Air Quality Assessment:
A37 Options and Feasibility Study

January 2020

Experts in air quality
management & assessment

Document Control

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1 Introduction

1.1 This report describes the potential air quality impacts associated with a number of options for improvement works on the A37 within Temple Cloud and Farrington Gurney. The assessment has been carried out by Air Quality Consultants Ltd on behalf of Jacobs.

1.2 Bath and North East Somerset Council (B&NES) are considering four schemes to improve air quality on the A37 within Temple Cloud and Farrington Gurney as part of the A37 Options and Feasibility Study. The proposed schemes all lie within Air Quality Management Areas (AQMAs) declared by B&NES for exceedances of the annual mean nitrogen dioxide objective. The proposed schemes aim to improve air quality within both villages.

1.3 The proposed schemes will lead to changes in vehicle flows on the A37, changes to vehicle speeds and road alignment which will impact on air quality at existing residential properties. Two options are considered within Temple Cloud:

- implementing vehicle width restrictions on the A37 within Temple Cloud with the aim of reducing the number of heavy vehicles through the centre of the village (Option 8); and
- cutting back vegetation to allow increases in traffic speeds where heavy vehicles are less likely to slow to pass one another (Option 9).

1.4 Two schemes are also assessed within Farrington Gurney and comprise road layout changes at the junction of the A37 and A362. Specifically:

- a proposed widening of the A37 around of the junction (Option 3); and
- a proposed roundabout to replace the T-junction (Option 5).

1.5 This report describes existing local air quality conditions (base year 2018), and the predicted air quality in the future assuming that the proposed schemes do, or do not proceed. The assessment of traffic-related impacts focuses on 2021 as this is the earliest year the schemes could be operational. The assessment focuses on nitrogen dioxide as this is the pollutant for which the AQMA is designated.

1.6 This report has been prepared taking into account all relevant local and national guidance and regulations.

2 Policy Context and Assessment Criteria

Air Quality Strategy

2.1 The Air Quality Strategy (Defra, 2007) published by the Department for Environment, Food, and Rural Affairs (Defra) and Devolved Administrations, provides the policy framework for air quality management and assessment in the UK. It provides air quality standards and objectives for key air pollutants, which are designed to protect human health and the environment. It also sets out how the different sectors: industry, transport and local government, can contribute to achieving the air quality objectives. Local authorities are seen to play a particularly important role. The strategy describes the Local Air Quality Management (LAQM) regime that has been established, whereby every authority has to carry out regular reviews and assessments of air quality in its area to identify whether the objectives have been, or will be, achieved at relevant locations, by the applicable date. If this is not the case, the authority must declare an Air Quality Management Area (AQMA), and prepare an action plan which identifies appropriate measures that will be introduced in pursuit of the objectives.

National Air Quality Plan

2.2 Defra has produced an Air Quality Plan to tackle roadside nitrogen dioxide concentrations in the UK (Defra, 2017); a supplement to the 2017 Plan (Defra, 2018a) was published in October 2018 and sets out the steps Government is taking in relation to a further 33 local authorities where shorter-term exceedances of the limit value were identified, which included Bath and North East Somerset due to exceedances predicted on London Road. Alongside a package of national measures, the 2017 Plan and the 2018 Supplement require those identified English Local Authorities (or the GLA in the case of London Authorities) to produce local action plans and/or feasibility studies. These plans and feasibility studies must have regard to measures to achieve the statutory limit values within the shortest possible time, which may include the implementation of a Clean Air Zone (CAZ).

Local Air Quality Plans and Policies

Bath Clean Air Zone (CAZ)

2.3 After significant consultation with the public, the council has decided on a class C CAZ, charging most higher-emission vehicles to drive in the city centre from late 2020. Private cars and motorbikes will not be charged. The scheme also features traffic management measures in central Bath, and a range of support to lessen the impact of the zone and encourage a shift to cleaner travel and transport. It is unknown form work undertaken to date what impact the implementation of the CAZ might have on the A37 and therefore the study area for this report and it has therefore not explicitly been taken into account.

Local Air Quality Action Plan

2.4 In Farrington Gurney and Temple Cloud, monitoring demonstrated exceedances of the annual mean nitrogen dioxide air quality objective. B&NES Council therefore declared AQMAs at these two locations. These villages were outside the scope of the CAZ and therefore this report forms part of the process to evaluate options to improve air quality within these AQMA's for inclusion in an Air Quality Action Plan to address the AQMA declarations.

Assessment Criteria

2.5 The Government has established a set of air quality standards and objectives to protect human health. The 'standards' are set as concentrations below which effects are unlikely even in sensitive population groups, or below which risks to public health would be exceedingly small. They are based purely upon the scientific and medical evidence of the effects of an individual pollutant. The 'objectives' set out the extent to which the Government expects the standards to be achieved by a certain date. They take account of economic efficiency, practicability, technical feasibility and timescale. The objectives for use by local authorities are prescribed within the Air Quality (England) Regulations (2000) and the Air Quality (England) (Amendment) Regulations (2002).

2.6 The objective for nitrogen dioxide was to have been achieved by 2005, and continue to apply in all future years thereafter. Measurements across the UK have shown that the 1-hour nitrogen dioxide objective is unlikely to be exceeded at roadside locations where the annual mean concentration is below 60 $\mu g/m^3$ (Defra, 2016). Therefore, 1-hour nitrogen dioxide concentrations will only be considered if the annual mean concentration is above this level.

2.7 The objectives apply at locations where members of the public are likely to be regularly present and are likely to be exposed over the averaging period of the objective. Defra explains where these objectives will apply in its Local Air Quality Management Technical Guidance (Defra, 2016). The annual mean objective for nitrogen dioxide is considered to apply at the façades of residential properties, schools, hospitals etc.; it does not apply at hotels. The 1-hour mean objective for nitrogen dioxide applies wherever members of the public might regularly spend 1-hour or more, including outdoor eating locations and pavements of busy shopping streets.

2.8 The European Union has also set limit values for nitrogen dioxide (The European Parliament and the Council of the European Union, 2008). The limit values for nitrogen dioxide are the same numerical concentrations as the UK objectives, but achievement of these values is a national obligation rather than a local one. In the UK, only monitoring and modelling carried out by UK Central Government meets the specification required to assess compliance with the limit values. Central Government does not normally recognise local authority monitoring or local modelling studies when determining the likelihood of the limit values being exceeded, unless such studies have been audited and approved by Defra and DfT's Joint Air Quality Unit (JAQU), as is the case with modelling undertaken in central Bath for the CAZ feasibility study.

2.9 The relevant air quality criteria for this assessment are provided in Table 1.

Table 1: Air Quality Criteria for Nitrogen Dioxide

Pollutant	Time Period	Objective
Nitrogen Dioxide	1-hour Mean	200 µg/m^3 not to be exceeded more than 18 times a year
	Annual Mean	40 µg/m^3

Descriptors for Air Quality Impacts and Assessment of Significance

2.10 There is no official guidance in the UK in relation to development control on how to describe air quality impacts, nor how to assess their significance. The approach developed jointly by Environmental Protection UK (EPUK) and the Institute of Air Quality Management (IAQM)[1] (Moorcroft and Barrowcliffe et al, 2017) has therefore been used. This includes defining descriptors of the impacts at individual receptors, which take account of the percentage change in concentrations relative to the relevant air quality objective, rounded to the nearest whole number, and the absolute concentration relative to the objective. The overall significance of the air quality impacts is determined using professional judgement, taking account of the impact descriptors. Full details of the EPUK/IAQM approach are provided in Appendix A1. The approach includes elements of professional judgement, and the experience of the consultants preparing the report is set out in Appendix A2.

1 The IAQM is the professional body for air quality practitioners in the UK.

3 Assessment Approach

Proposed Schemes

3.1 The four schemes being considered by B&NES are located along the A37 in Temple Cloud and Farrington Gurney. The schemes in Temple Cloud comprise:

- Option 8: Vehicle width restrictions preventing wider HDVs travelling through Temple Cloud along the A37; and
- Option 9: Vegetation cut backs alongside the A37 to allow wider vehicles to pass in either direction without needing to slow down.

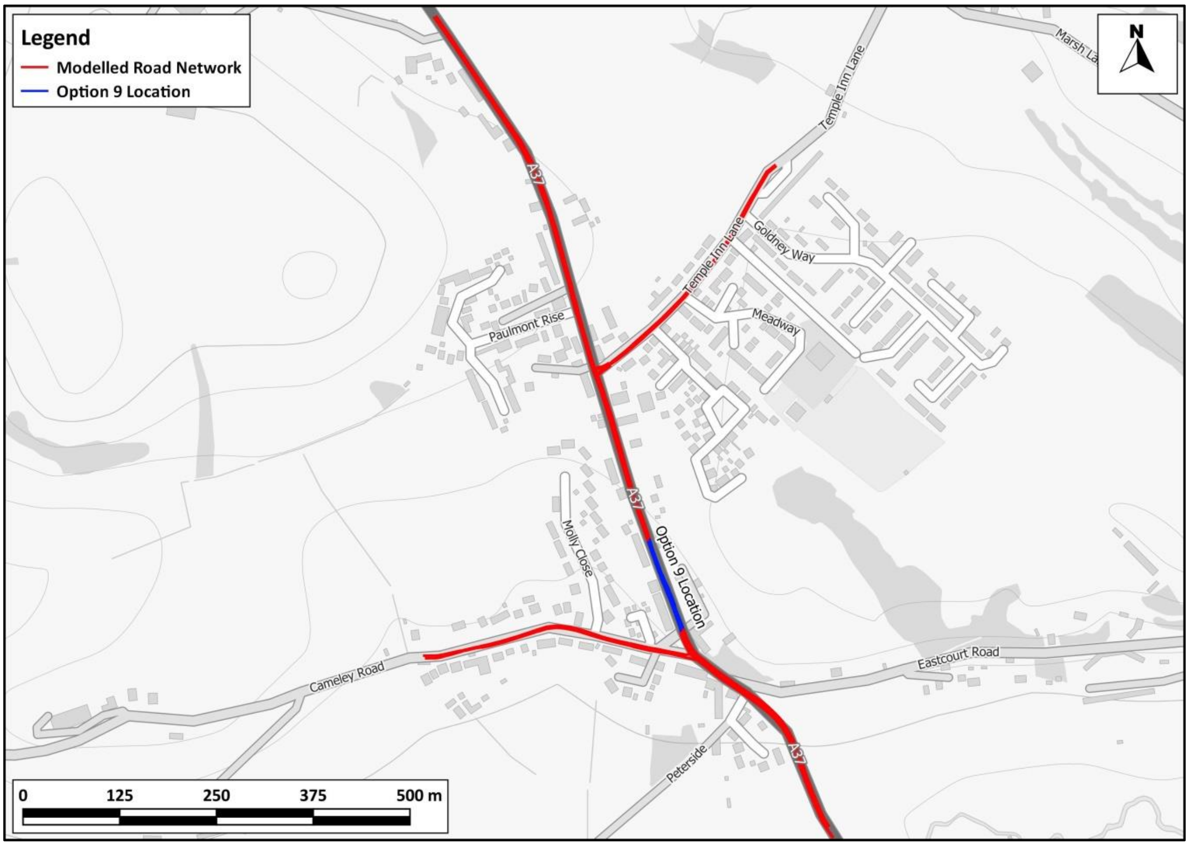

Figure 1: Temple Cloud Study Area

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3.2 The schemes in Farrington Gurney comprise:

- Option 3: A37 widening around the junction between the A37 and A362, with an additional southbound lane being added north of the junction; and
- Option 5: Constructing a roundabout to replace the T-junction between the A37 and A362.

Figure 2: Farrington Gurney Study Area, Baseline (left), Roundabout Option (top right), A37 Widening Option (bottom right)

3.3 The impacts of the proposed schemes on air quality have been assessed using detailed dispersion modelling, using the outputs of the VISSIM micro-simulation traffic model.

Assessment Scenarios

3.4 Nitrogen dioxide concentrations have been predicted for a base year (2018) and the schemes earliest first full operational year (2021). For 2021, predictions have been made assuming that each scheme does proceed (With Scheme), and does not proceed (Without Scheme).

Modelling Methodology

3.5 Concentrations have been predicted using the ADMS-Roads dispersion model. Details of the model inputs, assumptions and the verification are provided in Appendix A3. Where assumptions have been made, a realistic worst-case approach has been adopted.

