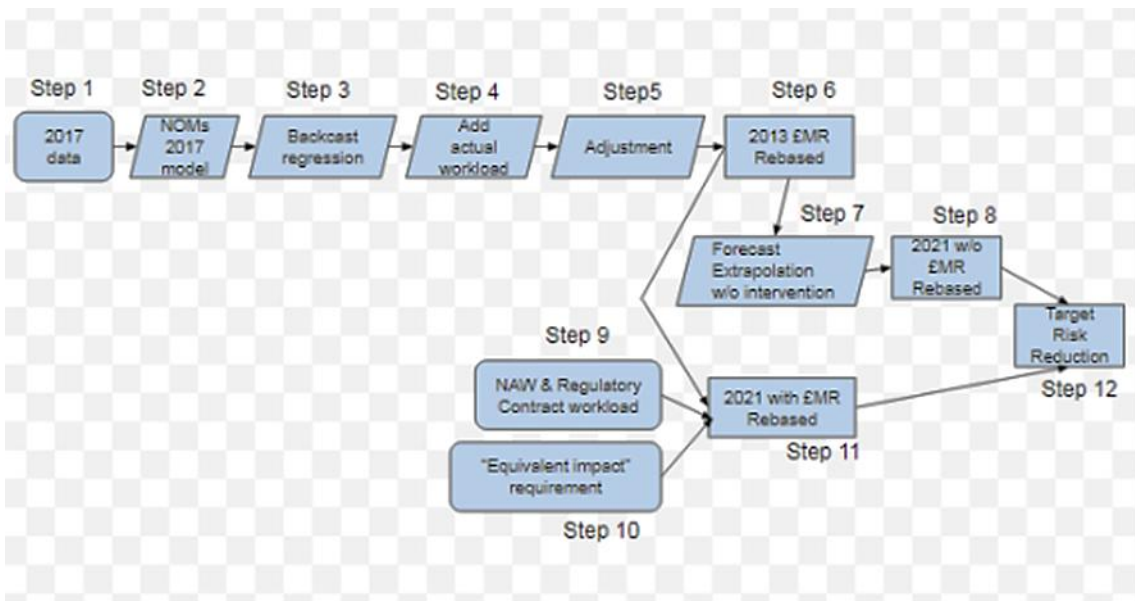


Figure 1: Process for developing and testing rebased targets

Step 1 – 2017 Data

- As outlined in Section 4 of this document. NGN undertook an extensive refresh of its data to inform the NOMS models for the 2017 RRP submission. The data measurement date was 31 March 2017.

Step 2 -NOMS 2017 Model

- NGN executed each of the NOMs models, using data collated in step 1 for each asset class. This resulted in a monetised risk baseline curve over time, which is simplistically represented in Figure 2 below.

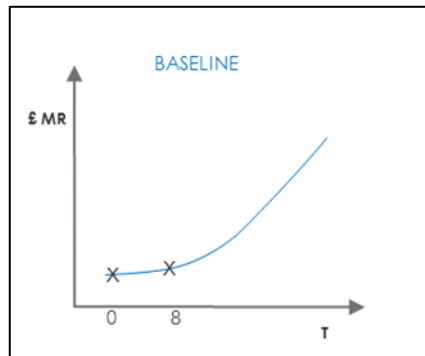


Figure 2: Representation of Monetised risk baseline curve.

Step 3 – Back Cast Regression

Using the curve in Figure 2, NGN undertook statistical testing to understand the most appropriate way to back cast the regression.

- For Risers, Mains, Services and Governors, statistical testing determined that the early part of the curve (up to 2024) is linear. Consequently, statistical general linear modelling has been applied to back-cast the baseline risk to 2013 for these asset groups. A simplistic representation of this approach is shown in Figure 3 where the solid portion of the line represents the modelled deteriorations using the current NOMs forecast, and the dotted line represent the back fit of the linear modelling to 2013.

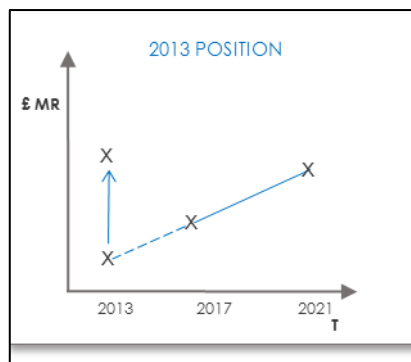


Figure 3: Representation of linear regression.

- For Pressure Control, Filters, LTS and Pre-heating, linear modelling was found not to be appropriate. Back-casting was carried out using polynomial regression instead of linear regression for these assets.

Step 4 – Add actual Workload

Step 3, establishes the 2013 position based on the 2017 Asset base. In order to represent the asset base as it was in 2013 it is necessary to add back in the risk that was removed due to interventions delivered from 2013 to 2017 in the years that they were carried out. This is shown in Figure 4, with the stepped line from the 2017 position to 2013 indicating the addition of risk as interventions already delivered are removed (and subsequently the benefit they delivered is also removed).



Figure 4: Representation of method to add in actual workload.

- For pipeline assets, actual workload was converted to a monetised risk value by multiplying by monetised risk per unit (asset or unit length) at cohort level from the 2017 NOMs Model by actual workload.
- For above ground assets (AGIs), the benefit in risk reduction at 2021 per asset is calculated by matching Interventions to the NAW by Criticality and Health ranking. Criticality bandings are inferred from NOMs outputs using the equation:

$$\text{Criticality} = \text{Monetised Risk} \div \text{Asset Health Failures}$$

- The criticality bandings are proportioned to reflect those in the Regulatory Contract adjusted workbook (NAW). Once banded by Criticality runs of the NOMs models are carried out by forcing all models to be HI5 using the condition or effective age triggers as appropriate. Further runs are carried out setting all the assets to be HI4, etc. For more details see Section 5.
- Weighted average risk reductions per asset can be calculated for the required HI / CI bandings. These average £MR/ asset values can be used to add actual risk back in to 2013 and remove planned Regulatory Contract workload to reach the Rebased 2021 with intervention target.

Step 5 – Adjustment

In order to ensure the 2013 position accurately reflects the monetised risk deterioration of the baseline risk curve, it was necessary to adjust each of the annual risk positions each year on the addition of workloads using the following formula.

$$2017 \text{ £MR (per unit)} \times \text{No. Units workload} \times \frac{\text{year of application of workload ETMR}}{2017 \text{ ETMR}}$$

Step 6 - 2013 £MR Rebased

The application of steps 1-5 above, resulted in the establishment of the 2013 rebased positions for monetised risk as show in Figure 4 above.

Step 7 – Forecast Extrapolation without Intervention

Using 2013 rebased position, (outlined in Figure 4), the 2021 position without intervention can be forecast by applying the same gradient as used to back cast to the 2013 position. This is shown in Figure 5.

Step 8 – 2021 W/O £MR Rebased

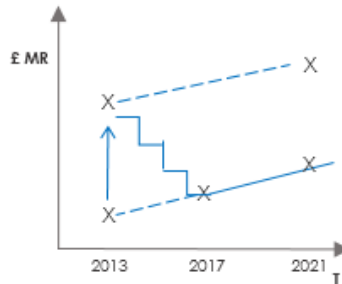


Figure 5: Pictorial Representation of method used to forecast target to 2021 without intervention

- As shown in Figure 5, using the Rebased 2013 position, the Rebased 2021 without intervention is determined by forecasting up to 2021 assuming the same gradient as back-casting where back-casting has used linear regression.
- Where back-casting has used polynomial regression, polynomial forecasting is used up to 2021 using effective age to find the start point of the curve (effectively the polynomial curve is laterally translated to the 2013 Rebased position).

Step 9 – NAW and Regulatory Contract Workload

The 2021 with intervention Rebased Target is determined by forecasting forward from the Rebased 2013 position and removing monetised risk relating to the workload volumes detailed in the Network Asset Workbook (NAW), adjusted for the actual workload volumes recorded in the Regulatory Contract. As for back-casting, this workload has been converted to a monetised risk and removed on an annual basis in a manner similar to that described in step 4 above.

Intervention were mapped from the NAW HI / CI matrix system to the Monetised Risk system. Further detail is provided in the Intervention Methodology in Section 5 and “equivalent impact” assessment in Section 6.

