Air Quality
CONSULTANTS

# AQMA Review:
## Maidstone

February 2022

Experts in air quality
management & assessment

## Document Control

| Client | Maidstone Borough Council | Principal Contact | Stuart Maxwell |
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| Report Prepared By: | Joe Rondell, George Chousos, Dr Helen Pearce and Dr Kate Wilkins |
|---|---|

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**Air Quality Consultants Ltd**
**23 Coldharbour Road, Bristol BS6 7JT Tel: 0117 974 1086**
**24 Greville Street, Farringdon, London, EC1N 8SS Tel: 020 3873 4780**
**aqc@aqconsultants.co.uk**

Registered Office: 23 Coldharbour Road, Bristol BS6 7JT
Companies House Registration No: 2814570

# 1 Introduction

1.1 Maidstone Borough Council (MBC) declared an Air Quality Management Area (AQMA) for the annual mean nitrogen dioxide objective in 2008, encompassing the entire Maidstone conurbation. This AQMA was reduced in size in 2018, and now covers the majority of roads within the Maidstone urban area.

1.2 This report sets out a review of the AQMA in Maidstone, to determine compliance with the annual mean air quality objective for nitrogen dioxide. The review has been undertaken with a view to reducing the size of the AQMA. As outlined in the 2020 Annual Status Report (ASR) (Maidstone Borough Council, 2020), MBC believes that compliance has already been achieved in the majority of the area, and that there is scope for revoking the AQMA in its current form and declaring a smaller AQMA.

1.3 Initially, the monitoring data within the AQMA has been reviewed, along with the locations of relevant exposure, which have been used to define the locations that require detailed modelling. The review considers data from the network of nitrogen dioxide diffusion tubes and automatic monitoring sites operated by MBC.

1.4 Detailed modelling of the area of interest has been undertaken for a baseline year (2019) to inform the extent of the proposed new AQMA. A future year (2022) has also been modelled to predict changes in nitrogen dioxide concentrations in the study area over time, without intervention to reduce traffic emissions. Two future scenarios, in which all buses comply with the Euro VI emission standard, and in which all buses are converted to electric vehicles, have also been tested to assess the impacts of these hypothetical scenarios on concentrations in the study area.

1.5 This report has been carried out by Air Quality Consultants Ltd (AQC) on behalf of MBC. It has been prepared taking account of the requirements set out in LAQM.TG(16) (Defra, 2021a) for amending or revoking AQMA orders. The professional experience of the consultants who have undertaken the review is summarised in Appendix A1.

# 2 Review of AQMA

2.1 Monitoring sites within Maidstone are shown in Figure 1. Three distinctive areas of focus have been selected for analysis ('M20 and North Maidstone', 'Barming and West Maidstone' and 'Central Maidstone and the A229'). Each distinct area of the AQMA has been reviewed and overall conclusions drawn.

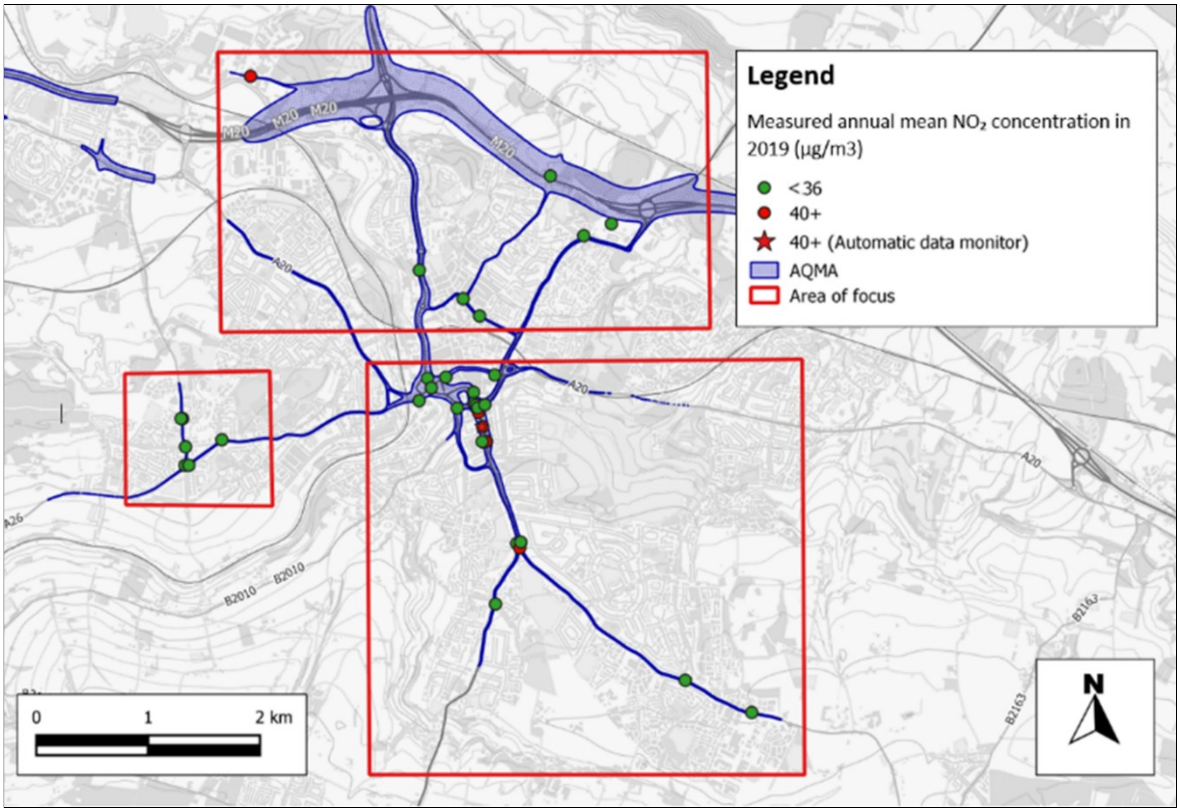


**Figure 1: AQMA and Areas of Focus in Maidstone Borough Council**



2.2 The following sections present monitoring data for each area of the AQMA highlighted in Figure 1.

## M20 and North Maidstone

2.3 Monitoring is carried out using diffusion tubes at seven locations in the north of Maidstone (see Figure 2). The monitoring locations are representative of worst-case exposure in the AQMA, being installed next to some of the busiest roads in the area.