Traffic Data and Emissions Calculation

3.6 Traffic data for the assessment have been provided by Jacobs Ltd, who have undertaken traffic modelling for the two schemes. Traffic data have been sourced using the VISSIM micro-simulation traffic model. This model comprises the A37 corridor from Cholwell Farm north of Temple Cloud, to the junction of the A37 with the A39 south of Farrington Gurney. It includes the side roads and junction of Temple Inn Lane, Cameley Road, Church Lane Ham Lane and the A362. The model has been developed as a 12-hour weekday model for the hours between 07:00 and 19:00. AQC has derived traffic data outside of these hours (including weekends) based on village specific diurnal profiles sourced from traffic counts in Temple Cloud and Farrington Gurney. Emissions have then been calculated for every hour using Defra's Emission Factor Toolkit (EFT v 9.0). Gradients and slope direction for each section of road within Temple Cloud have been included within the EFT[2] to take account of the effect of gradients on emissions. Gradients have been determined by reviewing changes in gradient within the study area and deriving heights using LIDAR.

Sensitive Locations

3.7 Concentrations of nitrogen dioxide have been predicted at a number of locations close to the proposed schemes, in proximity to the AQMAs. Receptors have been identified to represent a range of exposure, including the worst-case locations (these being at the façades of the residential properties closest to affected road links). When selecting receptors, particular attention has been paid to assessing impacts close to junctions, where traffic may become congested and where there

[2] The EFT uses the same coefficients for increasing emissions on gradients as outlined in Technical Guidance TG16.

is a combined effect of several road links, and close to those roads where changes in traffic volumes, fleet mix or speeds as a result of the schemes will be greatest.

3.8 A number of existing residential properties have been identified as receptors for the assessment. These locations are shown in Figure 3 and Figure 4. In addition, in Temple Cloud, concentrations have been modelled at three current diffusion tube monitoring sites, and a further five decommissioned diffusion tube monitoring locations within the study area. In Farrington Gurney concentrations have been modelled at five diffusion tube monitoring locations. These sites were modelled in order to verify the model outputs (see Appendix A4 for verification method).

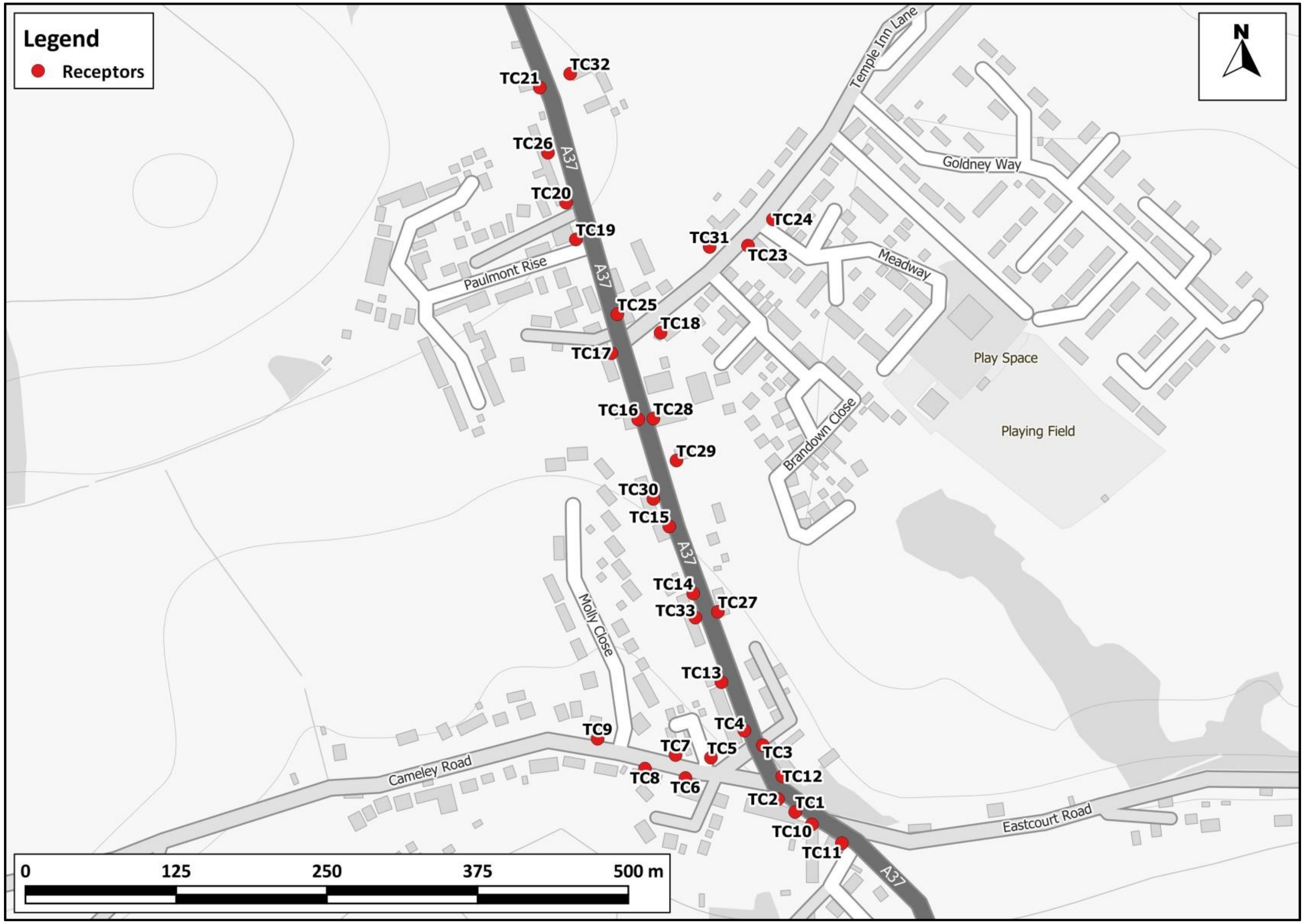

Figure 3: Temple Cloud Receptor Locations

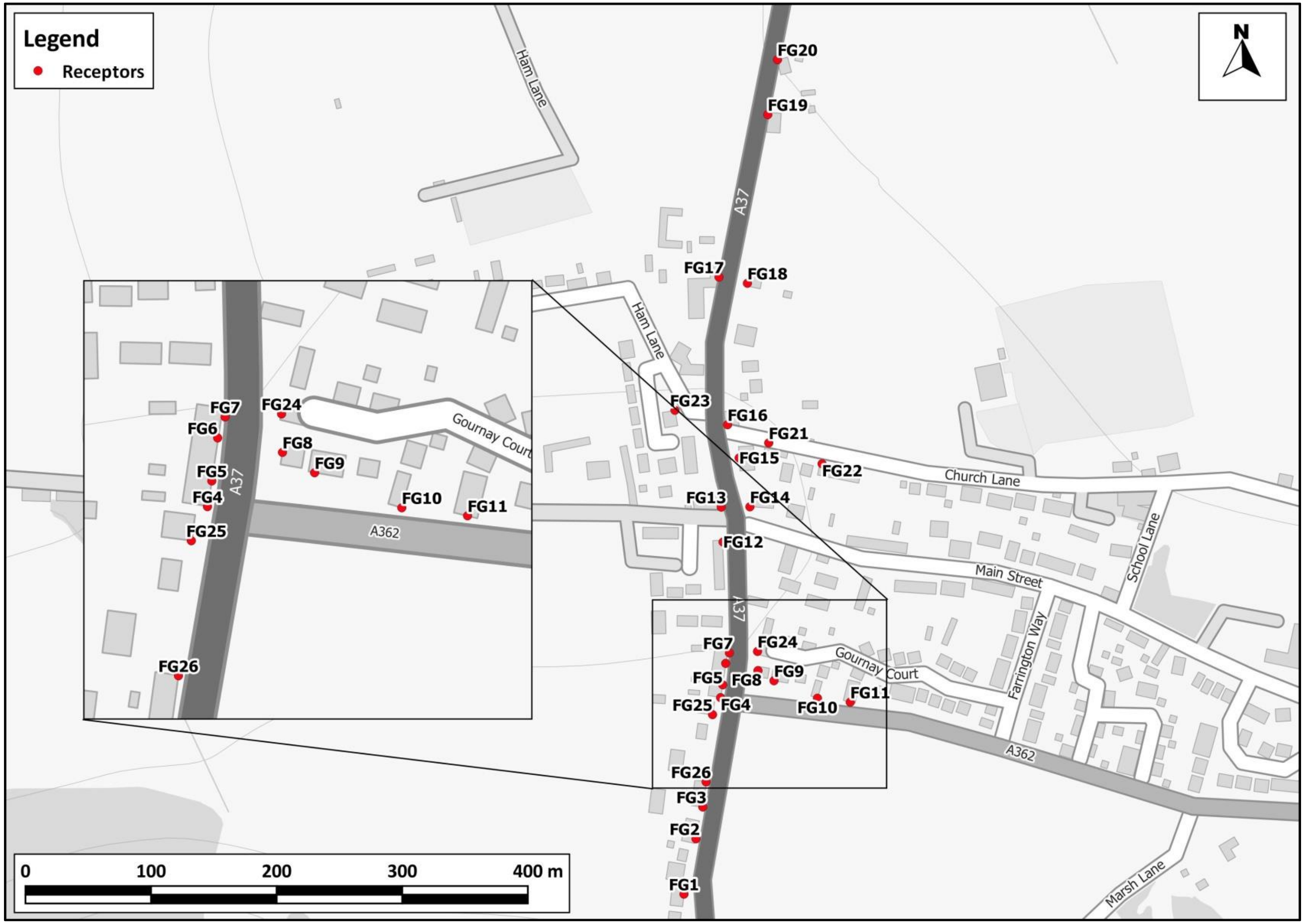

Figure 4: Farrington Gurney Receptor Locations

Uncertainty in Road Traffic Modelling Predictions

3.9 There are many components that contribute to the uncertainty of modelling predictions. The road traffic emissions dispersion model used in this assessment is dependent upon the traffic data that have been input, which will have inherent uncertainties associated with them. There are then additional uncertainties, as models are required to simplify real-world conditions into a series of algorithms.

3.10 An important stage in the process is model verification, which involves comparing the model output with measured concentrations (see Appendix A3). Because the model has been verified and adjusted, there can be reasonable confidence in the prediction of base year (2018) concentrations.

3.11 Predicting pollutant concentrations in a future year will always be subject to greater uncertainty. For obvious reasons, the model cannot be verified in the future, and it is necessary to rely on a series of projections provided by DfT and Defra as to what will happen to traffic volumes, background pollutant concentrations and vehicle emissions.

3.12 Traffic data have been provided by Jacobs for 2018. 2018 traffic flows have been used with 2021 emission factors, and therefore any growth in traffic flows have not been included within the assessment, which represents a limitation.

3.13 The Temple Cloud model has used the advanced street canyon module to consider reduced dispersion as a result of street canyon characteristics. The reduced dispersion within Temple Cloud is particularly difficult to represent within a dispersion model due to the irregular nature of the canyon properties such as varying distances from the road to the edge of the canyon, the varying porosity as a result of a combination of buildings and vegetation and variability in the heights of the canyons. In some locations the vegetation overhangs the carriageway, which is also not well represented by the current ADMS advanced canyon module. Currently the canyon edge overhangs the road. By applying Option 9 the canyon edge will move to the edge of the road. However due to limitations with the canyon model the benefits of increasing the canyon width have not been possible to represent within the model, and therefore the beneficial impacts of Option 9 maybe understated. Canyon properties have been represented within the model in as robust a way as possible, but represents further uncertainty within the results.

4 Baseline Conditions

Existing Conditions

4.1 Information on existing air quality has been obtained by collating the results of monitoring carried out by the local authority within the study area. Background concentrations have been defined using the national pollution maps published by Defra (2020). These cover the whole country on a 1x1 km grid.

Air Quality Management Areas

4.2 B&NES has investigated air quality within its area as part of its responsibilities under the LAQM regime. B&NES has declared AQMAs in Temple Cloud and Farrington Gurney for exceedances of the annual mean nitrogen dioxide objective, which are shown in Figure 5 and Figure 6.

4.3 In terms of PM_{10}, B&NES concluded that there are no exceedances of the objectives. It is, therefore, reasonable to assume that existing PM_{10} levels will not exceed the objectives within the study area.

Local Air Quality Monitoring

4.4 B&NES operates five automatic monitoring stations within its area. None of these are located in the study area close to modelled roads. The Council also operates a number of nitrogen dioxide monitoring sites using diffusion tubes prepared and analysed by Gradko (Somerset Scientific Services in 2016) (using the 20% TEA in water method). Results for the years 2016 to 2018 for the diffusion tubes within the study area are summarised in Table 2 and the monitoring locations are shown in Figure 5.