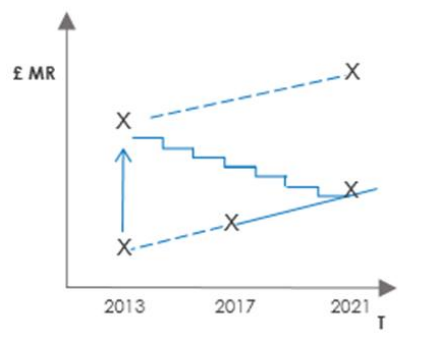


Figure 6: Pictorial representation of forecasting target to 2021 with interventions

Step 10 –Equivalent Impact Requirement

NGN undertook a series of tests on the outputs of the above process to demonstrate they have an equivalent impact to the original submission. These tests and the impact of testing are discussed further in section 7 and 8 of this report and Appendix 2.

Step 11 – 2021 with £MR rebased

In applying the NAW workbook and regulatory contract workloads as outlined in Steps 9 and 10, the 2021 risk position based on delivery of the GD1 regulatory contract can be forecast as shown in Figure 7, whereby the dotted line represents risk deterioration and no intervention and the stepped line represents the removal of risk each year by interventions planned in the regulatory contract.

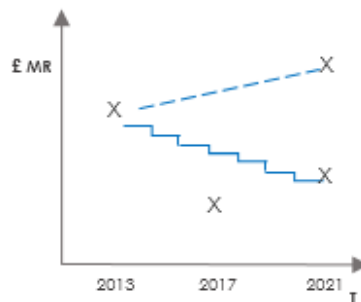


Figure 7: Representation of derivation of 2021 with intervention position using NAW workloads.

Step 12 – Target Risk Reduction

The difference between the Rebased 2021 with intervention Target (2021 position using stepped line in Figure 7) and Rebased 2021 without intervention Target (2021 position using dotted line in Figure 7) would be the Rebased Target Risk Reduction. In a Risk Trading future, this could be managed at the Network Level. In a transitory period, the individual asset class views could also be used.

NGN has used a statistical software package (R-Studio) to apply the methodology outlined above. This enables statistical testing of fitting and errors. Confidence intervals have been applied to take account of uncertainty. This enables monitoring and tracking of monetised risk levels and risk reductions at the asset class level as well as at the Network level, which facilitates a step towards asset risk management at a Network level rather than a silo-ed asset level which was a criticism by Ofgem of the Original workbooks.

This analysis could facilitate the application of dead bands at an asset class or network level to mitigate output uncertainty associated with the models.

4 Data Set Establishment

NGN do not have data extracts for NOMs Monetised Risk models as at 31 March 2013. As outlined in Section 3, dependent on asset class, to replicate or present this position would require:

- significant manual intervention;
- significant assumptions;
- significant associated uncertainty.

It was therefore decided to use 2017 datasets and back-cast and forecast from a known dataset point. Data was collected for each asset class as part of the 2017 RRP process, this included:

- GDN specific base data and risk map value data. Wherever possible, NGN have tried to collate at least 3 years-worth of data and calculate average values to avoid the effect of annual fluctuations.
- Common data, which data that is common across GDNs within each asset class
- Global data, which is data that is common across all models and all GDNs
- 2017 RRP data has been used as it represents the most accurate data capture following validation, average data over multiple years have been collated to smooth annual fluctuations, and condition data has been surveyed for AGI's within the year 2016/17.

NGN undertook a data gap analysis as part of the 2017 RRP process and this can be seen within NGN's Implementation (Data Gathering and Initiative) Plan.

5 Intervention Methodology

This section describes the intervention methodology used by NGN in the application of its Rebasing process outlined in Section 3 of this document.

Using the Asset Health and Criticality Network Asset Workbooks (NAW) at 2021, it is possible to identify the movement between the HI bandings for with and without investment, using the rules which are in line with the NOMs methodology:

- Movement to HI1 = replacement
- Movement to HI2 = refurbishment
- The highest health assets are all replaced before moving only a lower health banding/ refurbishments.

These movements are calculated for each asset class and each criticality level to understand the proportion of risk movement planned by the end of RIIO-GD1. The steps are as follows:

- To ensure consistency with the NOMs methodology amend the condition scores or effective age within core base data (CBD) of the MRS Excel Models to reflect each HI banding and calculate the risk reduction for each asset intervention.
- Calculate the criticality score as detailed in Section 3 to attain the Monetised risk reduction for each intervention, by Health and Criticality Banding.
- This combined with the proportional risk movement in the Asset Health and Criticality Workbooks at 2021 gives the average risk reduction per intervention according to the Regulatory Contract.

A comparison of the original NAW compared with the Rebased workbook is shown in Appendix 3.

6 Additional Information/Assumptions

The following section outlines the assumptions that NGN has applied for certain asset types in applying the rebasing methodology.

Offtake / PRS – Pressure Control, Filters, Pre-heating and Odorant & Metering

1. In the case of Buildings, Fences and Telemetry, only the health index will be taken into account due to the complexity of accounting for combined health and criticality matrices on the primary asset and the secondary asset. These assets will be treated by taking the 2017 base data and only increasing the fence/building/ control system condition (where they exist) and taking an average risk reduction for the health index and weighted in line with the numbers of replacements.
2. Buildings can only be modelled if they are Regulator Buildings using NOMs. The Regulatory Contract stated that Building replacements/Refurbishment can consist of Regulator buildings, Boiler Buildings and E&I buildings. One third of NGN's total buildings are Regulator Buildings and as such risk reduction shall be calculated for one third of the proposed Regulatory Contract workload on the Pressure Control Model.
3. Where fences occur on an Offtake it has been assumed that the Offtake has one pressure control system, one filter system, one preheater system, one odorant system and one meter system. Where a fence is on a PRS it has been assumed that the PRS site has one pressure control system, one filter system, but may or may not have one preheater system. For preheating, preheating systems are proportioned to filter systems to determine the number of fence replacements to be put through the Preheating model.
4. Consequential testing showed based on volumes alone we would be targeting HI3 replacements in the future workload, whilst the regulatory contract expected to target HI4/5 assets. This leads to significant risk reduction due to the effect gamma has on the deterioration rate on probability of failure, using the regulatory contract volumes and HI4/5 health/criticality risk reduction. Assets on site will be in conditions HI4/5 when we come to replace them in the next years, which is not reflected in the 2017 RRP base data. As such NGN have tested inflating the risk of future investment assets to HI5 to demonstrate the risk reduction given that these assets are in worse condition in reality vs the data condition.

7 Equivalent Impact Testing

As part of the requirement for rebasing the NAW and Monetised Risk Targets, Ofgem require each GDN to perform a series of tests on the outputs of the above process to demonstrate they have an equivalent impact to the original submission.

The tests completed were:

- Test 1 – Asset base test. To ensure that the asset base used in the MR risk models reflect the asset base.
- Test 2 – Volumes of investment test. To ensure the volume of the specific intervention driver is the same volume as was stated in the original FP Business Plan (Regulatory Contract).
- Test 3 – Asset Condition/ performance test. To ensure that the modelled asset condition/ performance is the same as the 2013 asset base.
- Test 4 – Consequence test. To identify if any investment is made in condition grades where it would not be expected.

If any of these tests were failed, for a particular Health Index Asset Category, then a qualitative assessment was undertaken relating to the failed categories only. These detailed additional tests included:

- Confirmation of asset condition in the data set compared with expected condition on site.
- Confirmation of other reasons why investment is deemed suitable where the Health/Criticality bandings differ, e.g. improved accuracy/ efficiency.

8 Rebasing Results

Below are NGN's Rebased Monetised Risk positions:

- Position as at 1 April 2013
- Position as at 31 March 2021 without intervention
- Position as at 31 March 2021 with intervention

Based on NGN's Methodology, NGN's Rebased Risk Target at 2021 would be £65.225m (£207.678m - £142.453m). NGN advocates the use of deadbands to mitigate uncertainty output risk associated with the NOMS and recommends that deadbands are applied to output targets to account for any movement or changes in models year to year, without the need to reforecast targets.