2.4 As shown in Figure 3 and Table 1, there is a downward trend in concentrations of annual mean nitrogen dioxide between 2016 and 2020 adjacent to the M20 and in North Maidstone. At all locations except monitor Maid116, concentrations have been below the objective in 2017, 2018, 2019, and less than 90% of the objective in 2019 and 2020.

2.5 Exceedances of the annual mean objective have been measured at monitor Maid116 every year since monitoring commenced at that location in 2017. This monitor is located on a telegraph pole 1 m from the kerb of Forstal Road, 4.3 m from the façade of Forstal Road Cottages (the closest location of relevant exposure). In 2019 and 2020, once distance corrected to the façade of the property, the objective was achieved at monitor Maid116 (37.6 µg/m$^3$ and 31.6 µg/m$^3$, respectively) and in 2018 the objective was just achieved (calculated to be 40 µg/m$^3$ at the façade).

2.6 In early 2020, activity in the UK was disrupted by the COVID-19 pandemic. As a result, concentrations of traffic-related air pollutants fell appreciably (Defra Air Quality Expert Group, 2020). While the pandemic may cause long-lasting changes to travel activity patterns, it is reasonable to expect a return to more typical activity levels in the future. It is thus likely that 2020 presents as an atypically low pollution year for roadside pollutant concentrations, as will 2021.

2.7 While 2020 was not a representative year, considering the recent trends in the monitoring data, is it recommended the AQMA is revoked in northern Maidstone and this area of the M20, including at Forstal. It is recommended that, if practical, a diffusion tube is located on one of the Forstal Road Cottages to ensure compliance. However, it is considered that façade concentrations are likely to reduce further in future years and exceedances are unlikely.