Table 2: Summary of Annual Mean Nitrogen Dioxide (NO_2) Diffusion Tube Monitoring (2016-2018) [a]

Site No.	Site Type	Site Name	Location	2016	2017	2018
Temple Cloud						
DT96	Roadside	Temple Cloud 1	A37	**90**	**67**	**59.5**
DT108	Roadside	Temple Cloud 2	A37	**48**	**50**	**40.1**
DT109	Roadside	Temple Cloud 3	A37	**46**	**45**	**40.0**
DT110	Roadside	Temple Cloud 4	A37	**53**	**69**	-
DT111	Roadside	Temple Cloud 5	A37	**51**	**52**	-
DT131	Roadside	Temple Cloud 6	Cameley Road	-	11	-
DT132	Roadside	Temple Cloud 7	Temple Inn Lane	-	14	-
DT133	Roadside	Temple Cloud 8	Temple Inn Lane	-	21	-
	Farrington Gurney					
DT126	Roadside	Farrington Gurney 1	A37	**-**	**54**	**43**
DT134	Roadside	Farrington Gurney 2	A37	**-**	**52**	39
DT136	Roadside	Farrington Gurney 3	A37	**-**	**42**	39.6
DT137	Roadside	Farrington Gurney 4	A37	**-**	28	25
DT138	Roadside	Farrington Gurney 5	A362	**-**	39	38
Objective				**40**		

[a] Exceedances of the objectives are shown in bold.

4.5 Monitoring results show a downward trend in concentrations over the past three years in Temple Cloud, however ideally five years of data would be available to have confidence in the observed trends. Concentrations have historically been exceeded at the majority of monitoring locations within Temple Cloud since 2016 and there remains a number of exceedances of the objective.

4.6 Measured concentrations in Farrington Gurney in 2018 are lower than in 2017, however there is insufficient data with which to determine a trend in concentrations of nitrogen dioxide. Concentrations above the air quality objectives have been measured at three of the five diffusion tubes in 2017. Measured concentrations were lower in 2018 with only one location measuring an exceedance of the objective.

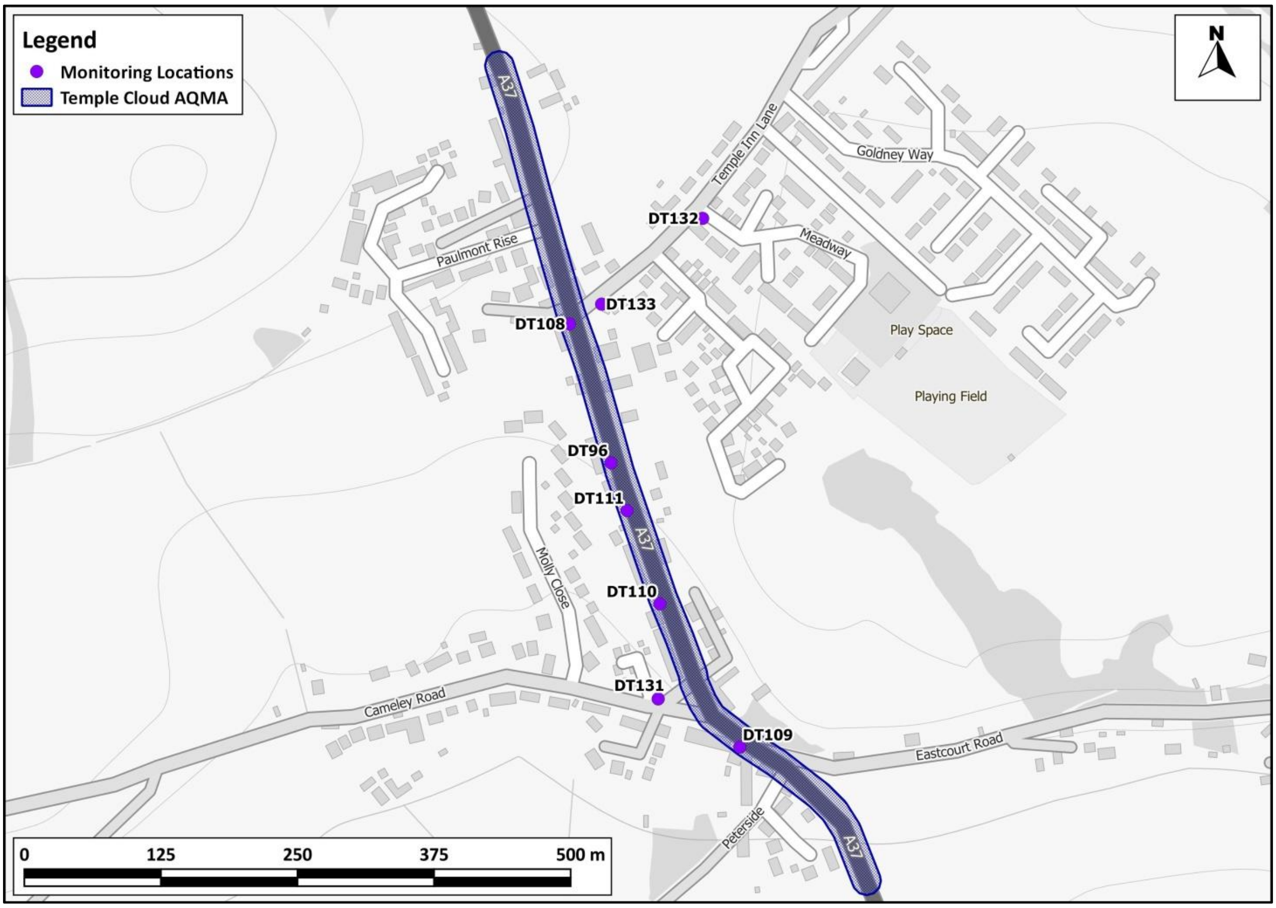

Figure 5: Temple Cloud AQMA and Monitoring Locations

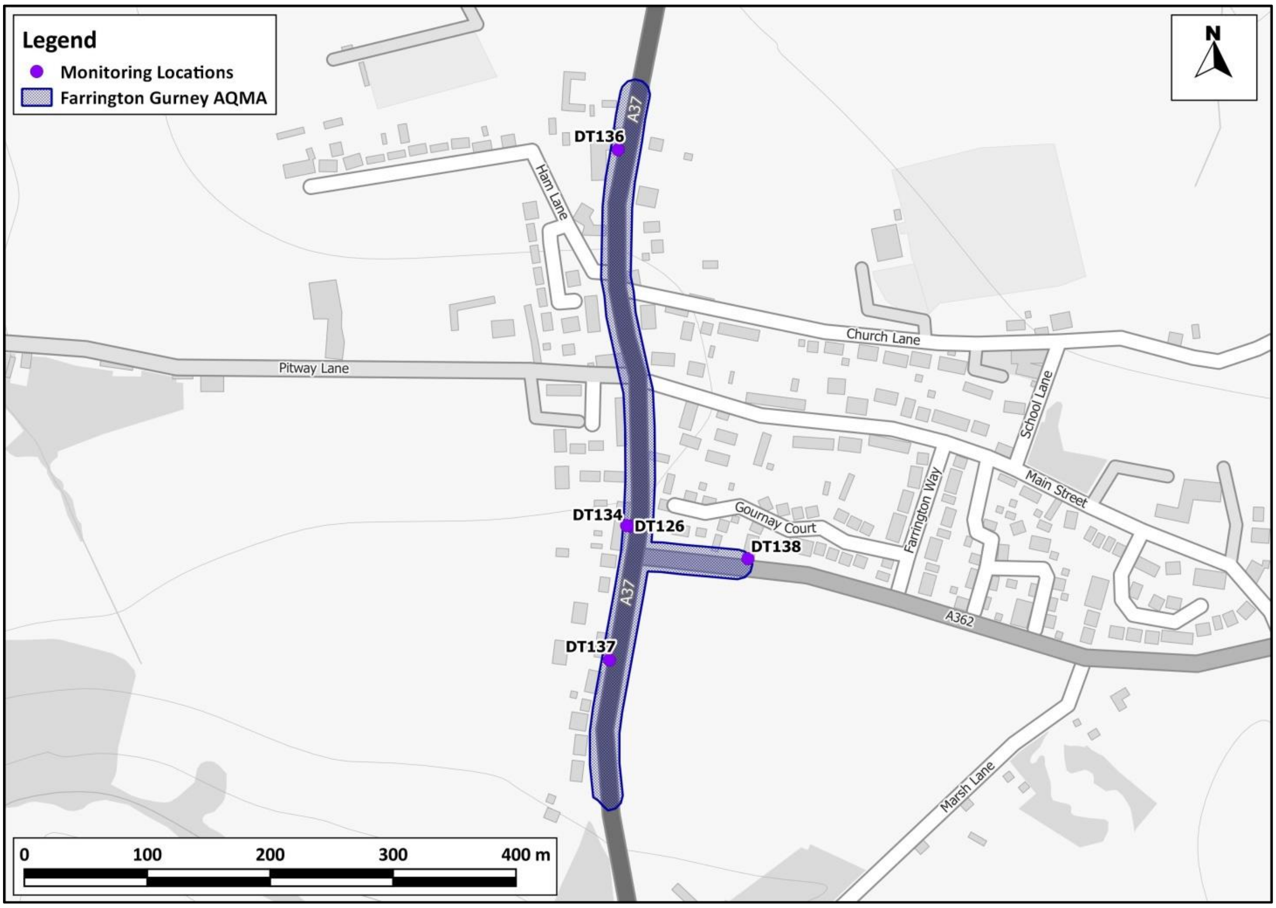

Figure 6: Farrington Gurney AQMA and Monitoring Locations

4.7 B&NES operates two particulate matter automatic monitoring stations within its area. Neither of these are located in close proximity to the assessed scheme. These automatic monitors have not recorded an exceedance of the particulate matter objectives, and under B&NES Council LAQM responsibilities they have concluded that there are no exceedances of the objectives within the Borough, and so particulate matter has not been considered further within this assessment.

Background Concentrations

4.8 Estimated background concentrations in the study area have been determined for 2018 and the completion year of 2021 in Temple Cloud and Farrington Gurney using Defra's background maps (Defra, 2020). The background concentrations are set out in Table 3 and have been derived as described in Appendix A3. The background concentrations are all well below the objectives.

Table 3: Estimated Annual Mean Background Pollutant Concentrations in 2018 and 2021 (µg/m³)

Year	NO_2
Temple Cloud	
2018	6.2 – 6.6
2021	5.5 – 5.8
Farrington Gurney	
2018	6.3
2021	5.5
Objectives	**40**

The range of values is for the different 1x1 km grid squares covering the study area.

Baseline Dispersion Model Results

Temple Cloud

4.9 Baseline concentrations of nitrogen dioxide have been modelled at each of the existing receptor locations (see Figure 3 for receptor locations). The nitrogen dioxide results, which cover both the existing (2018) and future year (2021) baseline (Without Scheme), are illustrated in Figure 7 and Figure 8 with full results presented in Appendix A4. The modelled road components of nitrogen oxides have been increased from those predicted by the model based on a comparison with local measurements (see Appendix A3 for the verification methodology).

2018 Baseline

4.10 The predicted annual mean concentrations of nitrogen dioxide, are above the objective at a number of receptors in 2018, which are all confined within the AQMA. The predicted concentration at receptors TC4 and TC13 are above 60µg/m³ and therefore there is a risk of an exceedance of the 1-hour mean objective. These predicted concentrations are higher at TC4 than at DT96 as the receptor is closer to the road, in a location with poorer dispersion and where traffic speeds are slower.

2021 Baseline

4.11 The predicted annual mean concentrations of nitrogen dioxide remain above the objective at four receptors (TC4, TC13, TC15 and TC16) in 2021. These receptors are all located within the AQMA between Cameley Road and Temple Inn Lane. The concentration at TC4 remains above 60µg/m³ and therefore there continues to be a risk of exceedances of the 1-hour objective at this receptor.

TC14 is located in a similar context to the four exceeding receptors (TC4, TC13, TC15 and TC16), but is predicted to be compliant in 2021. This appears to be due to limitations within the model in relation to uncertainties with modelling street canyons and concentrations may therefore be under predicted at TC14.