No	Primary Assets	Secondary Asset	Units	Rebased 2013	Rebased 2021 without intervention	Rebased 2021 with intervention
				Monetised Risk (£m)	Monetised Risk (£m)	Monetised Risk (£m)
1	LTS Pipelines	LTS Pipelines - Piggable	Km	11.292	11.377	11.138
		LTS Pipelines - Non Piggable	Km			
2	Distribution Mains	Iron Mains	Km	68.583	93.568	69.160
		PE Mains	Km			
		Steel Mains	Km			
		Other Mains	Km			
3	Services	Services	Number of	29.627	39.924	32.396
4	Risers	Risers	Number of	0.597	0.823	0.808
5	Offtake/ PRS Filters & Pressure Control	Offtake Filters	Systems	6.068	8.362	4.798
		PRS Filters	Systems			
		Offtake Slamshut/ Regulators	Systems	5.678	6.091	4.504
		PRS Slamshut/ Regulators	Systems			
6	Offtake/PRS Pre Heating	Offtake Pre-heating	Systems	20.955	30.868	11.861
		PRS Pre-heating	Systems			
7	Offtake Odorant & Metering	Odourisation & Metering	Systems	12.827	13.097	4.295
8	District, I&C and Service Governors	District Governors	Number of	3.148	3.563	3.489
		I&C Governors	Number of			
		Service Governors	Number of			
Total Network Risk				158.774	207.674	142.449

9 Summary of Tests

This section details the results of the testing phase to account for the equivalent impact, volume and coincidental testing. The results are shown in Table 2 below. In applying its rebasing methodology using the statistical approach outlined in Section 3, NGN met the requirements of Test 2 and 4 across the asset types by the nature of the methodology. This is detailed below, along with comments regarding compliance with Test 1 and Test 3:

Test 1: Asset Base Test - Not applicable to NGN as there is no 2013 data base to compare outputs. NGN have used a known 2017 asset dataset to calculate risk and back-cast from this.

Test 2: Volumes of investment test – The NAW workload and regulatory contract is being used to derive the interventions that have been applied therefore we are compliant with this test. (See attached spreadsheet for comparison of the original NAW and the Rebased workbook).

Test 3: Asset Condition/ performance test – Ensures the methodology looks at the workbooks as per Test 2 and that the rebasing methodology applied the interventions in the same HI categories (for exception see Appendix 1). Testing of performance looks for delivery of equivalent or greater risk reduction than in the original business plan. This is demonstrated in Appendix 4 which outlines percentage reduction in monetised risk as a comparison.

Test 4: Consequential test - Ensures the methodology looks at the workbooks as per Test 2 and that the rebasing methodology applied the interventions in the same HI categories (for exception see Appendix 1).

Asset Type	Test 1	Test 2	Test 3	Test 4
LTS	N/A	PASS	FAIL	PASS
Mains	N/A	PASS	PASS	PASS
Services	N/A	PASS	PASS	PASS
Risers	N/A	PASS	PASS	PASS
Pressure Control	N/A	PASS	PASS	PASS
Filters	N/A	PASS	PASS	PASS
Pre-heating	N/A	PASS	PASS	PASS
Odorant	N/A	PASS	PASS	PASS
Metering	N/A	PASS	PASS	PASS
Governors	N/A	PASS	FAIL	PASS

Table 2: Results of NGN Equivalent impact testing for each asset group

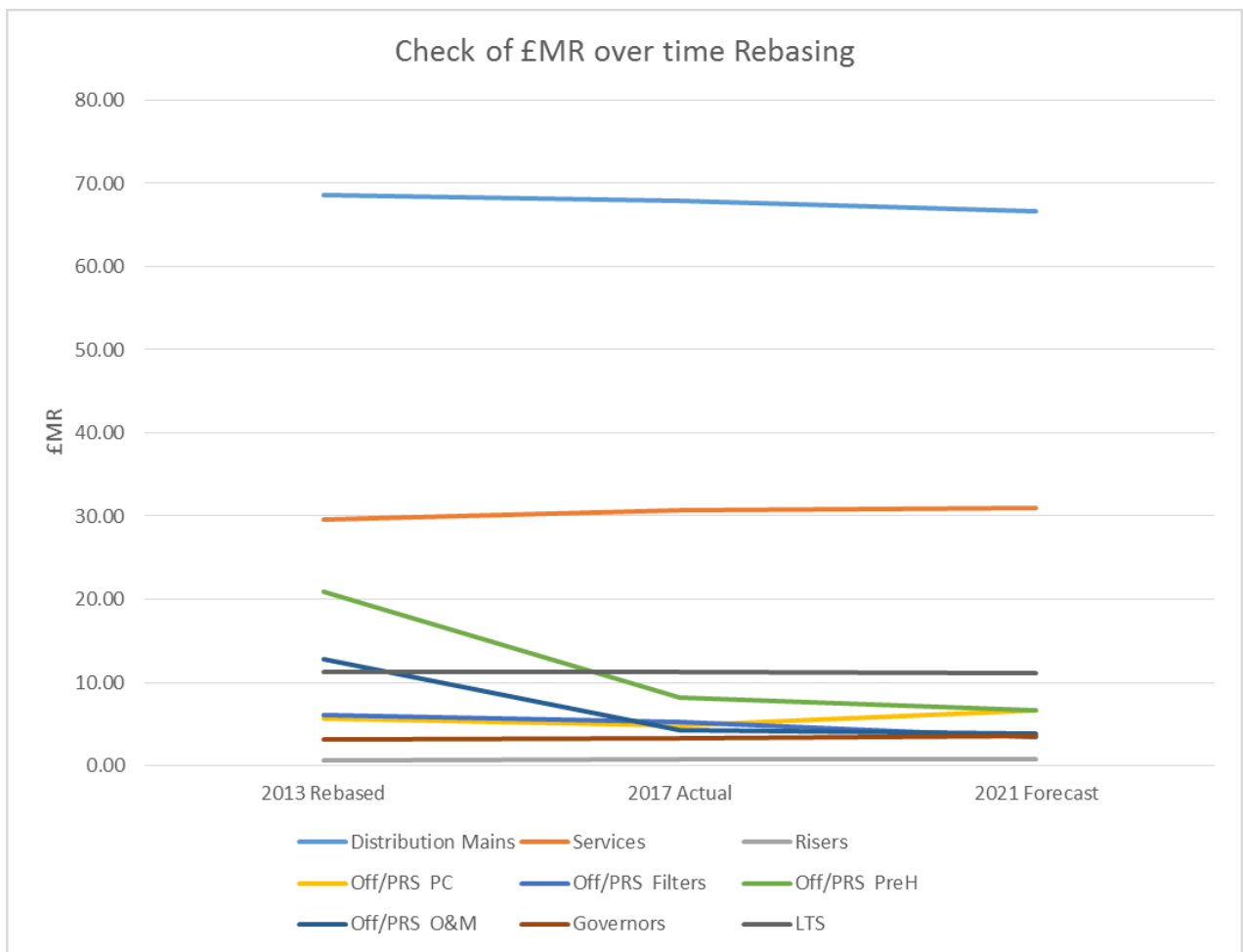
Further detail relating to failed tests can be found in the Appendix 1

Summary

Outlined in Table 3 below is a summary of the movement in NGN’s monetised risk from Rebased 2013 position, allowing for actual interventions to 2017 and forecast interventions to 2021 (this was presented in NGNs commentary specific to NOMS for its RRP 2017 position).

	2013 Rebased	2017 Actual	2021 Forecast	Movement in Risk over time
Distribution Mains	68.58	67.90	66.70	Gradually decreasing risk
Services	29.63	30.65	30.91	Slightly increasing risk
Risers	0.60	0.71	0.81	Slightly increasing risk
Off/PRS PC	5.68	4.86	6.59	Increase in risk
Off/PRS Filters	6.07	5.23	3.49	Decrease in risk
Off/PRS PreH	20.96	8.12	6.59	Graded decrease in risk (accentuated by gamma)
Off/PRS O&M	12.83	4.27	3.85	
LTS	11.29	11.21	11.11	Slightly decreasing risk
Governors	3.15	3.348	3.526	Increase in risk
NETWORK LEVEL	158.77	136.28	133.58	Decrease in risk

Table 3: Summary of NGN's monetised risk over time



Appendix 1 - Failed Testing

If any of these tests were failed, for a particular Health Index Asset Category, then a qualitative assessment was undertaken relating to the failed categories only. These detailed additional tests included:

- Confirmation of asset condition in the data set compared with expected condition on site.
- Confirmation of other reasons why investment is deemed suitable where the Health/Criticality bandings differ, e.g. improved accuracy/ efficiency.

Governors – Test 3 (Asset Condition/ performance test): Failed

Volumes of interventions within original health categories are being matched (see Test 2: PASS). However, Governors are not delivering the expected risk reduction based on the equivalence test we have applied. This may be due to a limitation of granularity of the test applied.

Applying Test 3 (where some assumptions were needed for Governors – see Appendix 4) NGN were expecting a risk reduction of 6% based on original NAW compared to a reduction of 2% observed in the Rebasing result.