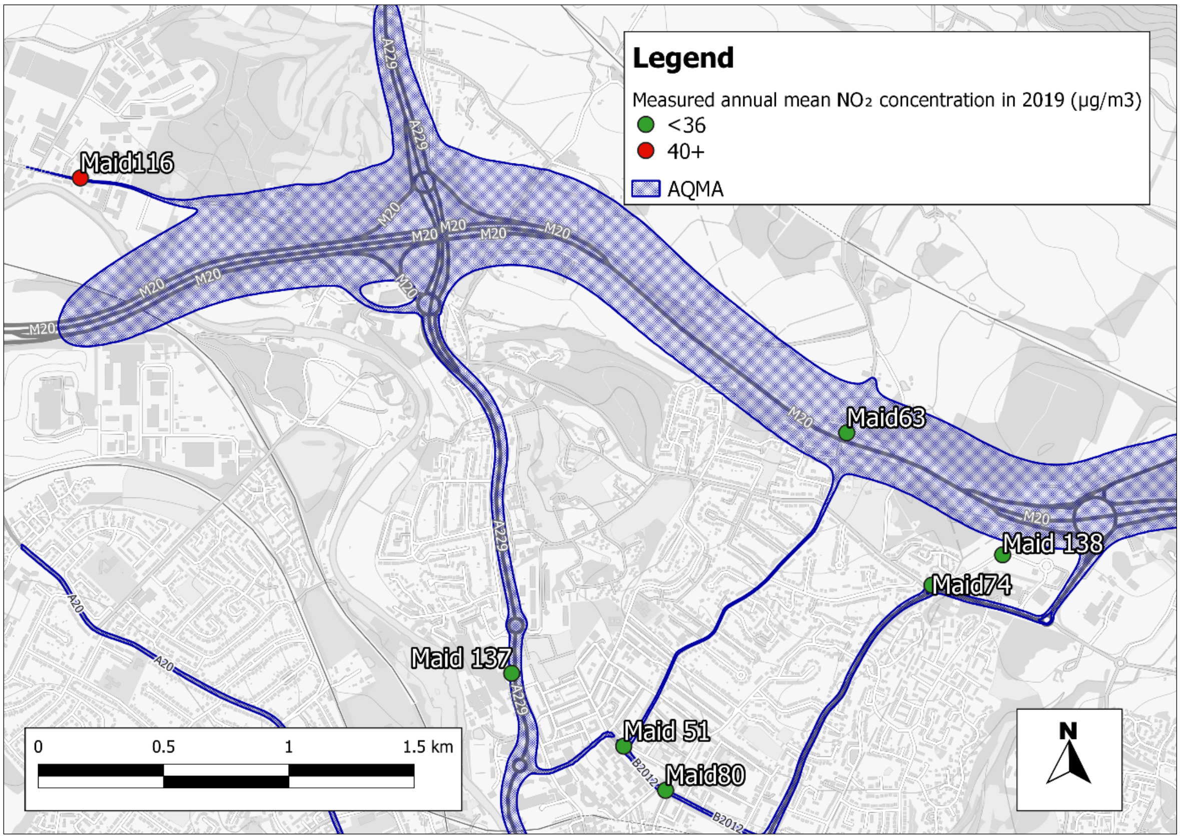


**Figure 2: Air Quality Monitoring along the M20 and North Maidstone**

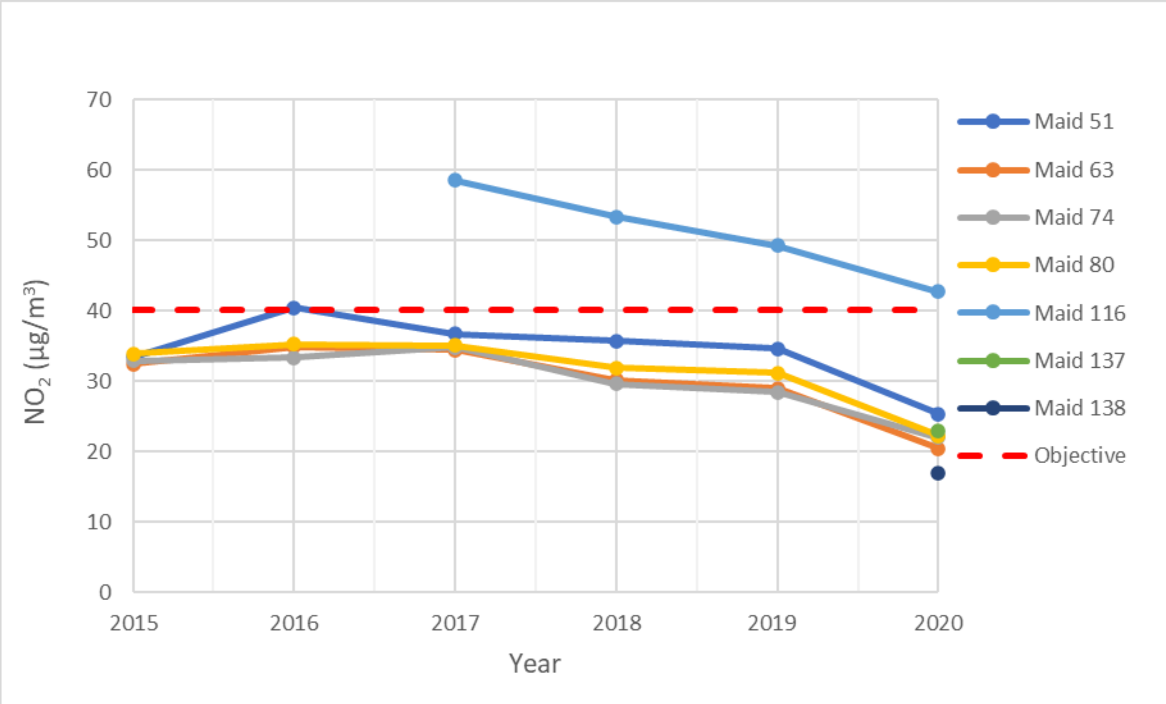


**Figure 3: Annual Mean $NO_2$ at Diffusion Tube Monitoring Sites along the M20 and in North Maidstone**

**Table 1: Summary of Annual Mean Nitrogen Dioxide Monitoring (2016-2020) along the M20 and in North Maidstone (µg/m³) [a]**

| Site | Site Type | Location | Distance to kerb (m) | Distance to relevant exposure [b] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Maid 51** | Roadside | 576147, 156488 | 3.5 | 0 | 33.4 | **40.4** | 36.7 | 35.7 | 34.6 | 25.3 |
| **Maid 63** | Roadside | 577037, 157739 | 12.8 | 0 | 32.4 | 34.9 | 34.4 | 30.1 | 29.0 | 20.4 |
| **Maid 74** | Roadside | 577377, 157131 | 6.0 | 0 | 32.9 | 33.3 | 34.8 | 29.6 | 28.4 | 22.0 |
| **Maid 80** | Kerbside | 576314, 156312 | 1.0 | 4.5 | 33.9 | 35.2 | **35.0** | 31.9 | 31.1 | 22.2 |
| **Maid 116** | Roadside | 573979, 158756 | 1.0 | 4.3 | - | - | **58.5** | **53.3** | **49.2** | **42.7** |
| **Maid 137** | Roadside | 575700, 156779 | 2.0 | n/a | - | - | - | - | - | 23.0 |
| **Maid 138** | Roadside | 577659, 157252 | 2.0 | n/a | - | - | - | - | - | 16.9 |

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

[b] A distance of 0 m denotes that the monitoring site is representative of relevant exposure (e.g. on the façade of a residential property).

## Barming and West Maidstone

2.8 Monitoring is carried out at six locations within Barming and West Maidstone, as shown in Figure 4 and Table 2. There have been no measured exceedances of the annual mean nitrogen dioxide objective since 2016 at any monitoring site in this area, and concentrations have all been well below the objective since 2018. There is also a clear downward trend in measured concentrations at these locations, as shown in Figure 5. It is therefore recommended that this section of the AQMA is revoked.