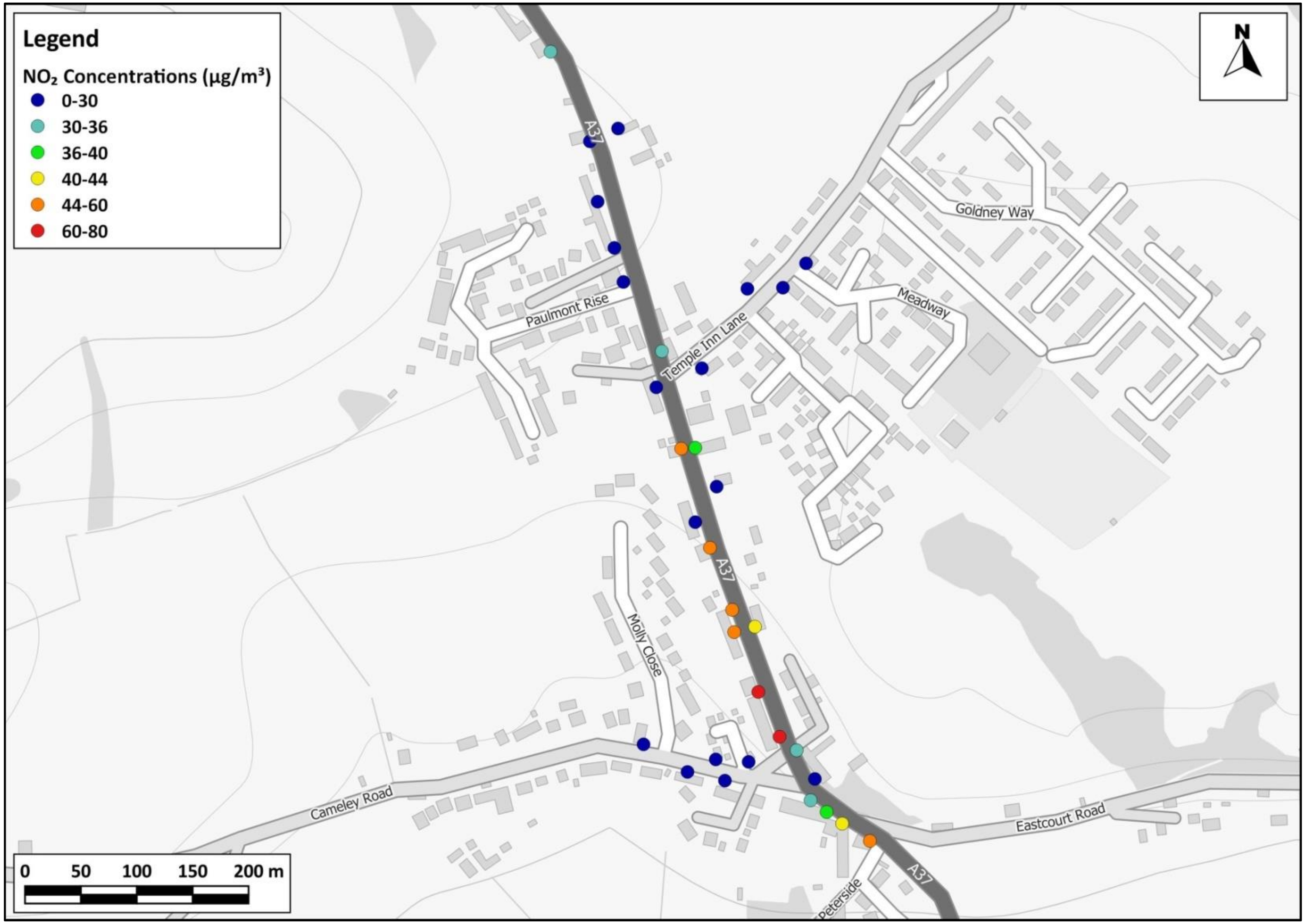

Figure 7: Predicted Annual Mean NO_2 in Temple Cloud in the 2018 Baseline Scenario (µg/m³)

Figure 8: Predicted Annual Mean NO_2 in Temple Cloud in the 2021 Baseline Scenario (µg/m^3)

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Farrington Gurney

4.12 Baseline concentrations of nitrogen dioxide have been modelled at each of the existing receptor locations (see Figure 4 for receptor locations). The nitrogen dioxide results, which cover both the existing (2018) and future year (2021) baseline (Without Scheme), are illustrated in Figure 9 and Figure 10. The modelled road components of nitrogen oxides have been increased from those predicted by the model based on a comparison with local measurements (see Appendix A3 for the verification methodology).

2018 Baseline

4.13 The predicted annual mean concentrations of nitrogen dioxide, are above the objective at a number of receptors in 2018, most of which are located within the AQMA. There are four exceeding receptors outside of the AQMA, two of these are directly adjacent to the AQMA near the A37 and A362 junction, and the remaining two are located on the A37 to the north of Farrington Gurney. The annual mean nitrogen dioxide concentrations are below 60 µg/m^3 at every receptor; it is, therefore, unlikely that the 1-hour mean nitrogen dioxide objective will be exceeded (see Paragraph 2.6).

2021 Baseline

4.14 The predicted annual mean concentrations of nitrogen dioxide in 2021 are below the objective at all receptors. Concentrations are also below 60 µg/m^3 at every receptor; it is, therefore, unlikely that the 1-hour mean nitrogen dioxide objective will be exceeded (see Paragraph 2.6).

Figure 9: Predicted Annual Mean NO_2 in Farrington Gurney in the 2018 Baseline Scenario (µg/m³)

Figure 10: Predicted Annual Mean NO_2 in Farrington Gurney in the 2021 Baseline Scenario (µg/m³)

5 Scheme Impact Assessment

5.1 The assessment has considered the impact of the proposed improvement schemes on local air quality. The schemes will either redistribute vehicles on the local road network and/or lead to changes in vehicle speeds and road alignment along the A37. The improvement schemes will influence emissions of nitrogen oxide and therefore concentrations of nitrogen dioxide.

5.2 The predicted annual mean concentrations of nitrogen dioxide, the change in concentrations and the predicted impacts at each receptor for each of the proposed schemes are set out in the follow sections. The full results for nitrogen dioxide are summarised in Appendix A4.

Temple Cloud

Option 8 (Vehicle Width Restrictions)

5.3 The implementation of Option 8 (vehicle width restrictions) is predicted to lead to substantial reductions in concentrations along the A37. Predicted concentrations at the majority of receptors are predicted to be below the air quality objective with the exception of TC4 where a concentration of 42.7 $\mu g/m^3$ is predicted.

5.4 Option 8 is predicted to lead to slight to substantial beneficial impacts at receptors on the A37 (and negligible impacts at receptors located on side roads). Annual mean concentrations are predicted to reduce by over 10 $\mu g/m^3$ at three receptors with concentrations predicted to reduce by over 17.5 $\mu g/m^3$ at receptor TC4 which is the worst-case receptor[3]. This reduces the predicted concentration at TC4 to below 60 $\mu g/m^3$, reducing the risk of an exceedance of the short term objective as described in Paragraph 2.6.

5.5 Significant beneficial impacts are experienced throughout Temple Cloud with Option 8, largely due to reductions in the number of HDVs along the A37 though the whole of Temple Cloud. The vehicle width restrictions within Temple Cloud could provide further beneficial impacts within Farrington Gurney, with the diversion of HDVs away from the A37, however the scope of these impacts has not been considered within this study. The assessment does not however consider the impact of the displaced vehicles from the A37 onto roads outside of Temple Cloud, which would be expected to lead to adverse impacts to air quality elsewhere. A further study would be required to quantify the impacts of diverted traffic on existing properties outside of Temple Cloud.

[3] Emissions on roads adjacent to this receptor are predicted to reduce by approximately 40%

Figure 11: Predicted Annual Mean NO_2 in Temple Cloud with Option 8 (µg/m³)

Figure 12: Option 8 Change in Concentrations and Predicted Impacts in Temple Cloud

Option 9 (Cutting back vegetation)

5.6 The implementation of Option 9 (cutting back vegetation) leads to a reduction in nitrogen dioxide concentrations along the A37, however the changes aren't as significant as for Option 8.

5.7 Predicted concentrations are predicted to remain above the objective at four receptors (potentially a fifth when considering the potential under prediction at TC14), however concentrations at TC4 are predicted to reduce below 60µg/m^3, reducing the risk of an exceedance of the short term objective as described in Paragraph 2.6. The cutting back of vegetation is predicted to lead to a reduction in concentrations of 2.5 µg/m^3 at the worst case property (TC4). The measure is predicted to result in moderate to substantial beneficial impacts at the worst-case receptors, with negligible impacts at all other receptors within Temple Cloud.

Figure 13: Predicted Annual Mean NO_2 in Temple Cloud with Option 9 (µg/m³)

Figure 14: Option 9 Change in Concentrations and Predicted Impacts in Temple Cloud

Anticipated Year of Objective Compliance

5.8 The air quality assessment of proposed options has shown that air quality will significantly improve with the measures proposed, however compliance with the air quality objective is unlikely to be achieved. The anticipated year of compliance for each of the options in Temple Cloud is shown in Table 4. The year of compliance has been calculated using Defra's annual mean roadside concentration projections (Defra, 2020) to provide B&ANES with an indication of when air quality within Temple Cloud could comply with the air quality objectives. The factors presented by Defra show the projected decrease in roadside NO_2 concentrations from 2017 to 2030, due to reductions in vehicle emissions predicted due to improvements in the fleet. They do not, however, include any local measures which may be implemented (such as the Bath CAZ or any other Action Plan measures). Table 4 shows the anticipated reduction in annual mean concentrations at the receptors which are predicted to be exceeding the objective in 2021.

Table 4: Anticipated Year of Objective Compliance

Year	NO_2 Emissions Reduction Factor	Option 8	Option 9			
		TC4 NO_2 concentration ($\mu g/m^3$)	TC4 NO_2 concentration ($\mu g/m^3$)	TC13 NO_2 concentration ($\mu g/m^3$)	TC15 NO_2 concentration ($\mu g/m^3$)	TC16 NO_2 concentration ($\mu g/m^3$)
2021	1	**42.7**	**58.1**	**50.0**	**41.7**	**40.5**
2022	0.948	**40.5**	**55.1**	**47.4**	39.5	38.4
2023	0.901	38.5	**52.4**	**45.1**	37.6	36.5
2024	0.857	36.6	**49.8**	**42.9**	35.7	34.7
2025	0.817	34.9	**47.4**	**40.8**	34.1	33.1
2026	0.780	33.3	**45.3**	39.0	32.5	31.6
2027	0.746	31.9	**43.4**	37.3	31.1	30.2
2028	0.715	30.6	**41.6**	35.8	29.8	29.0
2029	0.689	29.4	40.0	34.5	28.7	27.9
2030	0.667	28.5	38.7	33.3	27.8	27.0

[a] Exceedances shown in bold.

5.9 Compliance with the annual mean nitrogen dioxide objective is not anticipated until 2023 when taking into account Option 8, and not until 2029 when taking into account Option 9 measures. This is however an indicative prediction; dispersion modelling for each year would be necessary to more accurately predict this.

Farrington Gurney

Option 3 (Widening the A37 around the A37 and A362 junction)

5.10 The implementation of Option 3 (widening the A37 around the A37 and A362 junction) is predicted to lead to a large reduction in concentrations at receptors close to the junction between the A37 and A362 where the road layout modification will occur, with reductions in concentrations predicted of up to 8.4µg/m^3. Moderate and slight beneficial impacts are predicted at the worst-case receptors next to the junction. All other impacts are predicted to be negligible, with the exception of two slight beneficial impacts located on the A37 adjacent to Pitway Lane and Church Lane.

5.11 All concentrations of nitrogen dioxide are predicted to be below the annual mean objective with or without the implementation of the scheme and therefore concentrations are also predicted to be below 60 µg/m^3, indicating that exceedances of the 1-hour mean nitrogen dioxide objective are unlikely.

Figure 15: Predicted Annual Mean NO_2 in Farrington Gurney with Option 3 (µg/m³)

Figure 16: Option 3 Change in Concentrations and Predicted Impacts in Farrington Gurney

Option 5 (Roundabout)

5.12 The implementation of Option 5 (construction of a roundabout to replace the A37/ A362 T-junction) leads to a substantial reduction in nitrogen dioxide concentrations along the A37 adjacent to the A37/ A362 junction with reductions up to 14.2 µg/m^3 predicted at the worst-case receptors next to the junction. Close to the junction impacts are predicted to range from moderate to substantial beneficial due to increased traffic speeds due to removal of the traffic lights and road realignment increasing distance of receptors to the carriageway.

5.13 There are however increases in concentrations at three receptors to the south of the proposed roundabout along the A37, causing one slight adverse impact, which is as a result of the junction (and therefore slower traffic) moving south towards these receptors. However at this receptor, concentrations are not predicted to exceed 27.3 µg/m^3, and so concentrations will remain well below the objective.

5.14 All concentrations of nitrogen dioxide are predicted to be below the annual mean objective with or without the implementation of the scheme and therefore concentrations are also predicted to be below 60 µg/m^3, indicating exceedances of the 1-hour mean nitrogen dioxide objective are unlikely.