The NOMs methodology baseline financial (inspection and survey costs, maintenance cost, etc) comprise around 40% of the total monetised risk for Governors. This therefore reduces the potential risk reduction by intervention available as these baseline costs will remain on the new/ refurbished assets. This contributes to the 4% difference between “Expected Risk Reduction” and “Actual Risk Reduction” as Expected Risk Reduction is calculated by considering the difference in health and criticality scoring which does not take baseline costs into account.

LTS – Test 3: (Asset Condition/ performance test): Failed

Volumes of interventions within original health categories are being matched (see Test 2: PASS). However, LTS pipelines and associated secondary assets are not delivering the expected risk reduction based on the equivalence test we have applied. This may be due to a limitation of granularity of the test applied.

Applying Test 3 (where some assumptions were needed for LTS – see Appendix 4) NGN were expecting a risk reduction of 20% based on original NAW compared to a reduction of 1% observed in the Rebasing result.

The LTS Interventions are primarily refurbishments, which still carry significant length dependent baseline costs (condition monitoring, TD1 costs, surveillance costs) and high H&S consequences, meaning intervention benefit is minimal purely based on improving health bandings. The representation of CP and Overcrossings /River Crossings is no-longer comparable with the original methodology meaning that the Expected risk reduction is being over-estimated because the CP and Crossings risk cannot be separated from the Pipeline risk to enable. This is because they were treated as separate assets in the original business plan methodology, whereas they are treated as attributes which modify pipeline health and therefore risk in the NOMs methodology.

Appendix 2 – Rebasing Results

The following Appendix outlines a comparison of the rebased targets using regulatory contract interventions from 2013 to 2013 with and without versus our current performance and planned workloads to 2021.

Distribution Mains

1. Currently 54% of £24.4m Rebased Risk Reduction Target delivered at 2021 based on 2017 data and no further intervention (Point A / Point B in Figure A2-1). However, this outperformance is due to the forecast workload projected. At 2017, NGN actual delivery is on par with that stated in the Regulatory contract. This agrees with point 2 below.
2. Forecast 104% delivery of Rebased target based on current forecast interventions: £1.0m outperformance forecast (Point C / Point B)

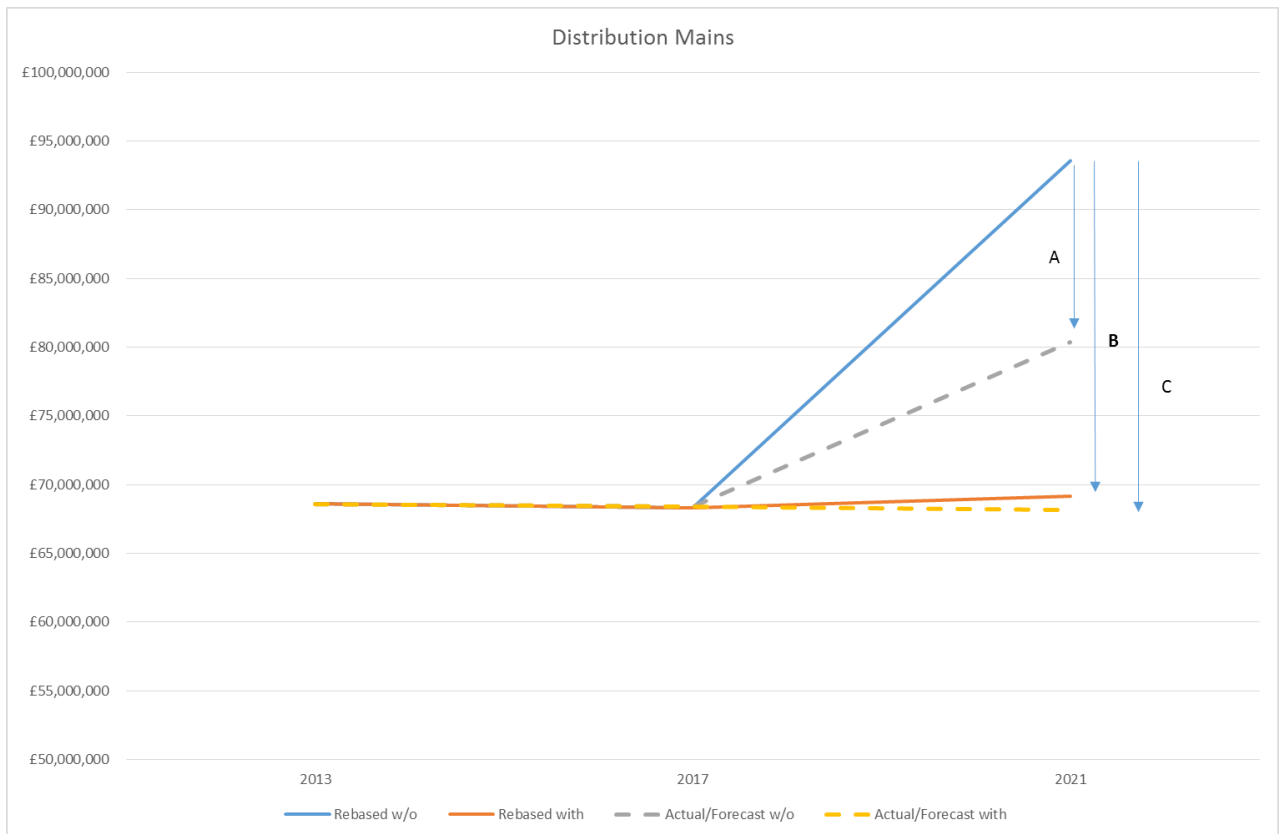


Figure A2-1: Distribution Mains Monetised Risk changes over RIIO-GD1, backcast from 2017 and forecast to show with and without interventions.

Services

1. Currently 48% of £7.5m Rebased Risk Reduction Target delivered at 2021 based on 2017 data and no further intervention (Point A / Point B in Figure A2-2)
 - a. i.e. 2% behind – this is largely accounting for the forecast underperformance in 2) below.
2. Forecast 97% delivery of Rebased target at 2021 based on current forecast interventions: £203k underperformance forecast (Point C / Point B)

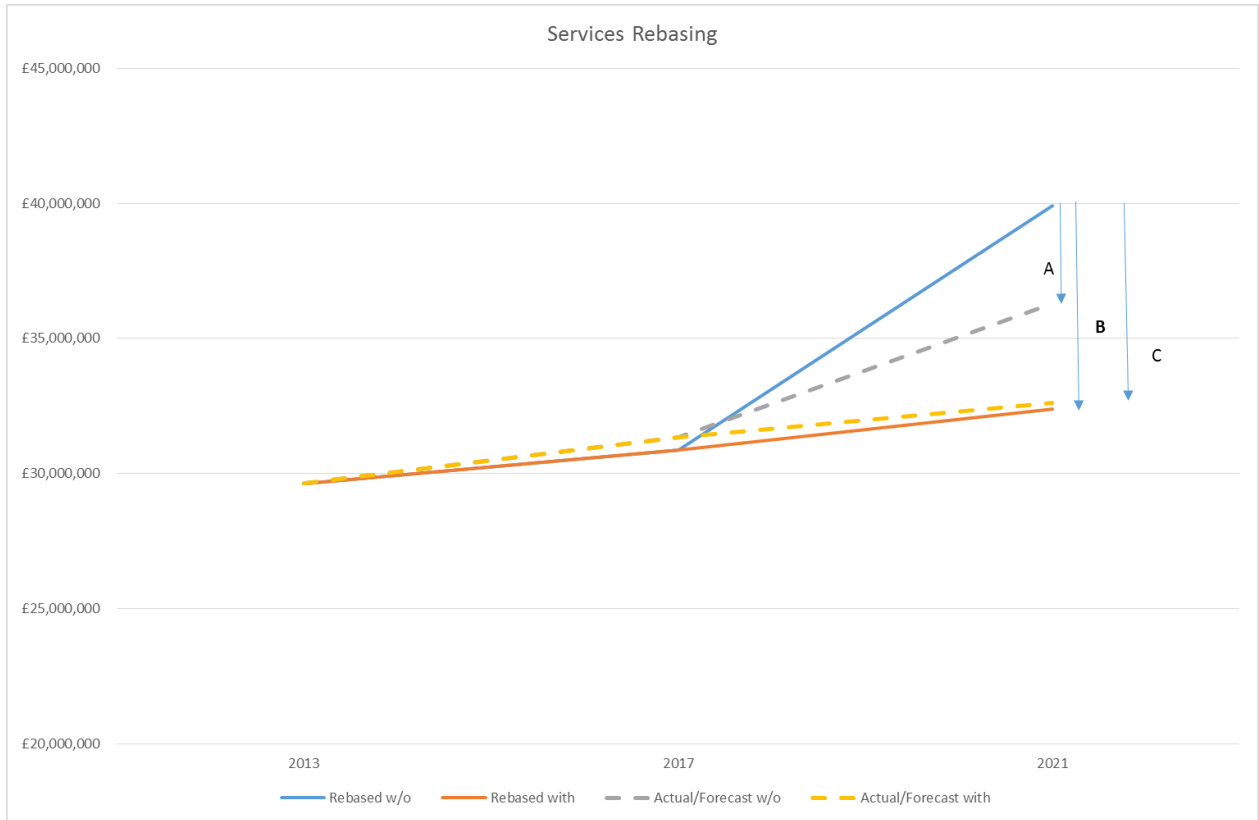


Figure A2-2: Services Monetised Risk changes over RII0-GD1, backcast from 2017 and forecast to show with and without interventions.