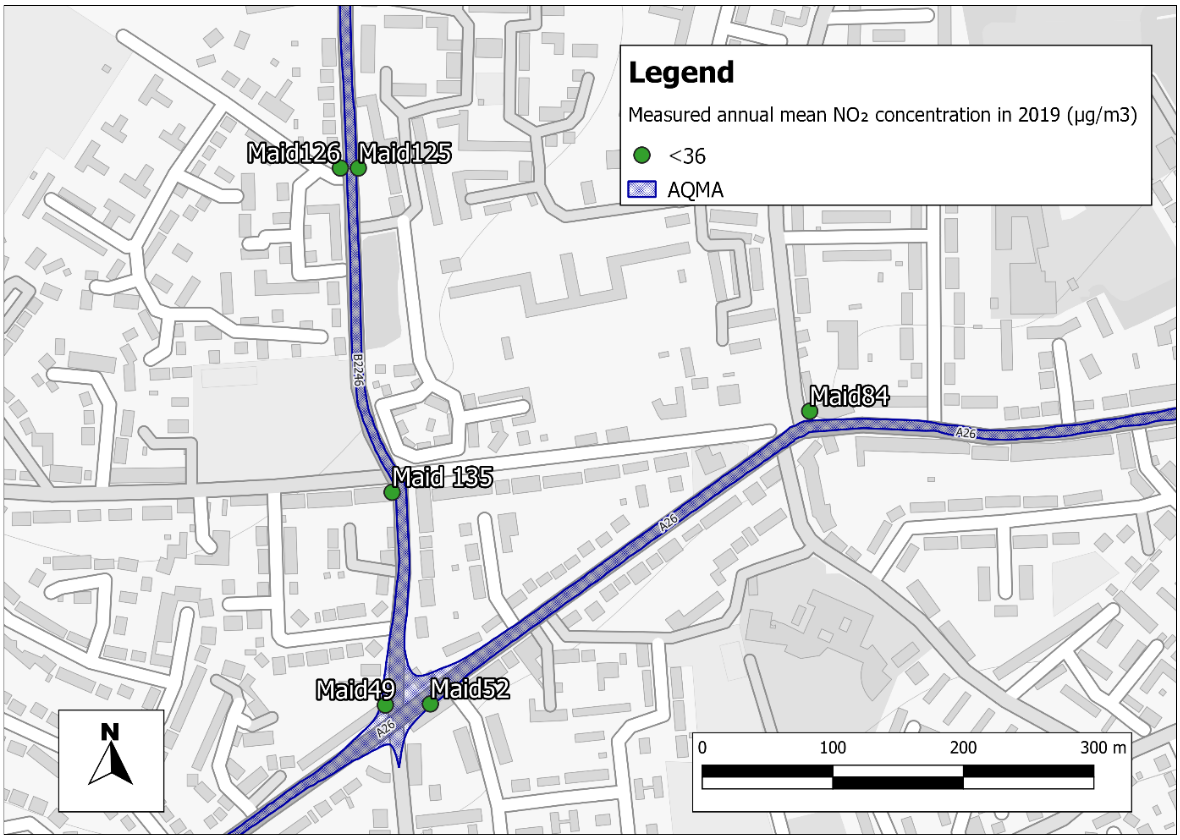


**Figure 4: Air Quality Monitoring in Barming and West Maidstone**

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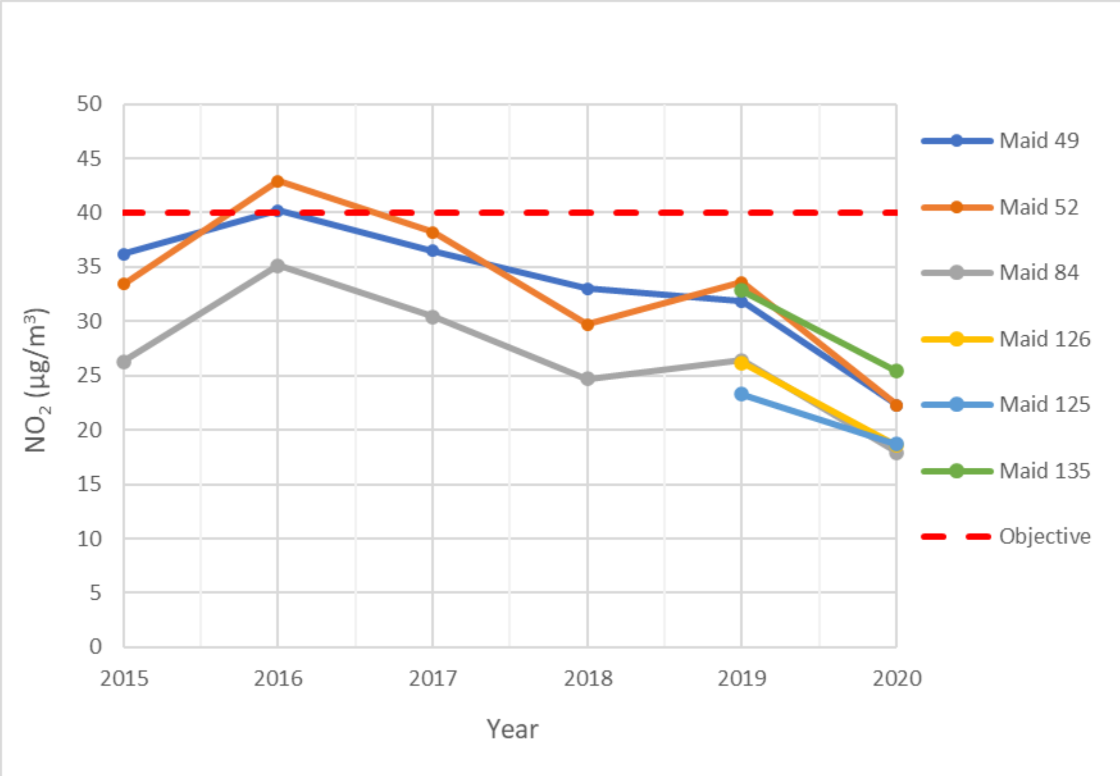


**Figure 5: Annual Mean $NO_2$ at Diffusion Tubes Monitoring Sites in Barming and West Maidstone**

**Table 2: Summary of Annual Mean Nitrogen Dioxide Monitoring (2016-2020) in Barming and West Maidstone (µg/m³) [a]**

| Site | Site Type | Location | Distance to kerb (m) | Distance to relevant exposure [b] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Maid 49** | Roadside | 573309, 154789 | 6.6 | 0.0 | 36.2 | **40.2** | 36.5 | 33.0 | 31.8 | 22.3 |
| **Maid 52** | Roadside | 573349, 154790 | 2.4 | 2.9 | 33.4 | **42.9** | 38.2 | 29.7 | 33.6 | 22.3 |
| **Maid 84** | Roadside | 573686, 155050 | 1.0 | 0.0 | 26.3 | 35.1 | 30.4 | 24.7 | 26.4 | 17.9 |
| **Maid 126** | Roadside | 573269, 155266 | 2.6 | 3.0 | - | - | - | - | 26.2 | 18.6 |
| **Maid 125** | Roadside | 573285, 155266 | 2.6 | 3.0 | - | - | - | - | 23.3 | 18.7 |
| **Maid 135** | Roadside | 573315, 154978 | 2.0 | 0.0 | - | - | - | - | 32.8 | 25.4 |

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

[b] A distance of 0 m denotes that the site is representative of relevant exposure (e.g. on the façade of a residential property).

## Central Maidstone and the A229

2.9 Monitoring is carried out at one automatic monitoring station (CM3) and 19 diffusion tube monitors within central Maidstone and adjacent to the A229, as shown in Figure 6. Annual mean results for the years 2015 to 2020 are summarised in Table 3. The monitoring data for years earlier than 2020 have been taken from MBC's 2020 ASR (Maidstone Borough Council, 2020), while data for 2020 have been taken from the Council's 2021 ASR (Maidstone Borough Council, 2021).

2.10 At all locations except CM3, Maid81, Maid96, Maid122 and Maid53 measured concentrations have been below the annual mean objective (in the majority of cases well below the objective) for a number of years.