Figure 17: Predicted Annual Mean NO_2 in in Farrington Gurney with Option 5 (µg/m^3)

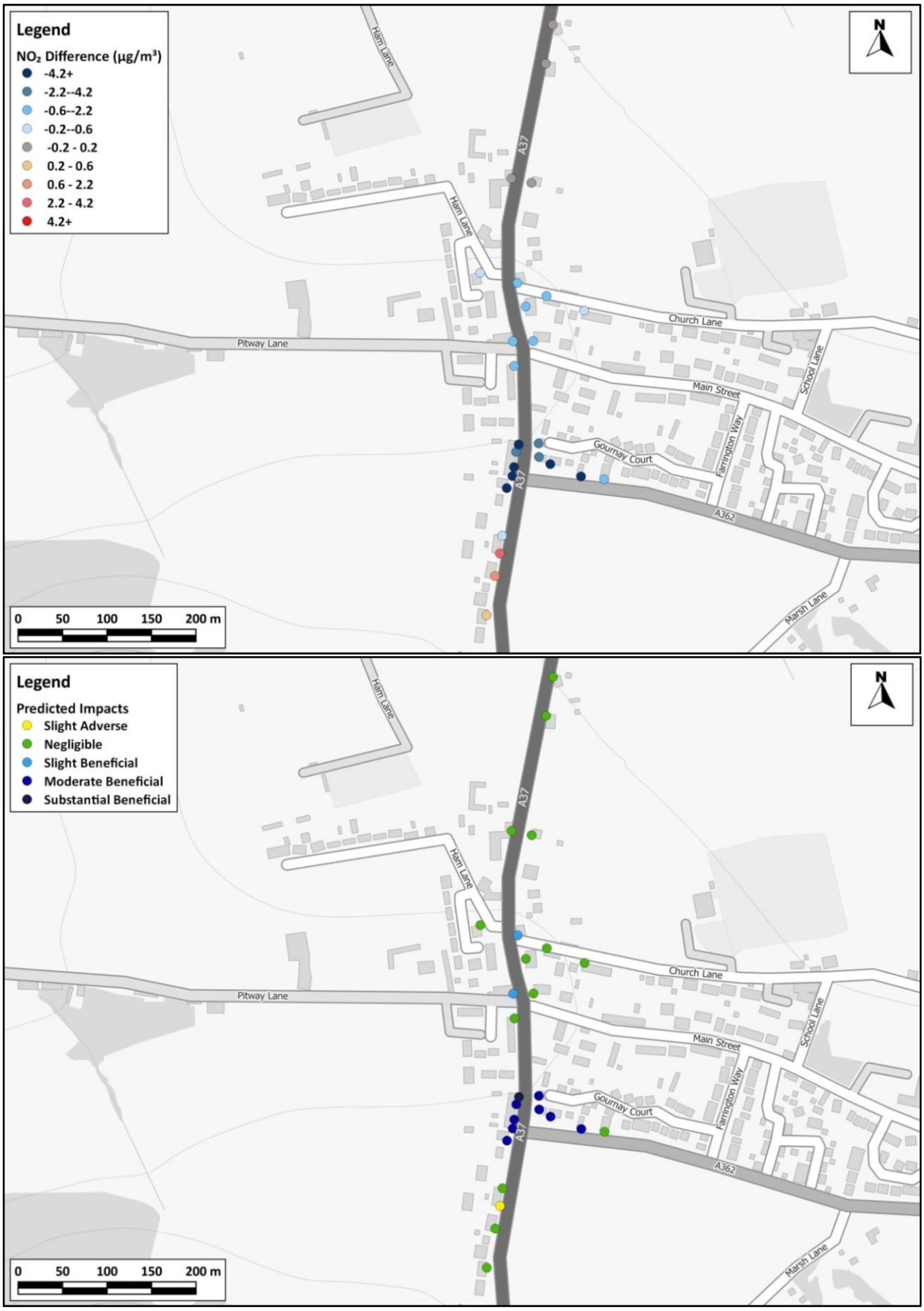

Figure 18: Option 5 Change in Concentrations and Predicted Impacts in Farrington Gurney

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Scheme Comparison

5.15 A comparison of the four different schemes and their impacts on air quality are summarised in Table 5. The number of modelled impacts provides a broad comparison between the schemes.

Table 5: Comparison between the Impacts of Options

Impact	Temple Cloud		Farrington Gurney	
	Option 8	Option 9	Option 3	Option 5
Substantial Beneficial	4	1	0	1
Moderate Beneficial	13	1	3	8
Slight Beneficial	6	3	5	2
Negligible	10	28	18	14
Slight Adverse	0	0	0	1
Moderate Adverse	0	0	0	0
Substantial Adverse	0	0	0	0
Lead to an exceedance of the objective?	0	0	0	0
Maximum Predicted Concentration	42.7	58.1	36.8	36.9
Number of receptors exceeding air quality objective	1	4/5	0	0

Summary

5.16 All options are anticipated to improve air quality at locations along the A37. On the whole the options all cause reductions in concentrations where the highest baseline concentrations are predicted, causing beneficial impacts in the most important areas.

5.17 In summary :

- Option 8 is predicted to result in moderate and substantial beneficial impacts along the A37 throughout Temple Cloud, however the potential for adverse impacts elsewhere in B&NES from the diverted traffic cannot be discounted. It is recommended that further assessment of the impacts of the diverted traffic is undertaken prior to the implementation of this option. One receptor is predicted to remain above the annual mean objective indicative of approximately two residential properties;
- Option 9 is predicted to cause reductions in concentrations at polluted locations along the A37 in Temple Cloud, however the beneficial impacts are much less significant than those in Option 8, with four to five receptors (indicative of approximately seven to eight residential properties) remaining above the annual mean objective, and one property is also at risk of exceedance of the 1-hour mean objective;

- Farrington Gurney is anticipated to have concentrations of nitrogen dioxide below the objective at all receptors in 2021 with or without the implementation of the proposed options;
- Option 3 is predicted to result in slight to moderate beneficial impacts at receptors located around the A73/ A362 junction in Farrington Gurney, with negligible to slight beneficial impacts predicted elsewhere in Farrington Gurney; and
- Option 5 is predicted to have moderate to substantial beneficial impacts at receptors located around the A73/ A362 junction in Farrington Gurney. However there will be one slight adverse impact at a receptor to the south of the proposed roundabout, in a location currently well below air quality objectives. Negligible to slight beneficial impacts are predicted elsewhere in Farrington Gurney.

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7 Glossary

AADT	Annual Average Daily Traffic
ADMS-Roads	Atmospheric Dispersion Modelling System model for Roads
AQC	Air Quality Consultants
AQAL	Air Quality Assessment Level
AQMA	Air Quality Management Area
DCLG	Department for Communities and Local Government
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
EFT	Emission Factor Toolkit
EPUK	Environmental Protection UK
Exceedance	A period of time when the concentration of a pollutant is greater than the appropriate air quality objective. This applies to specified locations with relevant exposure
HDV	Heavy Duty Vehicles (> 3.5 tonnes)
HMSO	Her Majesty's Stationery Office
IAQM	Institute of Air Quality Management
kph	Kilometres Per hour
LAQM	Local Air Quality Management
LDV	Light Duty Vehicles (<3.5 tonnes)
$\mu g/m^3$	Microgrammes per cubic metre
NO	Nitric oxide
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides (taken to be NO_2 + NO)
Objectives	A nationally defined set of health-based concentrations for nine pollutants, seven of which are incorporated in Regulations, setting out the extent to which the standards should be achieved by a defined date. There are also vegetation-based objectives for sulphur dioxide and nitrogen oxides
PM_{10}	Small airborne particles, more specifically particulate matter less than 10 micrometres in aerodynamic diameter

$PM_{2.5}$	Small airborne particles less than 2.5 micrometres in aerodynamic diameter
PPG	Planning Practice Guidance
Standards	A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal
TEA	Triethanolamine – used to absorb nitrogen dioxide

8 Appendices

A1 EPUK & IAQM Planning for Air Quality Guidance

A1.1 The guidance issued by EPUK and IAQM (Moorcroft and Barrowcliffe et al, 2017) is comprehensive in its explanation of the place of air quality in the planning regime and contains impact descriptors for the assessment of significance.

A1.2 There is no official guidance in the UK in relation to development control on how to describe the nature of air quality impacts, nor how to assess their significance. The approach within the EPUK/IAQM guidance has, therefore, been used in this assessment. This approach involves a two stage process:

- a qualitative or quantitative description of the impacts on local air quality arising from the development; and
- a judgement on the overall significance of the effects of any impacts.

Impact Descriptors

A1.3 Impact description involves expressing the magnitude of incremental change as a proportion of a relevant assessment level and then examining this change in the context of the new total concentration and its relationship with the assessment criterion. Table A1.1sets out the method for determining the impact descriptor for annual mean concentrations at individual receptors, having been adapted from the table presented in the guidance document. For the assessment criterion the term Air Quality Assessment Level or AQAL has been adopted, as it covers all pollutants, i.e. those with and without formal standards. Typically, as is the case for this assessment, the AQAL will be the air quality objective value. Note that impacts may be adverse or beneficial, depending on whether the change in concentration is positive or negative.

Table A1.1: Air Quality Impact Descriptors for Individual Receptors for All Pollutants [a]

Long-Term Average Concentration At Receptor In Assessment Year [b]	Change in concentration relative to AQAL [c]				
	0%	1%	2-5%	6-10%	>10%
75% or less of AQAL	Negligible	Negligible	Negligible	Slight	Moderate
76-94% of AQAL	Negligible	Negligible	Slight	Moderate	Moderate
95-102% of AQAL	Negligible	Slight	Moderate	Moderate	Substantial
103-109% of AQAL	Negligible	Moderate	Moderate	Substantial	Substantial
110% or more of AQAL	Negligible	Moderate	Substantial	Substantial	Substantial

[a] Values are rounded to the nearest whole number.

[b] This is the “Without Scheme” concentration where there is a decrease in pollutant concentration and the “With Scheme” concentration where there is an increase.

[c] AQAL = Air Quality Assessment Level, which may be an air quality objective, EU limit or target value, or an Environment Agency ‘Environmental Assessment Level (EAL)’.

Assessment of Significance

A1.4 The guidance recommends that the assessment of significance should be based on professional judgement, with the overall air quality impact of the development described as either ‘significant’ or ‘not significant’. In drawing this conclusion, the following factors should be taken into account:

- the existing and future air quality in the absence of the development;
- the extent of current and future population exposure to the impacts;
- the influence and validity of any assumptions adopted when undertaking the prediction of impacts;
- the potential for cumulative impacts and, in such circumstances, several impacts that are described as ‘*slight*’ individually could, taken together, be regarded as having a significant effect for the purposes of air quality management in an area, especially where it is proving difficult to reduce concentrations of a pollutant. Conversely, a ‘*moderate*’ or ‘*substantial*’ impact may not have a significant effect if it is confined to a very small area and where it is not obviously the cause of harm to human health; and
- the judgement on significance relates to the consequences of the impacts; will they have an effect on human health that could be considered as significant? In the majority of cases, the impacts from an individual development will be insufficiently large to result in measurable changes in health outcomes that could be regarded as significant by health care professionals.

A1.5 The guidance is clear that other factors may be relevant in individual cases. It also states that the effect on the residents of any new development where the air quality is such that an air quality objective is not met will be judged as significant. For people working at new developments in this situation, the same will not be true as occupational exposure standards are different, although any assessment may wish to draw attention to the undesirability of the exposure.

A1.6 A judgement of the significance should be made by a competent professional who is suitably qualified. A summary of the professional experience of the staff contributing to this assessment is provided in Appendix A3.

A2 Professional Experience

Dr Clare Beattie, BSc (Hons) MSc PhD CSci MIEnvSc MIAQM

Dr Beattie is an Associate Director with AQC, with more than twenty years' relevant experience. She has been involved in air quality management and assessment, and policy formulation in both an academic and consultancy environment. She has prepared air quality review and assessment reports, strategies and action plans for local authorities and has developed guidance documents on air quality management on behalf of central government, local government and NGOs. Dr Beattie has appraised local authority air quality assessments on behalf of the UK governments, and provided support to the Review and Assessment helpdesk. She has also provided support to the integration of air quality considerations into Local Transport Plans and planning policy processes. She has carried out numerous assessments for new residential and commercial developments, including the negotiation of mitigation measures where relevant. She has carried out BREEAM assessments covering air quality for new developments. Clare has worked closely with Defra and has managed the Defra Air Quality Grant Appraisal contract over a 4-year period. She is a Member of the Institute of Air Quality Management and is a Chartered Scientist.