Risers

1. Currently 45% of target of £0.015m Rebased Risk Reduction Target at 2021 based on 2017 data and no further intervention delivered
 - a. i.e. 5% behind – this (actual performance to date) is accounting for around a third of the forecast underperformance in 2) below.
2. Forecast 81% delivery of Rebased target at 2021 allowing for current forecast interventions: £3,000 underperformance forecast

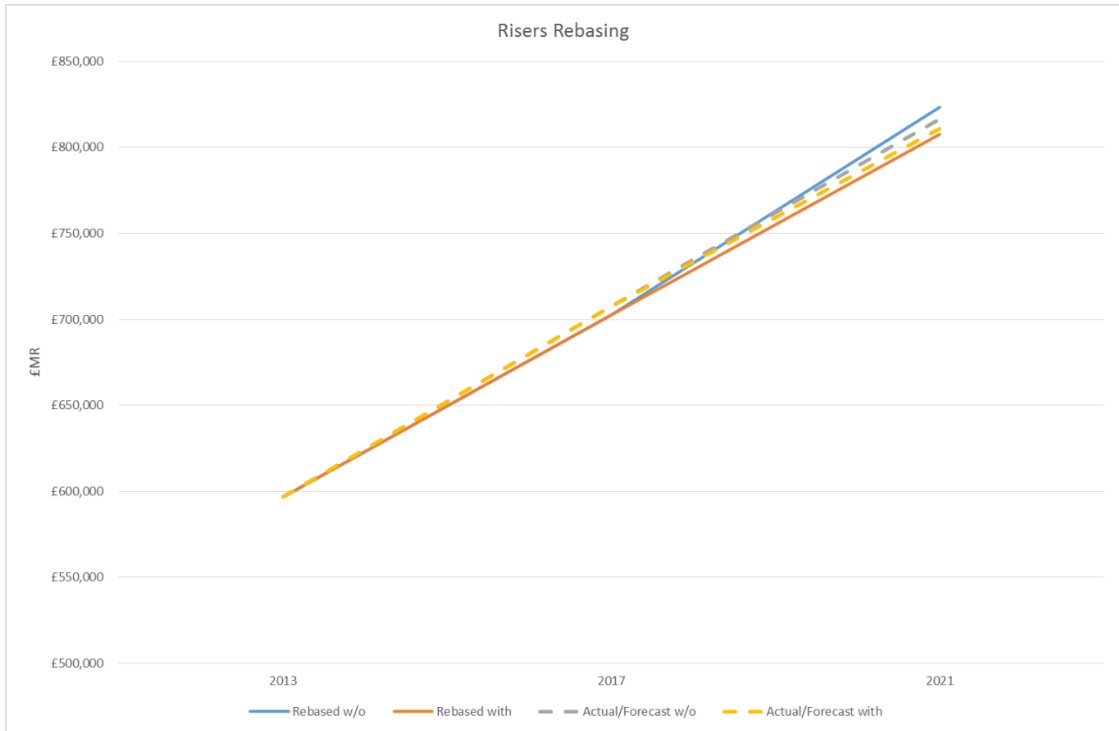


Figure A2-3: Risers Monetised Risk changes over RIIO-GD1, backcast from 2017 and forecast to show with and without interventions.

Governors

1. Currently 43% of target of £0.075m Rebased Risk Reduction Target at 2021 based on 2017 dataset assuming no further workload
 - a. i.e. 7% behind – this is largely due to the forecast workload projected which is less than final proposals workload and the proportion of refurbishment to replacement is also greater. This accounts for around a quarter of the forecast underperformance in 2) below.
2. Forecast 72% delivery of Rebased Risk reduction target at 2021 allowing for current forecast interventions: c. £21,000 underperformance forecast

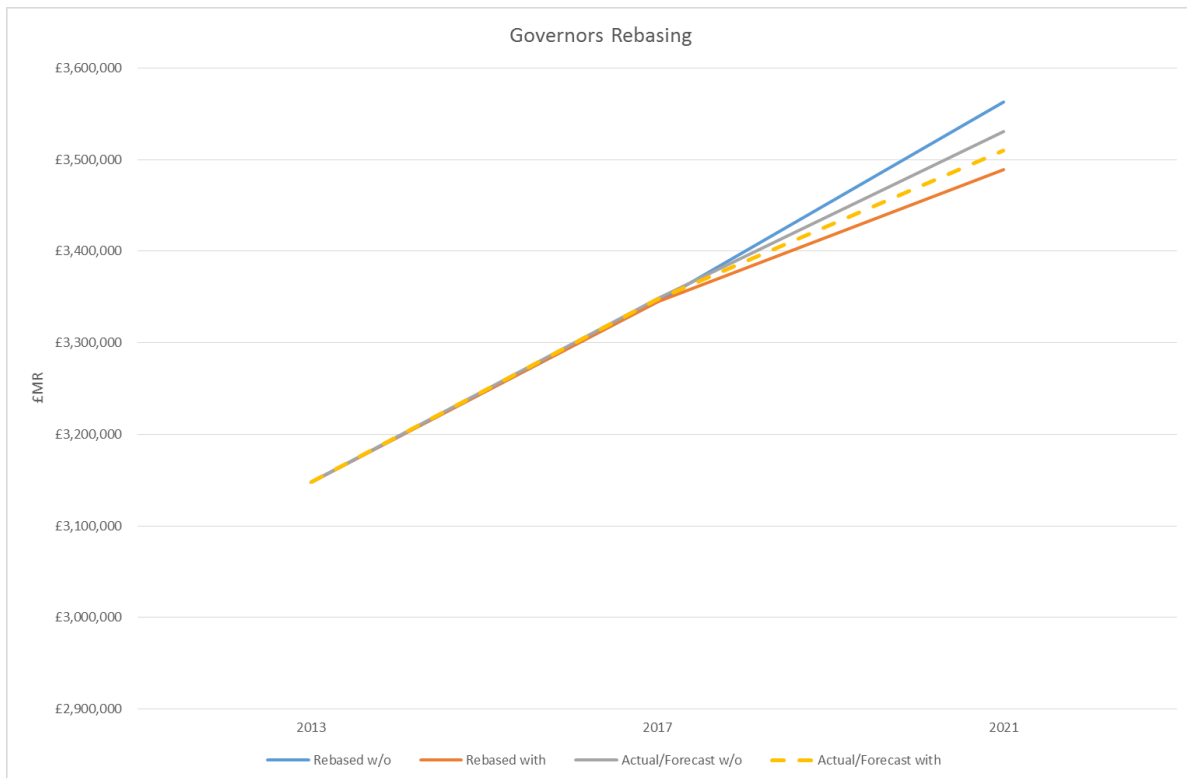


Figure A2-4: Governors Monetised Risk changes over RIIO-GD1, backcast from 2017 and forecast to show with and without interventions.

LTS

1. Currently at 64% of the £0.2m of Rebassed Risk Reduction Target delivered at 2021 based on 2017 data and no further intervention delivered (Point A / Point B in Figure A2-1).
 - a. This 14% outperformance has been driven through decommissioning a 3km non-piggable pipeline we are undertaking and front-end loaded overcrossing and river crossing interventions.
2. Forecast 116% delivery of Rebassed target: £0.038m outperformance forecast (Point C / Point B)
 - a. Additional outperformance of 2% has been driven through diversions (net 3.23km abandonment) we are undertaking. The outperformance in Years 5-8 is not proportional to 1-4 because of the polynomial profile of the monetised risk curve and the front-end loaded overcrossing and river crossing investment programmes mentioned in 1) above.