2.11 Monitors CM3, Maid81, Maid96, Maid122 and Maid53 are all located adjacent to the A229; CM3, Maid81, Maid96, Maid122 are all located adjacent to Upper Stone Street. Monitor Maid53 is located further to the south, outside the Wheatsheaf Pub at the junction of Loose Road and Sutton Road. Measured exceedances at these monitoring sites are significant, with concentrations, even in 2020, greater than 60 $\mu g/m^3$ at some locations, indicating the potential for exceedances of the 1-hour mean nitrogen dioxide objective. It is therefore recommended that detailed dispersion modelling of traffic emissions is carried out to determine the extent of exceedance at relevant locations within the area.

2.12 It is proposed that the model domain covers the A229 Upper Stone Street from the junction of Knightrider Street, up to the junction of Loose Road and Sutton Road. It should be noted that the Wheatsheaf Pub is likely to be demolished and is currently empty, and hence will not be used as a specific receptor in the modelling. Modelling will include specific receptor locations at heights of relevant exposure. The modelling will also incorporate the outcomes of traffic monitoring using Automatic Number Plate Recognition (ANPR) cameras, to provide an up-to-date indication of the vehicle fleet along Upper Stone Street (both in terms of vehicle type and Euro class of vehicle).

2.13 The monitoring data shown in Figure 7 indicate that annual mean nitrogen dioxide concentrations are reducing, but trends are not as clear cut as in other locations across Maidstone. Therefore, in order to provide a worst-case approach for re-defining the AQMA, 2019 will be used as the baseline for the modelling. A discussion of the modelling approach and results are included in Section 3.