Lucy Hodgins, BSc (Hons) MIEnvSc MIAQM

Lucy is a Senior Consultant with AQC, with over ten years' experience in the field of air quality. She has been involved in the assessment of air quality impacts for a range of industrial, commercial and residential projects using qualitative and quantitative methods, including dispersion modelling, utilising a variety of models including ADMS Roads, Breeze Roads, ADMS-5 and Breeze Aermod. She has been responsible for the preparation of road traffic and point source emissions assessments for residential, mixed-use and industrial developments. She has undertaken numerous operational dust assessments for mineral and waste facilities, as well as assessments of construction dust emissions. She has also undertaken assessments for energy from waste, anaerobic digestion and waste biomass facilities for a range of air pollutants, along with nuisance dust and odour. She is a Member of the Institute of Air Quality Management and the Institution of Environmental Sciences.

David Bailey, BSc (Hons) AMIEnvSci

Mr Bailey is a Consultant with AQC, having joined the Company in 2018. Prior to joining AQC he gained a degree in Environmental Science from the University of Brighton, where his studies included modules focused on Air Quality Management. He is now gaining experience in air quality and greenhouse gas assessments, with the use of dispersion modelling software ADMS-Roads and ADMS-5. In addition he has also gained experience in diffusion tube and automatic monitoring, including data ratification.

Full CVs are available at www.aqconsultants.co.uk.

A3 Modelling Methodology

Model Inputs

A3.1 Predictions have been carried out using the ADMS-Roads dispersion model (v4.1). The model requires the user to provide various input data, including emissions from each section of road and the road characteristics (including road width, street canyon width, street canyon height and porosity, where applicable). Vehicle emissions have been calculated based on vehicle flow, composition and speed data using the EFT (Version 9.0) published by Defra (2020).

A3.2 Hourly sequential meteorological data from Bristol Lulsgate for 2018 have been used in the model. The Bristol Lulsgate meteorological monitoring station is located at Bristol Airfield, approximately 13 km and 15 km to the north west Temple Cloud and Farrington Gurney respectively. It is deemed to be the nearest monitoring station representative of meteorological conditions in the vicinity of the study area.

A3.3 The majority of the A37 within Temple Cloud has street canyon-like features, which reduce dispersion of traffic emissions, and can lead to concentrations of pollutants being higher here than they would be in areas with greater dispersion. The majority of the A37 within Temple Cloud has, therefore, been modelled as a street canyon using ADMS-Roads' advanced canyon module, with appropriate input parameters determined from plans, on-site measurements, local mapping and photographs. The location and width of the canyons modelled in Temple Cloud are shown in Figure A3.1. Farrington Gurney has not been modelled with street canyons, due to the study area being more open, with greater dispersion properties.

Figure A3.1: Modelled Canyons in Temple Cloud

A3.4 Hourly traffic flows, %HDV's and hourly speeds have been provided by Jacobs, who have processed traffic data using the VISSIM micro-simulation traffic model. The traffic model is high resolution with a number of road links broken into two way flows. Weekday traffic data have been provided for the period 7am to 7pm. Separate diurnal flow profiles for Temple Cloud and Farrington Gurney derived from automatic traffic counts for 2019 for *'all vehicles',* and a separate profile for 'HGV's' have been used to predict LDV and HDV flows outside the available period for overnight and weekends. The average speed during the weekday interpeak period has been applied for overnight and weekend periods.

A3.5 The hourly traffic flows have been used to calculate hourly emissions for each link over the period of a week. Due to the large volume of data (hourly flows for Weekdays, Saturday and Sunday for over 300 links), the traffic data has not been reproduced here, and is available on request.

Background Concentrations

A3.6 The background pollutant concentrations across the study area have been defined using the national pollution maps published by Defra (2020). These cover the whole country on a 1x1 km grid and are published for each year from 2017 until 2030. The background annual nitrogen dioxide maps for 2018 have been calibrated against concurrent measurements from national monitoring sites (AQC, 2019b). The calibration factor calculated has also been applied to future year backgrounds. This has resulted in slightly higher predicted nitrogen dioxide concentrations for the future assessment year than those derived from the Defra maps.

Model Verification

A3.7 In order to ensure that ADMS-Roads accurately predicts local concentrations, it is necessary to verify the model against local measurements.

Temple Cloud

A3.8 Most nitrogen dioxide (NO_2) is produced in the atmosphere by reaction of nitric oxide (NO) with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emissions of nitrogen oxides ($NOx = NO + NO_2$). The model has been run to predict the annual mean NOx concentrations during 2018 at DT96, DT108 and DT109 diffusion tube monitoring sites. Concentrations have been modelled at 2.4 m, 2.58 m, and 2.55 m respectively, the height of the monitors.

A3.9 The model output of road-NOx (i.e. the component of total NOx coming from road traffic) has been compared with the 'measured' road-NOx. Measured road-NOx has been calculated from the measured NO_2 concentrations and the predicted background NO_2 concentration using the NOx from NO_2 calculator (Version 7.1) available on the Defra LAQM Support website (Defra, 2020).

A3.10 Two separate adjustment factors have been applied:

- Verification Factor 1: at receptors located along the A37 south of Temple Inn Lane/ north of Gillets Hill Lane and on all side roads; and
- Verification Factor 2: at all other receptors on the A37 north of Temple Inn Lane and south of Gillets Hill Lane.

A3.11 The locations where the verification factors have been applied are shown in Figure A3.2. Different factors have been applied to the study area because unadjusted results showed a greater under-prediction at DT96 than at DT108 and DT109. This analysis is discussed further in paragraph A3.20.

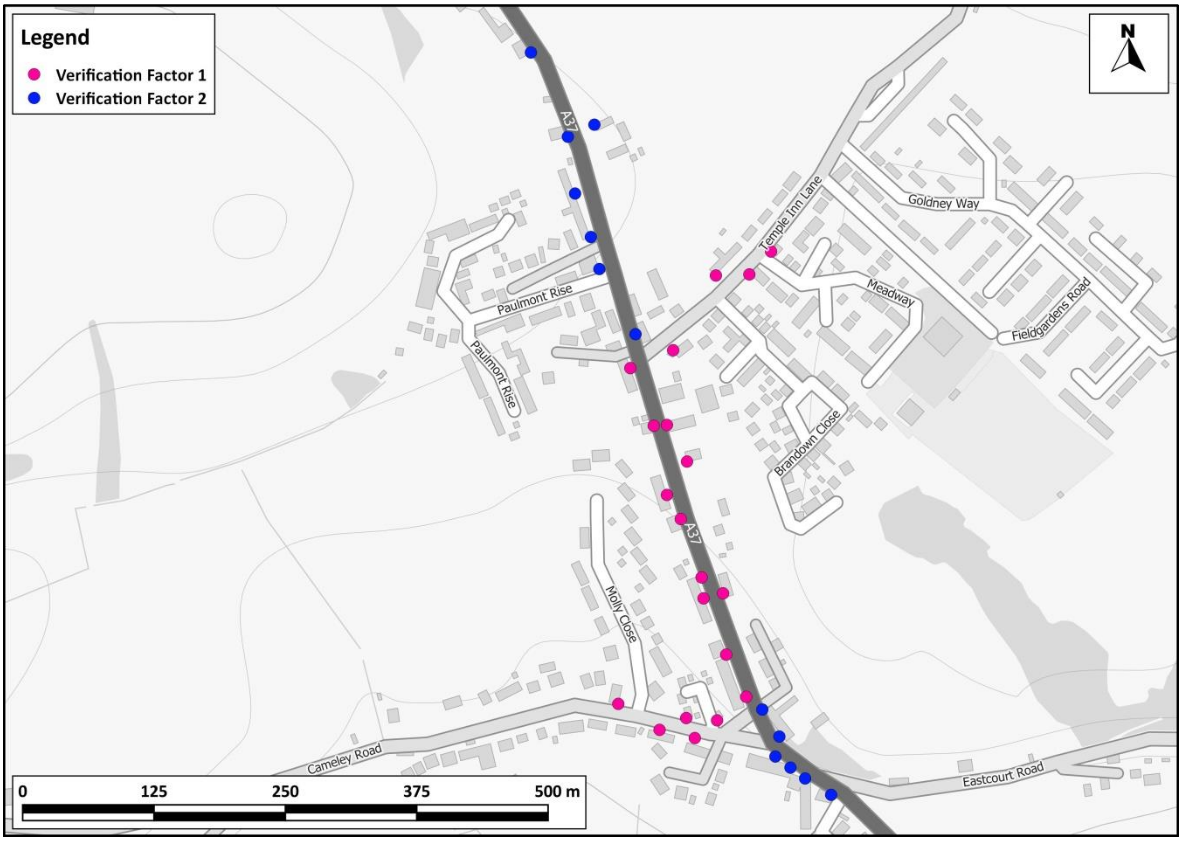

Figure A3.2: Areas Adjusted by Verification Factor 1 and Verification Factor 2

Verification Factor 1 – Receptors along the A37 south of Temple Inn Lane/ north of Gillets Hill Lane, and on all side roads

A3.12 An adjustment factor has been determined as the ratio of the 'measured' road contribution and the model derived road contribution from monitoring site DT96. This factor has then been applied to the modelled road-NOx concentration for selected receptors (see figure A3.2) to provide adjusted modelled road-NOx concentrations. The total nitrogen dioxide concentrations have then been determined by combining the adjusted modelled road-NOx concentrations with the predicted background NO_2 concentration within the NOx to NO_2 calculator (Defra, 2020).

A3.13 The data used to calculate the adjustment factor are provided below:

- Measured NO_2 : 59.5 μg/m^3
- Background NO_2 : 6.6 μg/m^3
- 'Measured' road-NOx (using NOx from NO_2 calculator): 123.2 μg/m^3
- Modelled road-NOx = 20.7 μg/m^3

- Road-NOx adjustment factor: 123.2/20.7 = **5.95**[4]

A3.14 The factor implies that the unadjusted model is under-predicting the road-NOx contribution. This is a common experience with this and most other road traffic emissions dispersion models.

Verification Factor 2 – other receptors on the A37 north of Temple Inn Lane and south of Gillets Hill Lane

A3.15 An adjustment factor has been determined as the slope of the best-fit line between the 'measured' road contribution and the model derived road contribution, forced through zero (Figure A3.3) for monitoring site DT108 and DT109. The calculated adjustment factor of **2.95** has been applied to the modelled road-NOx concentration for selected receptor (See figure A3.2) to provide adjusted modelled road-NOx concentrations.

A3.16 The total nitrogen dioxide concentrations have then been determined by combining the adjusted modelled road-NOx concentrations with the predicted background NO_2 concentration within the NOx to NO_2 calculator. Figure A3.4 compares final adjusted modelled total NO_2 at each of the monitoring sites to measured total NO_2.

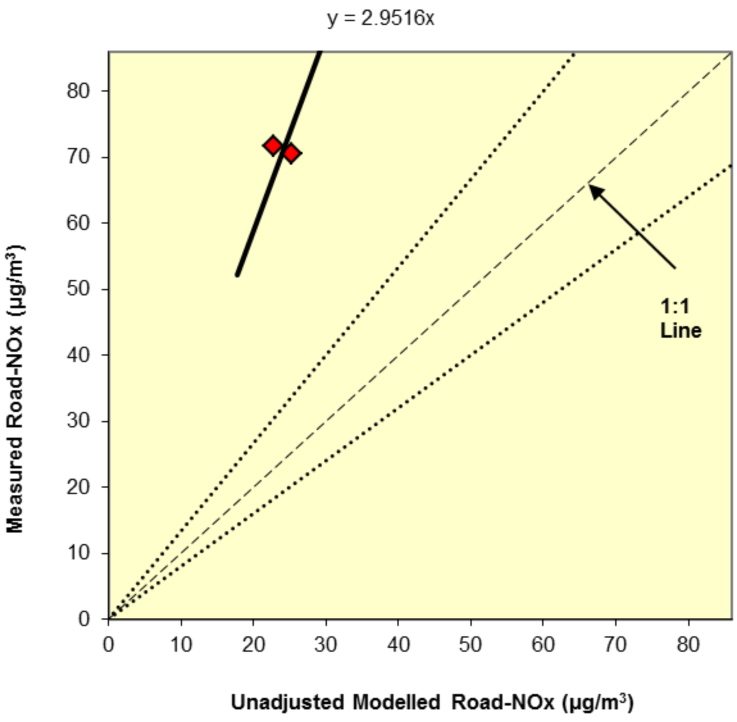

Figure A3.3: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations. The dashed lines show ± 25%.

[4] Based on un-rounded values.