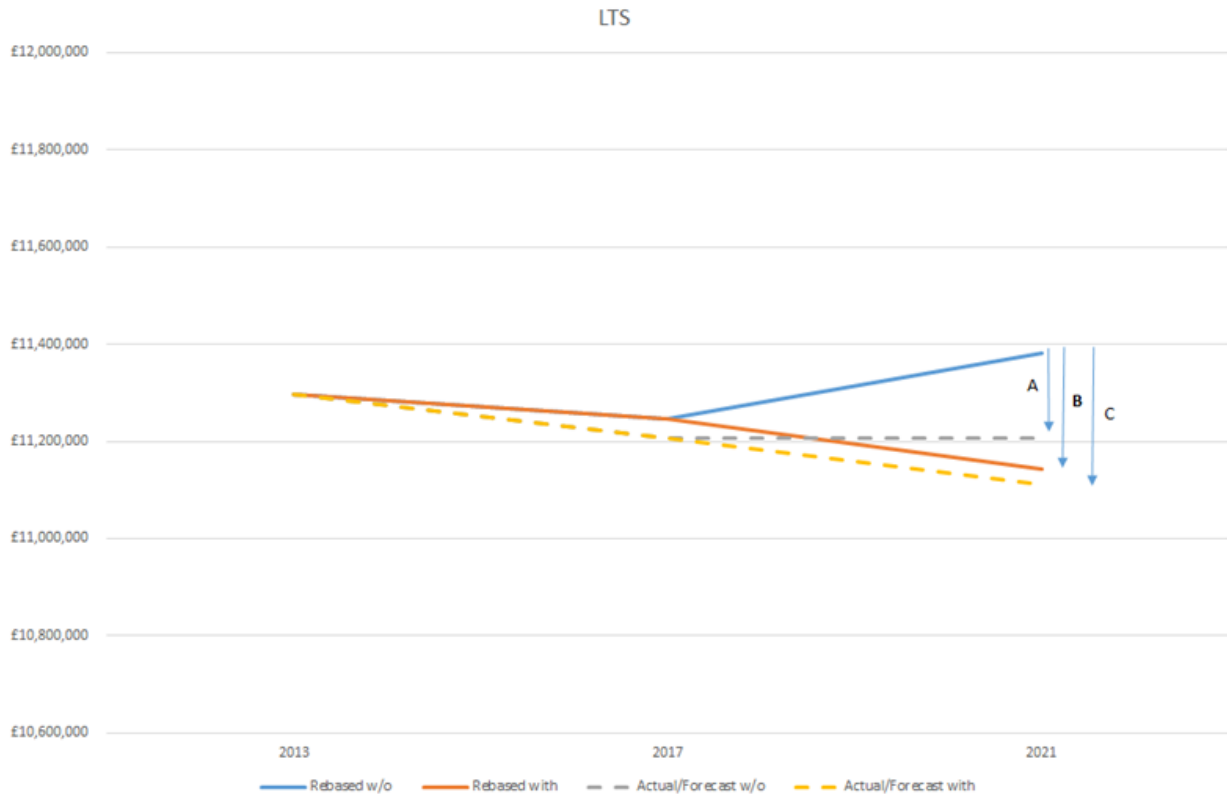


Figure A2-5: LTS Monetised Risk changes over RIIO-GD1, backcast from 2017 and forecast to show with and without interventions.

Offtake Odorant & Metering

1. Currently 90% of target of £8.8m Rebased Risk Reduction Target delivered at 2021 based on 2017 dataset assuming no further workload
 - a. i.e. 40% ahead: this is due to being 54% on odorant due to a front-load investment plan with all 19 planned odorant controllers having been replaced in Year1. We are 4% ahead in metering, with a back-end loading investment plan.
2. Forecast 108% delivery of Rebased target at 2021 assuming current forecast workload interventions to 2021: c. £0.7m outperformance forecast
3. There is an issue with the Offtake and PRS models with the deterioration coefficient 'gamma' that accelerates deterioration rapidly after a period of low level deterioration. This happens when the asset reaches HI5. This was built into the model after elicitation workshops, but is leading to spikes in deterioration and peaky risk profiles as can be seen in Figure A 2-6 below. This affects all asset classes within the Offtake/ PRS primary asset class.
4. There is also significant uncertainty about the inflationary impact of the fencing condition on probability of Failure *and* probability of consequence. The way the model is currently incorporating risk for fencing is an unrealistic reflection of reality.

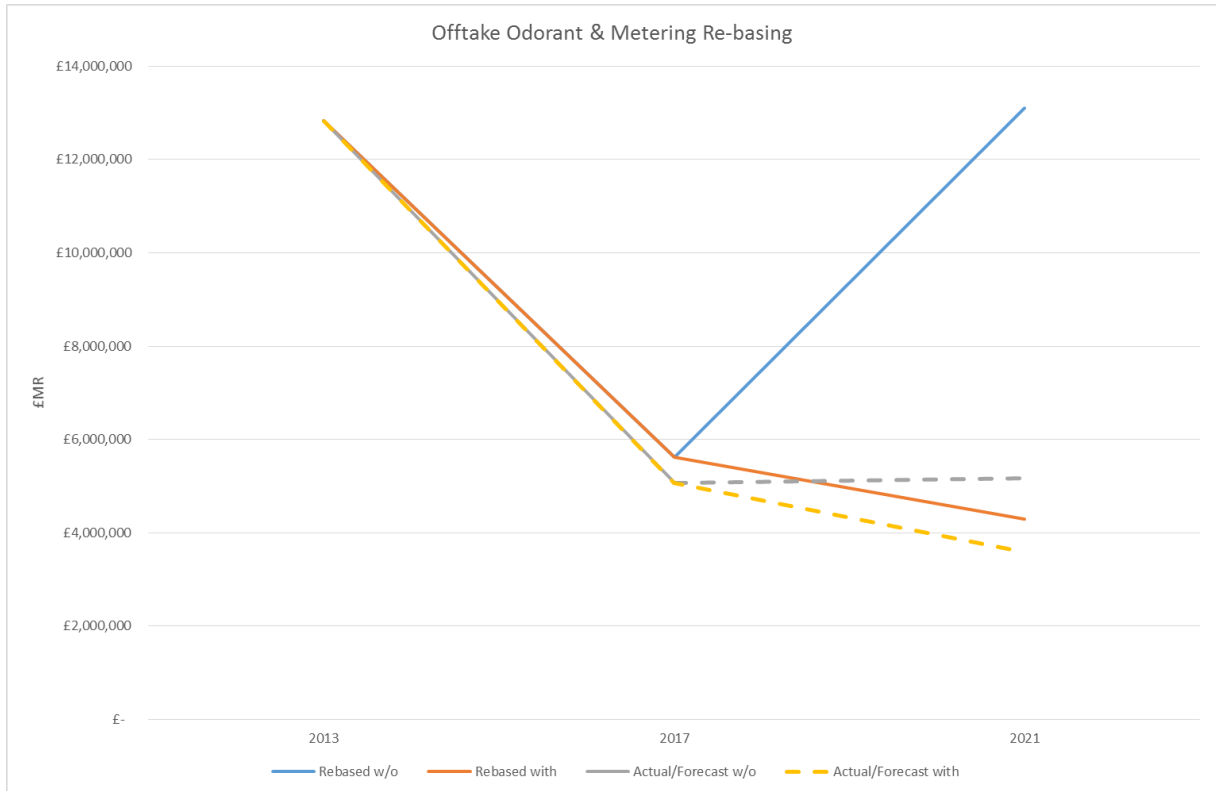


Figure A2-6: Odorant and Metering Monetised Risk changes over RIIO-GD1, backcast from 2017 and forecast to show with and without interventions.

Offtake/PRS Pre-heating

1. Currently 62% of target of £19.0m Rebased Risk Reduction Target at 2021 based on 2017 dataset assuming no further workload
2. i.e. 12% ahead – this is largely due to front-end loading the investment plan.
3. Forecast 99% delivery of Rebased target at 2021 assuming current forecast intervention workloads: c. £0.082m underperformance forecast
4. There is an issue with the Offtake and PRS models with the deterioration coefficient ‘gamma’ that accelerates deterioration rapidly after a period of low level deterioration. This happens when the asset reaches HI5. This was built into the model after elicitation workshops, but is leading to spikes in deterioration and peaky risk profiles as can be seen in Figure A 2-6 below. This affects all asset classes within the Offtake/ PRS primary asset class.
5. Consequential testing showed based on volumes alone we would be targeting HI3 replacements in the future workload, whilst the regulatory contract expected to target HI4/5 assets. This leads to significant risk reduction (due to the ‘gamma effect’), using the regulatory contract volumes and HI4/5 health/criticality risk reduction. Assets on site will be in conditions HI4/5 when we come to replace them in the next years, which is not reflected in the 2017 RRP base data. As such NGN have tested inflating the risk of future investment assets to HI5 to demonstrate the risk reduction given that these assets are in worse condition in reality vs the data condition.