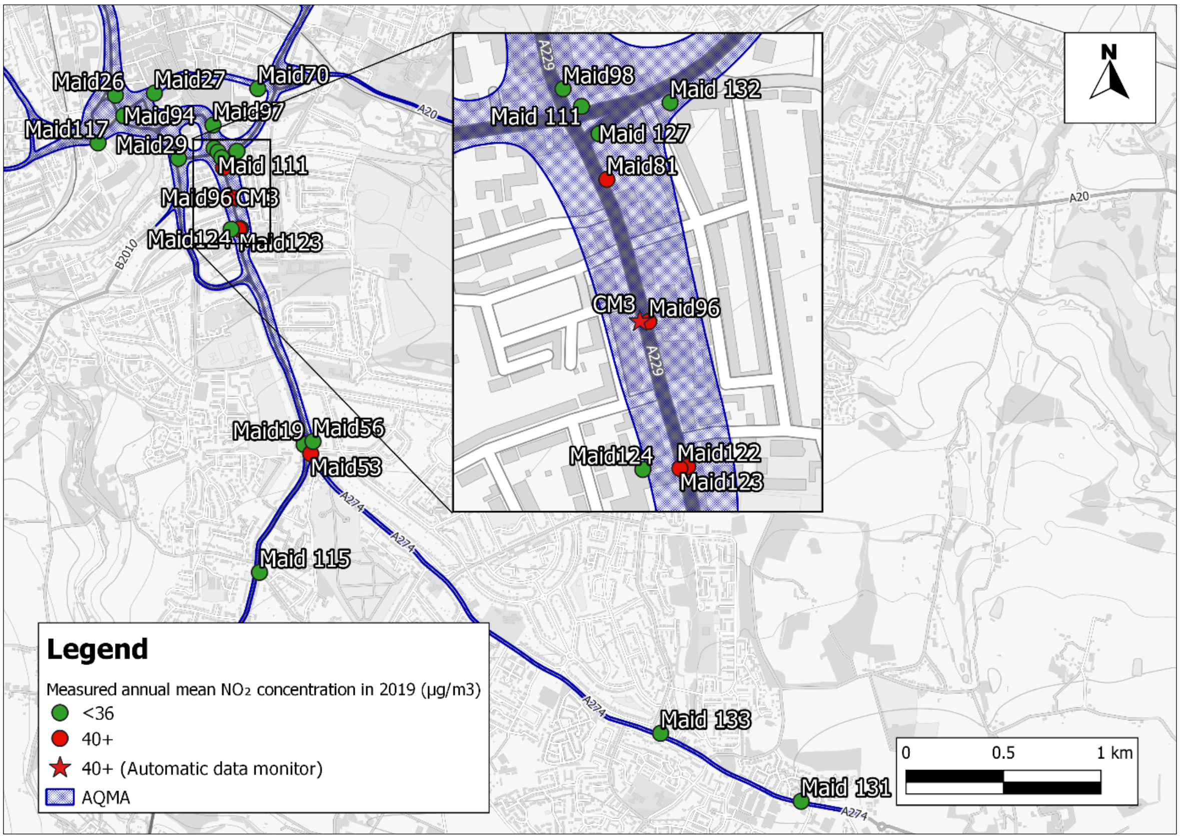


**Figure 6: Air Quality Monitoring in Central Maidstone and the A229**

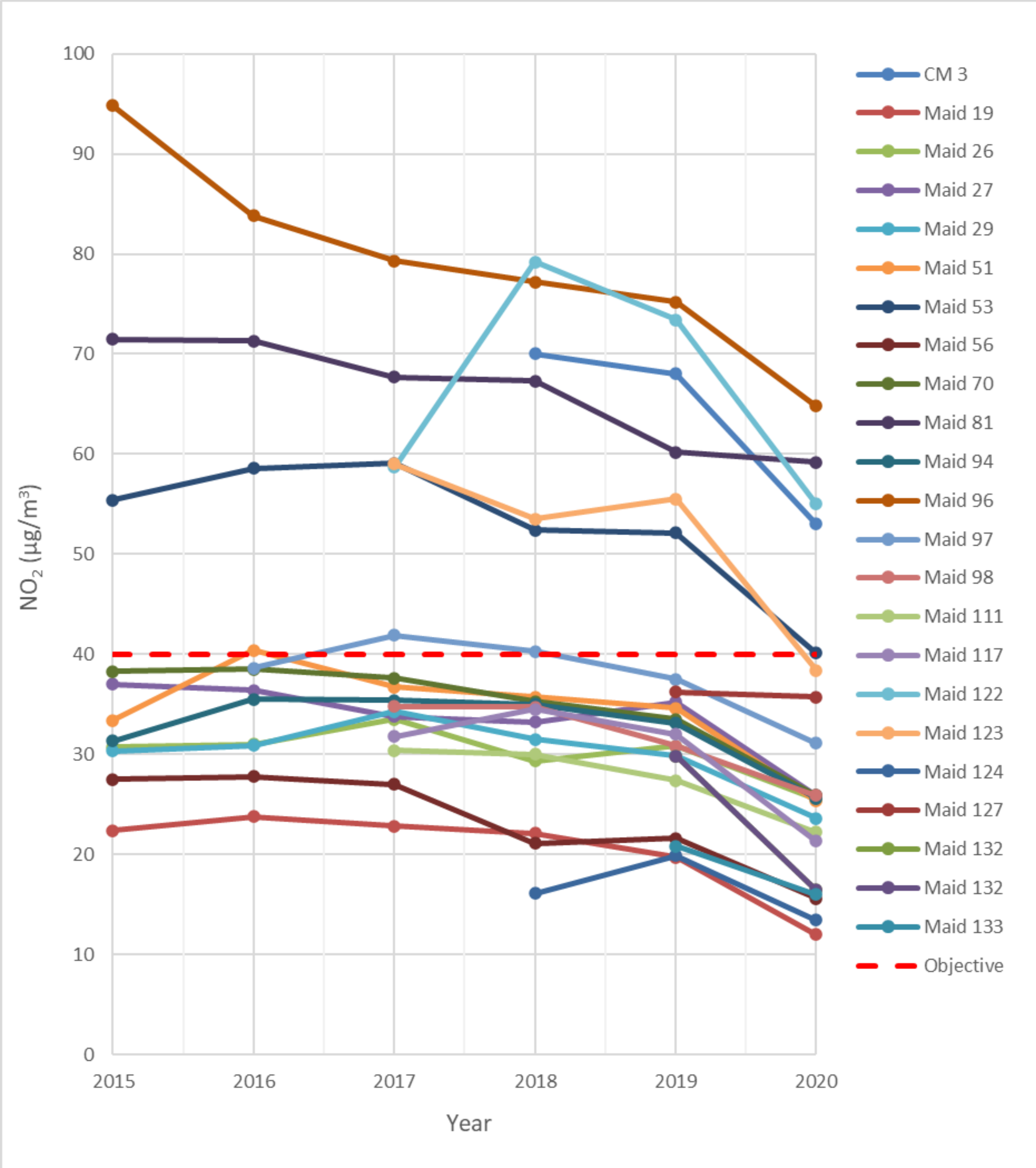


**Figure 7: Annual Mean Nitrogen Dioxide Concentrations in Central Maidstone and the A229**

**Table 3: Summary of Nitrogen Dioxide Monitoring (2015-2020) in Central Maidstone and the A229 (µg/m³)**

| Site | Site Type | Location | Distance to kerb (m) | Distance to relevant exposure [b] | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CM3** | Roadside | 576337, 155183 | 1.5 | n/a | - | - | - | **70** | **68** | **53** |
| **Maid 19** | Roadside | 576692, 153992 | 13.3 | 0 | 22.4 | 23.8 | 22.8 | 22.1 | 19.7 | 12.0 |
| **Maid 26** | Roadside | 575782, 155678 | 3.0 | 0 | 30.7 | 31.0 | 33.5 | 29.3 | 30.8 | 25.5 |
| **Maid 27** | Roadside | 575970, 155688 | 4.4 | 1.2 | 37.0 | 36.4 | 33.8 | 33.2 | 35.2 | 25.9 |
| **Maid 29** | Roadside | 576086, 155373 | 2.8 | 41 | 30.3 | 30.9 | 34.3 | 31.5 | 29.9 | 23.6 |
| **Maid 51** | Roadside | 576147, 156488 | 0 | 3.5 | 33.4 | **40.4** | 36.7 | 35.7 | 34.6 | 25.3 |
| **Maid 53** | Roadside | 576724, 153948 | 1.0 | 2.0 | **55.4** | **58.6** | **59.1** | **52.4** | **52.1** | **40.1** |
| **Maid 56** | Kerbside | 576735, 154007 | 15.1 | 0 | 27.5 | 27.8 | 27.0 | 21.1 | 21.6 | 15.6 |
| **Maid 70** | Roadside | 576469, 155710 | 1.3 | 1.7 | 38.3 | 38.5 | 37.6 | 35.3 | 33.5 | 25.9 |
| **Maid 81** | Kerbside | 576303, 155329 | 0 | 1.0 | **71.5** | **71.3** | **67.7** | **67.3** | **60.2** | **59.2** |
| **Maid 94** | Roadside | 575822, 155183 | 10.0 | 0 | 31.3 | 35.5 | 35.4 | 35.0 | 33.1 | 25.6 |
| **Maid 96** | Roadside | 576346, 155183 | 1.5 | 0 | **94.8** | **83.8** | **79.3** | **77.2** | **75.2** | **64.8** |
| **Maid 97** | Roadside | 576253, 155534 | 2.1 | 5.0 | - | 38.6 | **41.9** | **40.3** | 37.5 | 31.1 |
| **Maid 98** | Roadside | 576258, 155422 | 3.0 | 5.0 | - | 35.2 | 34.8 | 34.7 | 30.8 | 25.9 |
| **Maid 111** | Roadside | 576277, 155404 | 1.5 | 9.8 | - | - | 30.4 | 30.0 | 27.4 | 22.2 |
| **Maid 117** | Roadside | 575698, 155448 | 1.3 | 31.0 | - | - | 31.8 | 34.5 | 32.0 | 21.3 |
| **Maid 122** | Roadside | 576386, 155032 | 1.5 | 0 | - | - | **58.7** | **79.2** | **73.4** | **55.0** |
| **Maid 123** | Roadside | 576378, 1550532 | 1.5 | 6.9 | - | - | **59.0** | **53.5** | **55.5** | 38.4 |
| **Maid 124** | Roadside | 576340, 155031 | 40.0 | 0 | - | - | - | 16.1 | 19.9 | 13.4 |
| **Maid 127** | Roadside | 576295, 155376 | 1.5 | 2.0 | - | - | - | - | 36.2 | 35.7 |
| **Maid 132** | Roadside | 576368, 155408 | 2.0 | 2.0 | - | - | - | - | 29.8 | 16.4 |
| **Maid 132** | Roadside | 576368, 155408 | 2.0 | 1.7 | - | - | - | - | 29.8 | 16.4 |
| **Maid 133** | Roadside | 578412, 152598 | 4.6 | 0 | - | - | - | - | 20.8 | 16.0 |

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

[b] A distance of 0 m denotes that the site is representative of relevant exposure (e.g. on the façade of a residential property).