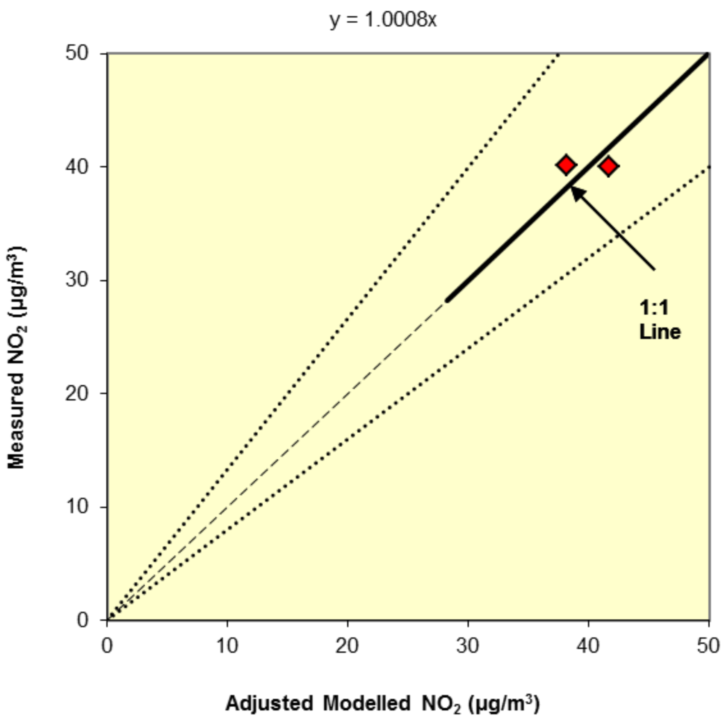

Figure A3.4: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations. The dashed lines show ± 25%.

Further Verification Analysis

A3.17 In 2018 monitoring results were available for three diffusion tubes. However in 2017 an additional five diffusion tube monitoring sites were operational (eight in total).

A3.18 In order to analyse the model's performance at all eight locations and therefore where the verification factors should be applied, the performance of the model was considered at all diffusion tubes which were active in 2017 and 2018. A 2017 model scenario was run to consider the model fit in 2017 (2017 meteorological data was used, but 2018 flows and emission factors were applied). The five additional diffusion tubes for 2017 (DT110, DT131, DT132, and DT133) were modelled at heights of 2.05 m, 2.2 m, 2.5 m, and 2.3 m respectively. DT111 was not included in the verification for 2017, due to a very poor fit in comparison with all other tubes, thought to be due to the tubes location within vegetation.

A3.19 An adjustment factor has been determined as the slope of the best-fit line between the 2017 and 2018 'measured' concentrations and 2017 and 2018 model derived road contribution, forced through zero (Figure A3.5). The calculated adjustment factor of 4.3 for all tubes has been applied to the modelled road-NOx concentration for each receptor to provide adjusted modelled road-NOx concentrations. Figure A3.6 then compares adjusted modelled total NO_2 at each of the monitoring sites for 2017 and 2018.

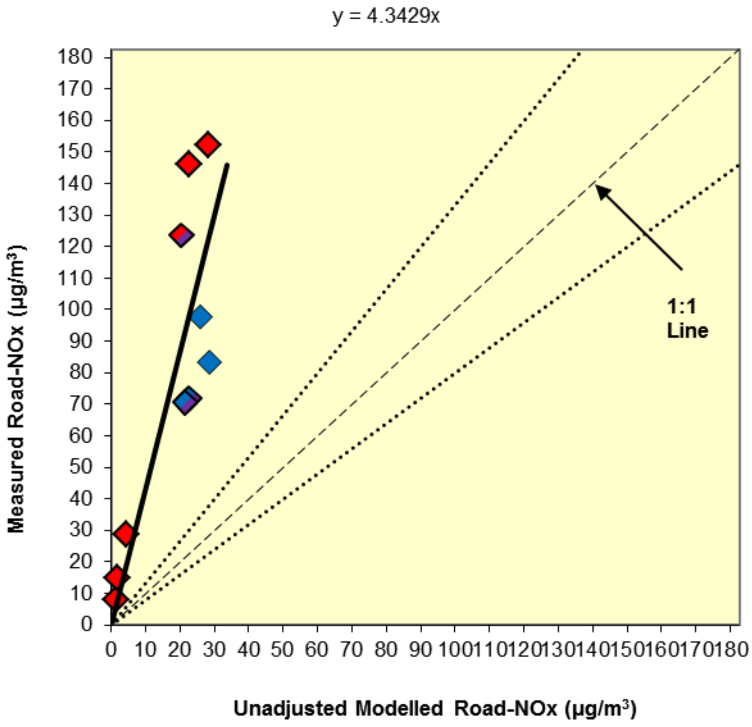

Figure A3.5: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations. The dashed lines show ± 25%. 2017 and 2018 Factors for DT108 and DT109 are shown in Blue. All other diffusion tubes are red. 2018 Diffusion Tubes are shown split with Purple.

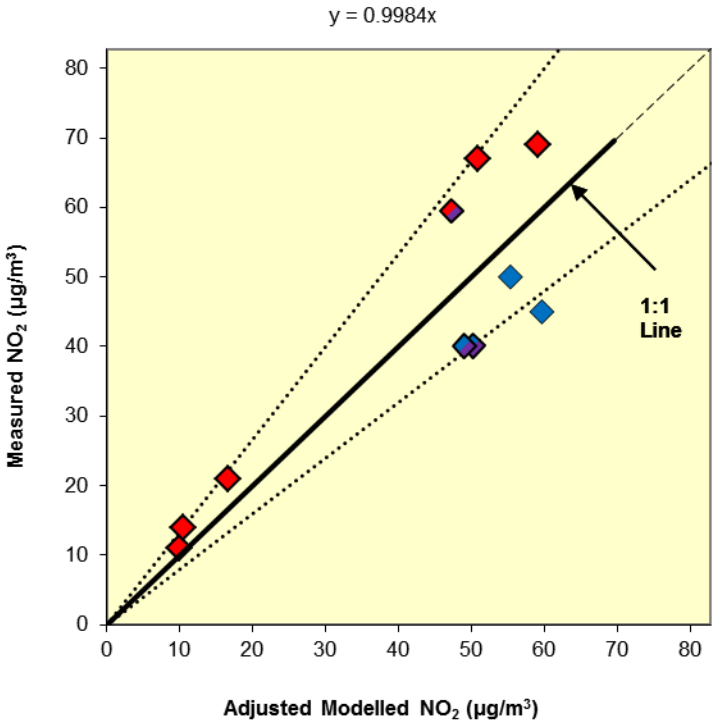

Figure A3.6: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations. The dashed lines show ± 25%. 2017 and 2018 Factors for DT108 and DT109 are shown in Blue, (all other diffusion tubes are red. 2018 Diffusion Tubes are shown split with Purple.

A3.20 As shown in Figure A3.6 the model is over predicting at four diffusion tubes (in blue) below the line, with all other diffusion tubes showing a trend. These four diffusion tubes correspond to DT108 and DT109 in 2017 and 2018 and therefore there is a clear trend for DT108 and DT109 having a different relationship to other locations within Temple Cloud. Therefore it was judged a separate verification factor should be applied to these locations.

A3.21 Figure A3.7 presents the adjusted modelled concentrations in 2018 at each DT tube (using the separate factors of 2.95 and 5.95) against the measured concentrations at the diffusion tubes in 2017 and 2018, which shows a good fit.

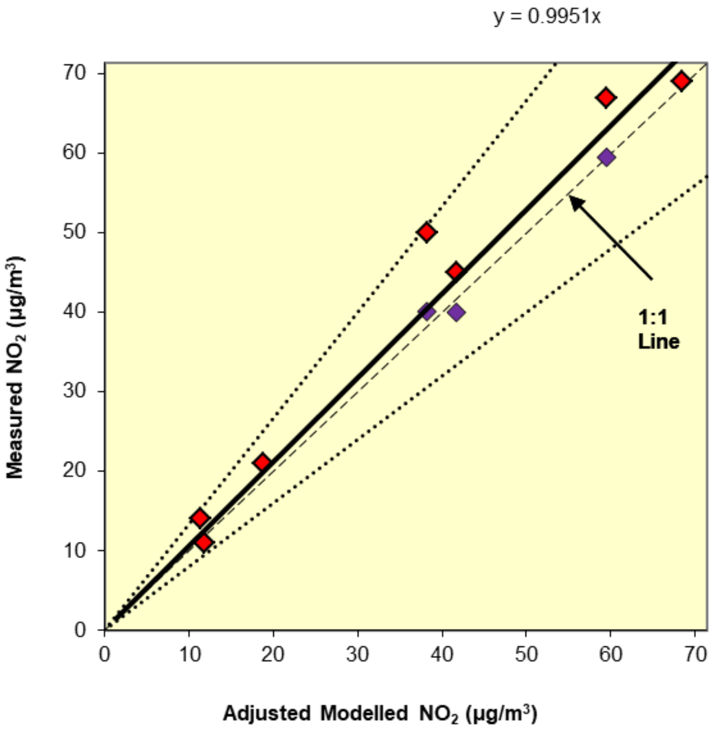

Figure A3.7: Comparison of Modelled Concentrations in 2018 and Measured Concentrations at Diffusion Tubes in 2017 and 2018. The dashed lines show ± 25%. The 2018 Diffusion Tubes are shown in Purple and 2017 in Red.

3.21.1 Table A3.1 shows the statistical parameters relating to the final performance of the model, as well as the 'ideal' values (Defra, 2018b). The values calculated for the model demonstrate that it is performing well.

Table A3.1: Statistical Model Performance

Statistical Parameter	Model-Specific Value	'Ideal' Value
Correlation Coefficient [a]	0.98	**1**
Root Mean Square Error (RMSE) [b]	2.37	**0**
Fractional Bias [c]	0.07	**0**

[a] Used to measure the linear relationship between predicted and observed data. A value of zero means no relationship and a value of 1 means absolute relationship.

[b] Used to define the average error or uncertainty of the model. The units of RMSE are the same as the quantities compared (i.e. µg/m³). TG16 (Defra, 2018b) outlines that, ideally, a RMSE value within 10% of the air quality objective (4µg/m³) would be derived. If RMSE values are higher than 25% of the objective (10 µg/m³) it is recommended that the model is revisited.

[c] Used to identify if the model shows a systematic tendency to over or under predict. Negative values suggest a model over-prediction and positive values suggest a model under-prediction.

Farrington Gurney

A3.22 In Farrington Gurney the model has been run to predict the annual mean NOx concentrations during 2018 at DT126, DT134, DT136, DT137, DT138 diffusion tube monitoring sites. Concentrations have been modelled at 2.1 m, 2.5 m, 2.08 m, 2.4 m, and 2.5 m respectively, the height of the monitors.

A3.23 An adjustment factor has been determined as the slope of the best-fit line between the 'measured' road contribution and the model derived road contribution, forced through zero (Figure A3.8). The calculated adjustment factor of **7.913** has been applied to the modelled road-NOx concentration for each receptor to provide adjusted modelled road-NOx concentrations.

A3.24 The total nitrogen dioxide concentrations have then been determined by combining the adjusted modelled road-NOx concentrations with the predicted background NO_2 concentration within the NOx to NO_2 calculator. Figure A3.9 compares final adjusted modelled total NO_2 at each of the monitoring sites to measured total NO_2.

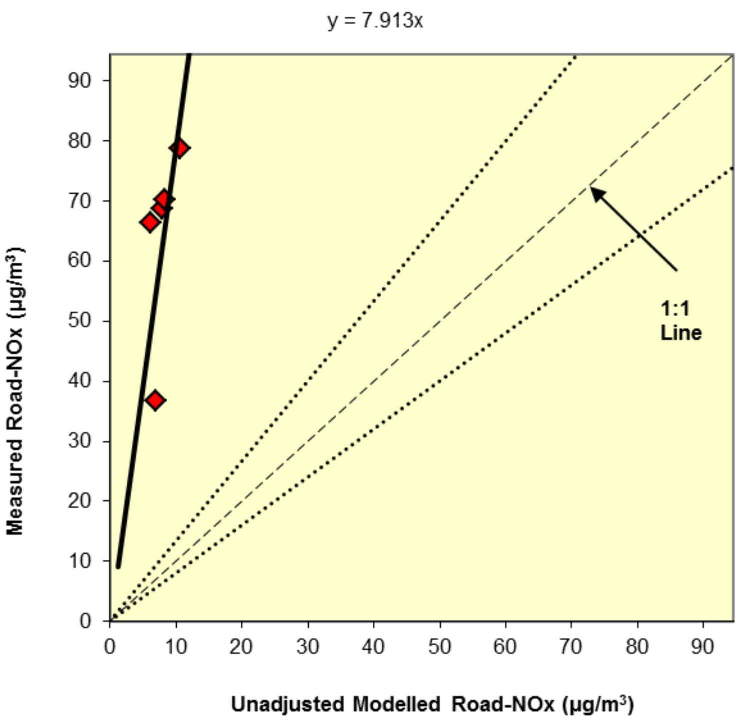

Figure A3.8: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations. The dashed lines show ± 25%.