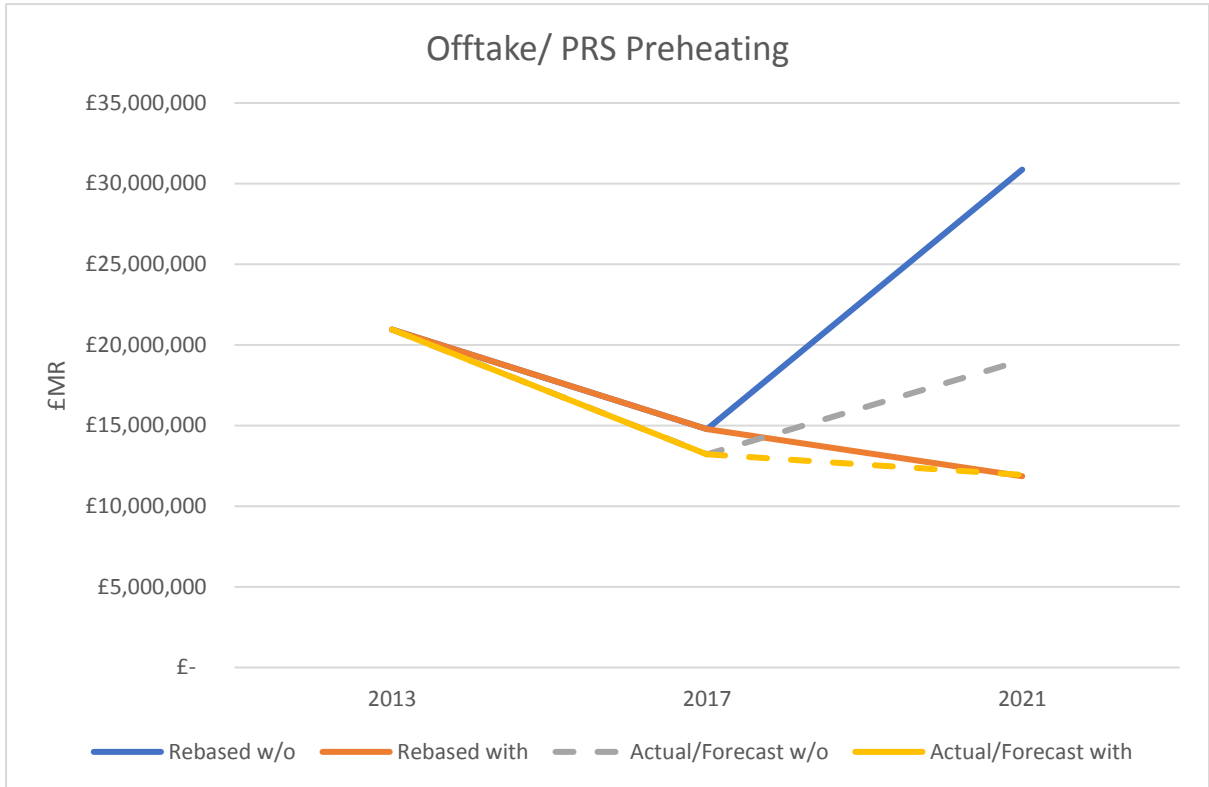


Figure A2-7: Preheating Monetised Risk changes over RIIO-GD1, backcast from 2017 and forecast to show with and without interventions.

Offtake/PRS Filters

1. Currently 32% of target of £3.6m Rebased Risk Reduction Target at 2021 due to 2017 dataset assuming no further workload
 - a. i.e. 18% behind – this is largely due to a back-end loaded replacement programme.
2. Forecast 115% delivery of Rebased target at 2021 assuming current forecast workload interventions: c. £0.5m outperformance forecast

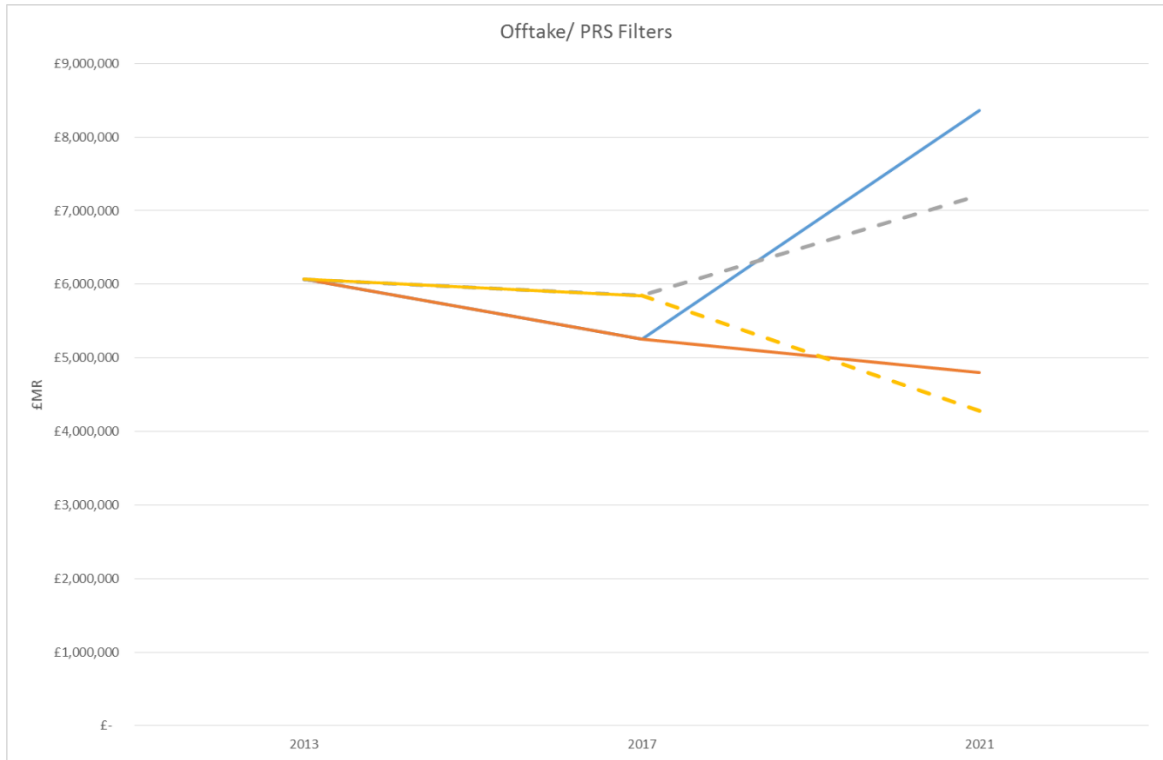


Figure A2-8: Filters Monetised Risk changes over RIIO-GD1, backcast from 2017 and forecast to show with and without interventions.

Offtake/PRS Pressure Control

1. Currently 46% of target of £1.6m Rebased Risk Reduction Target at 2021 based on 2017 dataset assuming no further workload
 - a. i.e. 4% behind – this is largely due to a back-end loaded investment plan (with a movement towards replacement from refurbishment).
2. Forecast 111% delivery of Rebased target at 2021 based on current forecast workload interventions: c. £0.18m outperformance forecast