# 3 Detailed Assessment of Upper Stone Street

## Modelling Methodology

3.1 Annual mean concentrations of nitrogen dioxide have been predicted for the existing and future baselines (2019 Baseline and 2022 Baseline, respectively) and two future scenarios (2022 Euro VI Bus and 2022 EV Buses). The 2022 Euro VI Bus scenario assumes all buses and coaches meet Euro VI emission standards. The 2022 EV Bus scenario assumes all buses and coaches are converted to electric vehicles. Concentrations have been predicted throughout Upper Stone Street and Loose Road using the ADMS-Roads dispersion model, with vehicle emissions derived using Defra's Emission Factor Toolkit (EFT) (v11.0). Details of the model inputs, assumptions and the verification are provided in Appendix A2, together with the method used to derive background concentrations. Where assumptions have been made, a realistic worst-case approach has been adopted.

### *Receptors*

3.2 Concentrations have been predicted at residential properties adjacent to Loose Road and Upper Stone Street, as derived from GIS data provided by MBC. Concentrations have been predicted at heights of relevant exposure. The specific receptors modelled are shown in Figure 8.

3.3 Concentrations have also been predicted across a 100 m x 100 m Cartesian grid centred on the junction of Sheal's Crescent and Loose Road (see Figure 9). Additional grids have also been considered at a spacing of 5 m x 5 m within 200 m of the modelled roads. The receptor grid has been modelled at a height of 1.5 m above ground level.

### *Traffic Data*

3.4 ANPR data, provided by Intelligent Data, were collected on Upper Stone Street between 29 September and 5 October 2021. The dataset provides traffic counts and a breakdown of vehicles by type and Euro class. This information has been used together with modelled traffic flows for 2019 in the area (provided by Kent County Council (KCC)), to estimate traffic flows, fleet composition and speed across the area of focus in 2019 and 2022.

3.5 Defra's EFT has been used to estimate vehicle emissions using the Fleet Projection Tool to factor the 2021 ANPR fleet mix by Euro class back to the 2019 baseline year and forward to the 2022 future year.

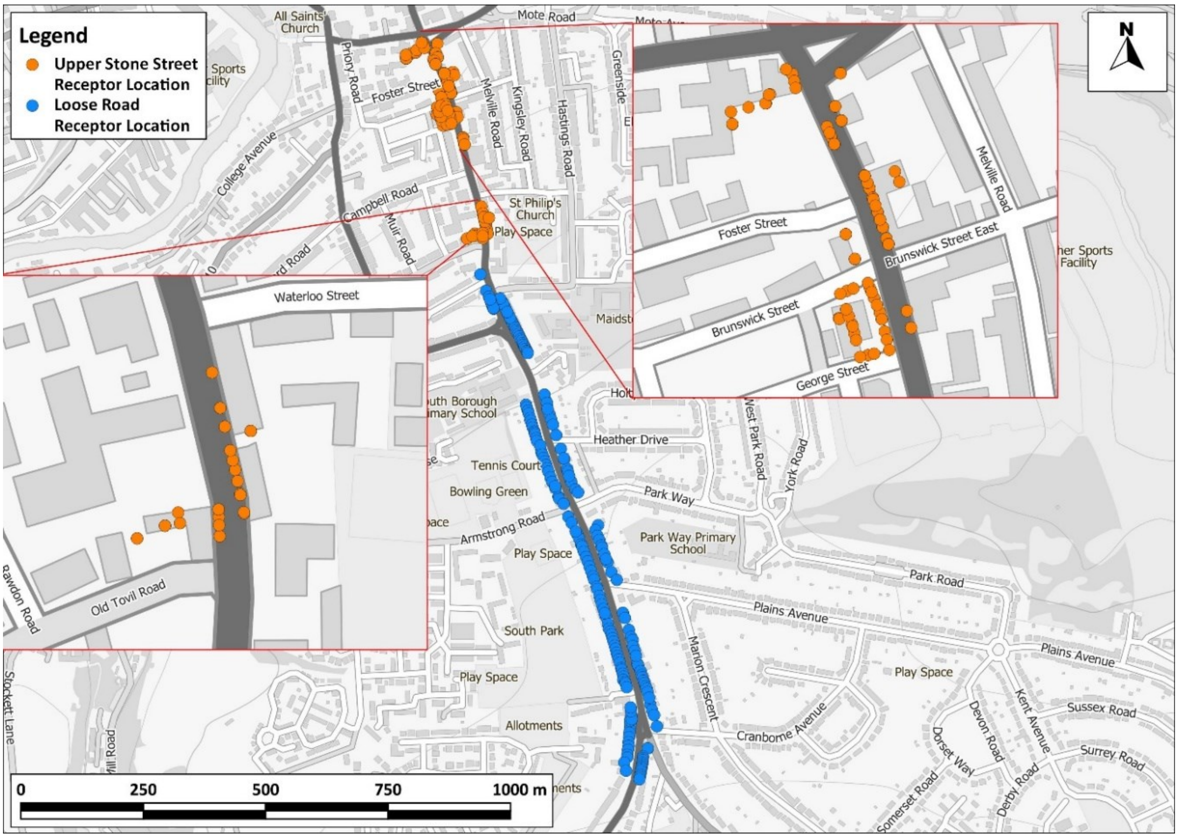


**Figure 8: Specific Receptor Locations**


**Figure 9: Nested Cartesian Grids of Receptors**



### *Uncertainty*

3.6 There are many components that contribute to the uncertainty of modelling predictions.

3.7 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, and any uncertainties inherent in these data will carry into the assessment. There will also be uncertainties associated with projecting the ANPR data from 2021 to 2019 and 2022 using Defra's EFT, and within the ANPR data themselves.