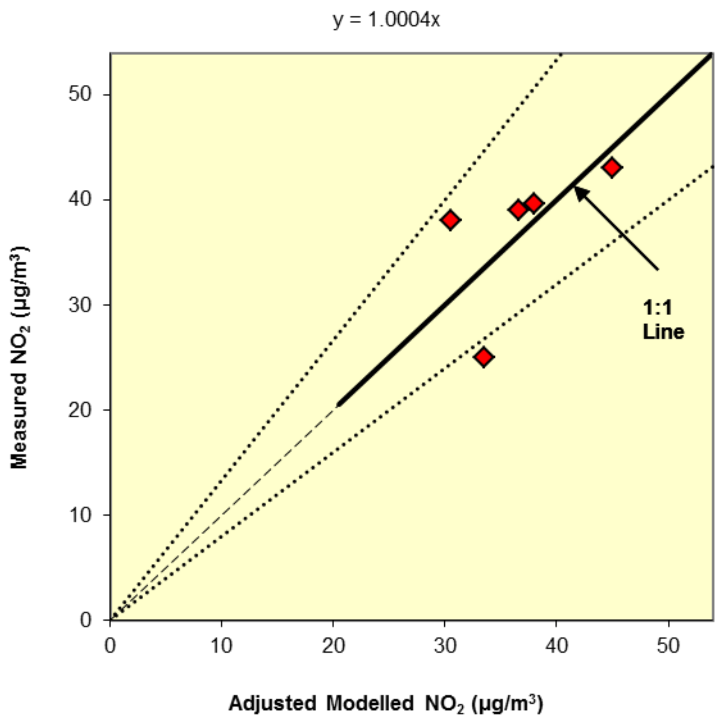

Figure A3.9: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations. The dashed lines show ± 25%.

3.24.1 Table A3.2 shows the statistical parameters relating to the performance of the model, as well as the 'ideal' values (Defra, 2018b). The RMSE value calculated is over 4 which suggests the model may not be performing well. Further analysis has been undertaken to discover what the cause behind this is, and how best to apply the verification.

Table A3.2: Statistical Model Performance

Statistical Parameter	Model-Specific Value	'Ideal' Value
Correlation Coefficient [a]	0.56	**1**
Root Mean Square Error (RMSE) [b]	5.31	**0**
Fractional Bias [c]	0.01	**0**

[a] Used to measure the linear relationship between predicted and observed data. A value of zero means no relationship and a value of 1 means absolute relationship.

[b] Used to define the average error or uncertainty of the model. The units of RMSE are the same as the quantities compared (i.e. µg/m³). TG16 (Defra, 2018b) outlines that, ideally, a RMSE value within 10% of the air quality objective (4µg/m³) would be derived. If RMSE values are higher than 25% of the objective (10 µg/m³) it is recommended that the model is revisited.

[c] Used to identify if the model shows a systematic tendency to over or under predict. Negative values suggest a model over-prediction and positive values suggest a model under-prediction.

Further Verification Analysis

A3.25 The model has produced a high verification factor (7.91), and a high RMSE value (5.31), a further analysis into the diffusion tubes has been undertaken to discover any trends or errors within the data.

A3.26 Figure A3.9 shows one diffusion tube is an outlier which is DT137 where concentrations are overpredicted; outside of the 25% error margin from the 1:1 line post applying the primary adjustment factor. The tube is located on a lamppost which was located adjacent to a tree which appeared to be growing close to, if not, around the lamppost. This has the potential to impact the dispersion of nitrogen dioxide around the diffusion tube. When removing this tube from the verification the verification factor increased marginally to 7.96 and the RMSE value reduced to 3.46.

A3.27 DT138 was also a slight outlier where the model appears to be under predicting more than the other monitors. The monitor is located adjacent to a bus stop, which could increase queuing traffic and emissions around the monitor, which could have potentially caused the higher verification factor. When DT138 and DT137 were both removed from the verification calculation a factor of 7.62 and RMSE of 1.8 were calculated.

A3.28 Overall the analysis of diffusion tubes within the verification factor showed the factor to be between 7.5 and 8.0 when removing DT137 and DT138. Although the RMSE value improved greatly when these tubes were removed, there is uncertainty in both monitoring and modelling and the most robust approach is considered to be to verify the model against all of the measurements together. Given the applied factor of **7.913** is at the upper end of the range, the model is judged to be conservative.

Model Post-processing

A3.29 The model predicts road-NOx concentrations at each receptor location. These concentrations have been adjusted using the adjustment factor set out above, which, along with the background NO_2, has been processed through the NOx to NO_2 calculator available on the Defra LAQM Support website (Defra, 2020). The traffic mix within the calculator has been set to “All other urban UK traffic”, which is considered suitable for Temple Cloud and Farrington Gurney. The calculator predicts the component of NO_2 based on the adjusted road-NOx and the background NO_2.

A4 Modelled Results

Temple Cloud

Table A4.1: Predicted Impacts on Annual Mean Nitrogen Dioxide Concentrations for Temple Cloud Options (µg/m³) [a]

Receptors	Baseline		Option 8			Option 9		
	2018	2021 Without Scheme	2021 With Scheme	% Change [b]	Impact Descriptor	2021 With Scheme	% Change [b]	Impact Descriptor
TC1	37.6	28.9	21.2	-19	Moderate Beneficial	27.2	-4	Negligible
TC2	34.8	26.5	19.1	-18	Moderate Beneficial	24.7	-4	Negligible
TC3	33.6	27.2	20.8	-16	Moderate Beneficial	26.7	-1	Negligible
TC4	**78**	**60.5**	**42.7**	-45	Substantial Beneficial	**58.1**	-6	Substantial Beneficial
TC5	11.6	9.5	8.5	-3	Negligible	9.4	0	Negligible
TC6	10.5	8.7	8.0	-2	Negligible	8.6	0	Negligible
TC7	10.7	8.8	8.2	-2	Negligible	8.8	0	Negligible
TC8	9.9	8.2	7.7	-1	Negligible	8.2	0	Negligible
TC9	10.4	8.7	8.3	-1	Negligible	8.7	0	Negligible
TC10	**41.3**	31.8	23.3	-21	Moderate Beneficial	30.1	-4	Slight Beneficial
TC11	**45.6**	34.9	25.6	-23	Moderate Beneficial	33.4	-4	Slight Beneficial
TC12	26.2	20.9	16.2	-12	Moderate Beneficial	19.7	-3	Negligible
TC13	**63.5**	**50.0**	38.4	-29	Substantial Beneficial	**50.0**	0	Negligible
TC14	**45.1**	34.2	25.2	-22	Moderate Beneficial	33.6	-1	Negligible
TC15	**54.7**	**42.9**	31.9	-28	Substantial Beneficial	**41.7**	-3	Moderate Beneficial
TC16	**52.6**	**40.8**	30.8	-25	Substantial Beneficial	**40.5**	-1	Slight Beneficial
TC17	26.5	20.7	16.4	-11	Moderate Beneficial	20.7	0	Negligible
TC18	17.0	13.6	11.8	-5	Negligible	13.6	0	Negligible
TC19	21.5	17.1	14.2	-7	Slight Beneficial	17.1	0	Negligible
TC20	20.1	16.0	13.4	-7	Slight	16.0	0	Negligible

Receptors	Baseline		Option 8			Option 9		
	2018	2021 Without Scheme	2021 With Scheme	% Change [b]	Impact Descriptor	2021 With Scheme	% Change [b]	Impact Descriptor
					Beneficial			
TC21	20.9	17.1	14.2	-7	Slight Beneficial	17.1	0	Negligible
TC22	33.4	26.9	22.3	-11	Moderate Beneficial	26.9	0	Negligible
TC23	13.6	11.2	10.5	-2	Negligible	11.2	0	Negligible
TC24	12.9	10.6	10.0	-1	Negligible	10.6	0	Negligible
TC25	33.6	26.7	21.6	-13	Moderate Beneficial	26.6	0	Negligible
TC26	22.1	17.5	14.4	-8	Slight Beneficial	17.5	0	Negligible
TC27	**40.9**	32.3	25.2	-18	Moderate Beneficial	32.2	0	Negligible
TC28	37.2	29.8	23.6	-15	Moderate Beneficial	29.7	0	Negligible
TC29	20.4	16.2	13.1	-8	Slight Beneficial	16.0	-1	Negligible
TC30	17.6	14.0	11.4	-6	Slight Beneficial	13.7	-1	Negligible
TC31	11.5	9.5	8.7	-2	Negligible	9.5	0	Negligible
TC32	12.4	10.2	9.0	-3	Negligible	10.2	0	Negligible
TC33	**45.1**	35.1	27.1	-20	Moderate Beneficial	35.1	0	Negligible
Objective	**40**			**-**	**-**	**40**	**-**	**-**

[a] Exceedances of the objective are shown in bold. Concentrations above 60µg/m³ are underlined

[b] % changes are relative to the objective and have been rounded to the nearest whole number.

Farrington Gurney

Table A4.2: Predicted Impacts on Annual Mean Nitrogen Dioxide Concentrations for Farrington Gurney Options (µg/m^3) [a]

Receptors	Baseline		Option 3			Option 5		
	2018	2021 Without Scheme	2021 With Scheme	% Change [b]	Impact Descriptor	2021 With Scheme	% Change [b]	Impact Descriptor
FG1	22.8	17.7	17.7	0	Negligible	17.9	1	Negligible
FG2	29.2	22.5	22.7	0	Negligible	23.8	3	Negligible
FG3	32.3	24.9	25.1	0	Negligible	27.3	6	Slight Adverse
FG4	**46.8**	37.6	29.2	-21	Moderate Beneficial	23.4	-36	Moderate Beneficial
FG5	**43.8**	34.7	29.5	-13	Moderate Beneficial	25.9	-22	Moderate Beneficial
FG6	**42.8**	33.3	31.2	-5	Slight Beneficial	29.3	-10	Moderate Beneficial
FG7	**49.8**	38.8	36.3	-6	Moderate Beneficial	34.3	-11	Substantial Beneficial
FG8	**41.0**	32.1	31.5	-2	Slight Beneficial	29.6	-6	Moderate Beneficial
FG9	35.2	27.8	26.3	-4	Negligible	23.2	-12	Moderate Beneficial
FG10	35.0	27.9	26.5	-3	Negligible	22.6	-13	Moderate Beneficial
FG11	31.1	24.8	24.0	-2	Negligible	23.5	-3	Negligible
FG12	34.6	26.7	25.1	-4	Negligible	24.5	-5	Negligible
FG13	**41.9**	32.4	31.1	-3	Slight Beneficial	30.6	-5	Slight Beneficial
FG14	36.4	28.1	26.5	-4	Negligible	26.0	-5	Negligible
FG15	35.6	27.5	26.5	-3	Negligible	26.3	-3	Negligible
FG16	**43.8**	33.9	33.2	-2	Slight Beneficial	33.2	-2	Slight Beneficial
FG17	**47.4**	37.0	36.8	0	Negligible	36.9	0	Negligible
FG18	31.0	24.0	23.8	0	Negligible	23.9	0	Negligible
FG19	**41.1**	32.2	32.2	0	Negligible	32.2	0	Negligible
FG20	**42.2**	33.1	33.1	0	Negligible	33.2	0	Negligible
FG21	21.8	16.9	16.4	-1	Negligible	16.3	-2	Negligible
FG22	15.2	12.0	11.7	-1	Negligible	11.6	-1	Negligible
FG23	18.4	14.3	14.1	-1	Negligible	14.1	-1	Negligible
FG24	**42.2**	32.8	32.9	0	Negligible	28.9	-10	Moderate Beneficial

Receptors	Baseline		Option 3			Option 5		
	2018	2021 Without Scheme	2021 With Scheme	% Change [b]	Impact Descriptor	2021 With Scheme	% Change [b]	Impact Descriptor
FG25	32.6	25.1	25.2	0	Negligible	24.7	-1	Negligible
FG26	36.3	28.6	24.9	-9	Slight Beneficial	18.7	-25	Moderate Beneficial
Objective		**40**		**-**	**-**	**40**	**-**	**-**

[a] Exceedances of the objective are shown in bold.

[b] % changes are relative to the objective and have been rounded to the nearest whole number.