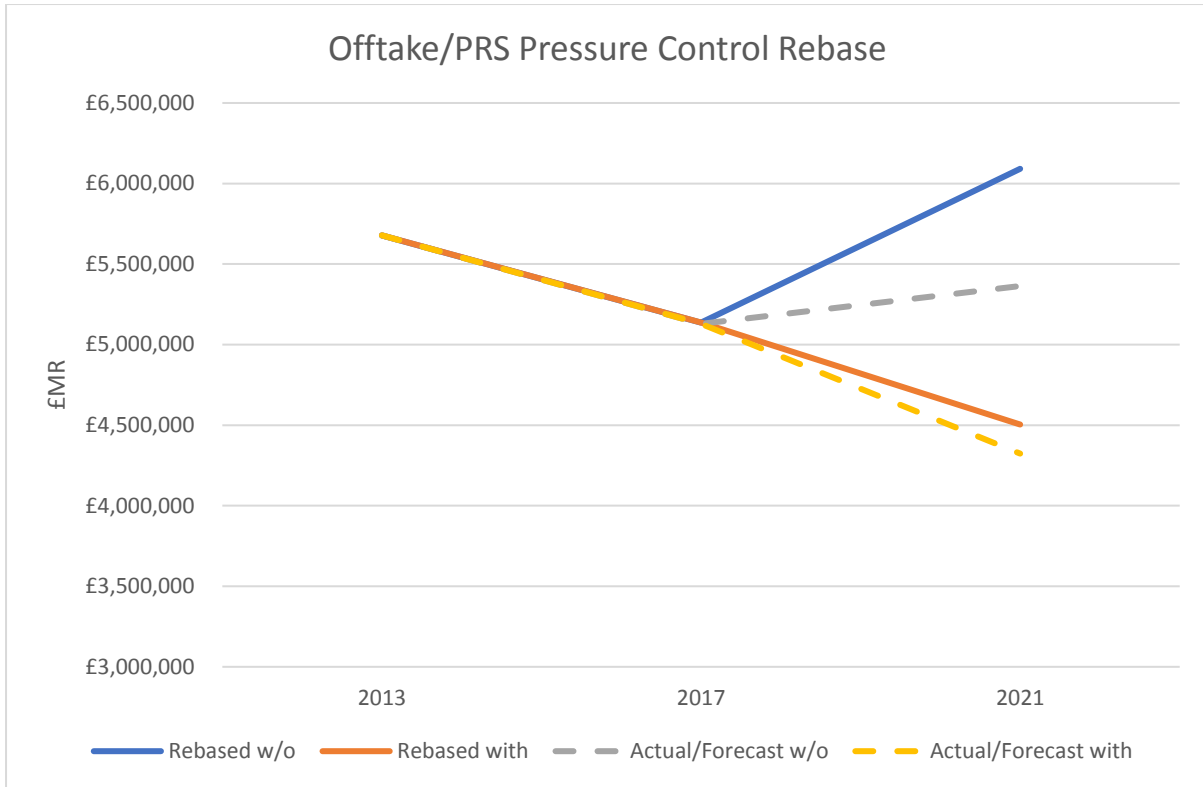


Figure A2-9: Pressure Control Monetised Risk changes over RIIO-GD1, backcast from 2017 and forecast to show with and without interventions.

Overall

	% of Target Risk Reduction at 2021 delivered to date	% of Target Risk Reduction at 2021 Forecast	Forecast Outperformance at 2021 (£m)
Distribution Mains	54%	104%	£1.000
Services	48%	97%	-£0.002
Risers	45%	81%	-£0.003
Governors	43%	72%	-£0.021
LTS	64%	116%	£0.038
Odorant & Metering	90%	108%	£0.700
Pre-heating	62%	99%	-£0.082
Filters	32%	115%	£0.500
Pressure Control	46%	111%	£0.180
Network Level			£2.310

Figure A2-10 Forecast overall outperformance at asset and Network level

Appendix 3 – NAW / Regulatory Contract workload comparison with Rebasing workload

Full details comparing the original NGN Network Asset Workbook (NAW) and the Rebased Workbook can be found in the supplementary spreadsheet: *NGN Rebasing submission and workbook comparison*. This details the following:

- The Original NAW Business plan workload
- The Adjusted NAW Regulatory Contract Workload
- Rebasing Intervention workload in line with the NOMs methodology

To obtain the Rebased workbook, the original NAWs have been used to identify the volume of workload to be completed in RIIO-GD1 as well as the types of assets for investment. These were then adjusted by the workloads agreed in the Regulatory Contract.

Below are details of how these workloads have then been converted to a monetised risk reduction for each asset class.

- Mains – Volume of non-pe replacement used combined with the average risk of a non-pe pipe (1km) and average risk of the replaced PE pipe (0.98km)
- Services – Volume of replacement services combined with the average risk of a non-pe service.
- Risers – Volume of riser replacement combined with the average risk of a riser pre-investment and average risk of a new riser.
- Governors – Volume of Governor Replacements/ Refurbs combined with the risk reduction for each volume of criticality, for which details are given in Section 3.
- Pressure Control – Volume of Pressure Control Replacements/ Refurbs combined with the risk reduction for each volume of criticality, for which details are given in Section 3.
- Filters – Volume of Filter Replacements combined with the risk reduction for each volume of criticality, for which details are given in Section 3.
- Preheater – Volume of Preheater Replacements combined with the risk reduction for each volume of criticality, for which details are given in Section 3.
- Odorant – Volume of Odorant Controller Replacements combined with the risk reduction for each volume of criticality, for which details are given in Section 3.
- Meters – Volume of Meter Replacements combined with the risk reduction for each volume of criticality, for which details are given in Section 3.
- LTS – Volume of LTS workload combined with the average risk reduction for each intervention.

Rebased Health and Criticality bandings to enable calculation of average risk/unit for Rebased Health and Criticality bandings

The movement from a 4x5 Health and Criticality matrix can be seen in Figure A3-1. All assets have the health score manually inflated to identical health scores and NOMs models are run to determine Monetised Risk. The outputs from the model are then converted into a criticality score, detailed in Section 3, and ranked highest to lowest. In District Governors there are 308 CI1 (Very High Criticality) so the top 308 assets ranked by criticality are represented by this CI1 banding. The same process is used for all AGIs.

For full details of the calculation of average risk/unit for Rebased Health and Criticality bandings See Section 5.

Asset categories	Component	Units	Criticality Index	Asset distribution based on estimated asset health index					Asset Register	
				Without Investment (50/50 Estimate)						
				Asset health index					31-Mar-21	
				HI1	HI2	HI3	HI4	HI5		
22	District Governors	Asset Level	Number of	Low	0	532	35	186	63	815
				Medium	0	525	32	178	58	793
				High	0	291	18	99	32	439
				Very High	0	204	13	69	23	308



1						
Asset Count No.	Asset Health Failures /Gov	Customer Risk £/Gov	Health & Safety Risk £/Gov	Carbon Risk £/Gov	Monetised Risk £/Gov	Criticality
1.000	0.00	£ -	£ 1.45	£ 367.95	£ 786.21	2249560.1
1.000	0.00	£ -	£ 2.61	£ 368.04	£ 1,346.87	1958396.8
1.000	0.00	£ -	£ 2.32	£ 368.04	£ 1,346.58	1957975.1
1.000	0.00	£ -	£ 1.45	£ 367.95	£ 585.21	1700787
1.000	0.00	£ -	£ 1.45	£ 367.95	£ 585.21	1700787
1.000	0.00	£ -	£ 1.46	£ 368.05	£ 1,126.72	1625156.2

Figure A3-1: Movement from a 4x5 HI/CI matrix to a decending criticality score. Top 308 represent C1, next 439 C2 etc.

Appendix 4 – Equivalent Impact Testing

Test 3 – Asset Condition/ performance test

Asset	Expected Risk Reduction	Actual Risk Reduction	Result
LTS	20%	1%	FAIL
Mains	21%	26%	PASS
Services	17%	19%	PASS
Risers	1%	2%	PASS
Pressure Control	18%	26%	PASS
Filters	25%	43%	PASS
Pre-heating	43%	62%	PASS
Odorant	49%	71%	PASS
Metering	41%	59%	PASS
Governors	6%	2%	FAIL

Table 4: Summary of NGN’s equivalent impact results

NGN have applied the method of comparing the old NAW relative risk reduction with the new Monetised relative risk reduction. This involves calculating a risk score based on the number of assets in each risk and criticality banding by a scoring matrix, see figure below. The relative change in risk reduction gives the values in Table 4 “Expected Risk Reduction”. This is then compared with the relative risk reduction using the rebased 2021 positions “Actual Risk Reduction”. Where the “Actual Risk Reduction” (Rebased Methodology) is greater or equal to “Expected Risk Reduction” (Original Business Plan) the test is considered to be a PASS.

For comments on LTS and Governors that have FAILED, see Appendix 1.

Note: This test will be impacted by secondary asset classes, and it is important to split out the sub-assets. This has been done for Offtakes and PRS in Table 4 above. However, secondary assets are still integrated for LTS (Pipelines: Sleeves, Block, Valves, etc), and Governors (DGs, I&Cs, SGs) as it was not possible to split the risk out accurately. In these cases, a weighting mechanism was applied to allow for the different proportions of monetised risk of each secondary asset within the primary asset class risk. These weightings were calculated from the 2017 NOMs models using the 2021 without intervention risk position.