3.8 Uncertainty is also introduced when modelling the impacts of street canyons within the ADMS dispersion model and calculating the effect of gradients on vehicle emissions within the EFT. Both of these effects have been considered within the modelling.

3.9 There are then additional uncertainties as models are required to simplify real-world conditions into a series of algorithms. An important stage in the process is model verification, which involves comparing the model output with measured concentrations (see Appendix A2). Because the model has been verified and adjusted, there can be reasonable confidence in the prediction of 2019 concentrations. LAQM.TG16 (Defra, 2021a) provides guidance on the evaluation of model performance. An analysis of the verification is shown in Table A2.3 in Appendix A2.

3.10 All of the measured concentrations presented will also have an intrinsic margin of error, which will also have been carried into the results of the modelling.

## Modelling Results

### *2019 Baseline Scenario*

3.11 Figure 10 shows modelled annual mean nitrogen dioxide concentrations at the lowest modelled height at the specific receptors in the 2019 Baseline. This indicates that the annual mean objective is achieved at the majority of receptors, however there are exceedances of the objective predicted along Upper Stone Street. All of these locations are within street canyons formed by the buildings along Upper Stone Street, which is also on a gradient. It is estimated that the annual mean nitrogen dioxide objective is exceeded at 44 residential receptors in 2019 (including multiple floor levels at the same location), of which an annual mean concentration of 60 μg/m$^3$ is exceeded at approximately nine.

3.12 Two isopleth maps of the modelled annual mean nitrogen dioxide concentrations in the 2019 baseline, at ground-floor level of Upper Stone Street and Loose Road are presented in Figure 11 and Figure 12, respectively.

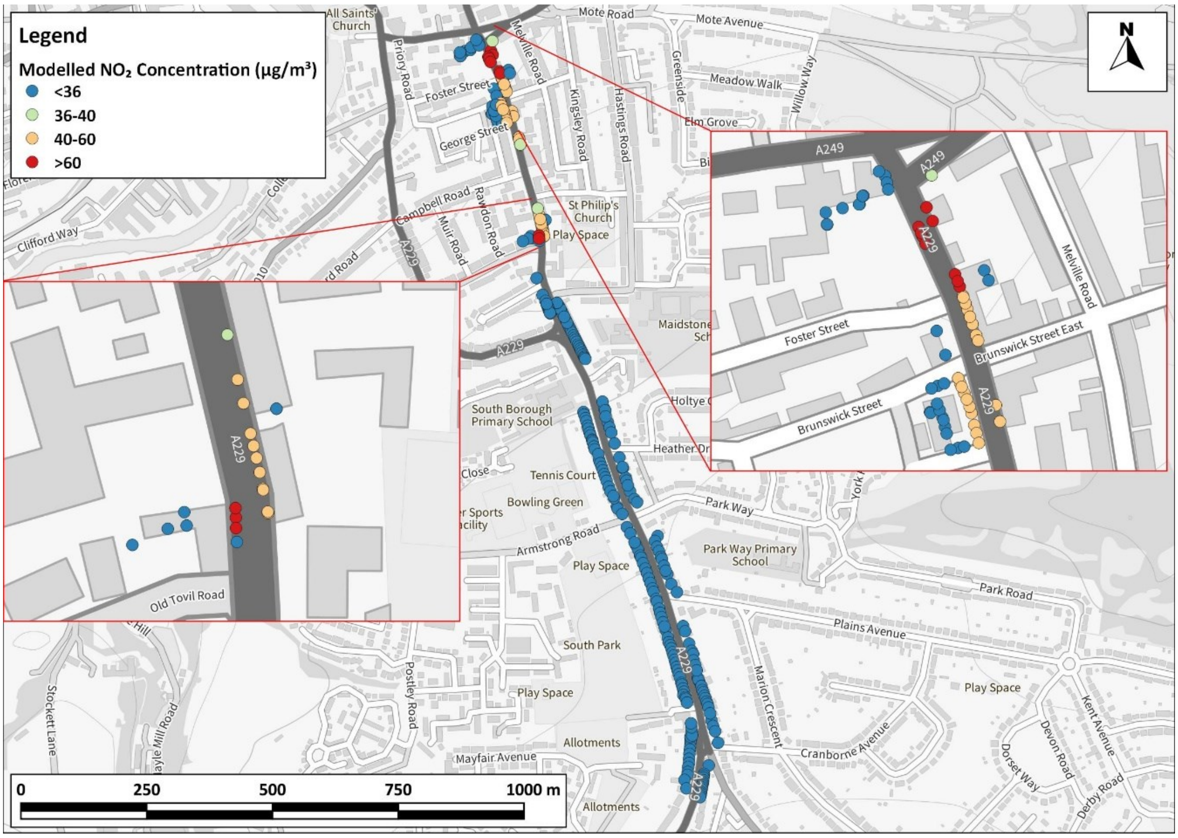


**Figure 10: Modelled Annual Mean Nitrogen Dioxide Concentrations at Specific Receptors in 2019 Baseline**


**Figure 11: Contour Map of Modelled Annual Mean Nitrogen Dioxide Concentrations in 2019 Baseline along Upper Stone Street**

Imagery ©2021 Google, Imagery ©2021 Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies


**Figure 12:** **Contour Map of Modelled Annual Mean Nitrogen Dioxide Concentrations in 2019 Baseline along Loose Road**

Imagery ©2021 Google, Imagery ©2021 Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies

3.13 Figure 11 indicates that the annual mean objective is predicted to be exceeded at locations adjacent to Lower Stone Street, Upper Stone Street and Mote Road, Loose Road, and at a small section along Sutton Road in 2019. However, it should be noted that the only locations of relevant exposure to the annual mean nitrogen dioxide objective at which the objective is predicted to be exceeded are adjacent to Upper Stone Street. The contour bandings should be treated with caution, as the inclusion of street canyons within the modelling leads to large concentration gradients inside versus outside the canyon.

3.14 In general, the model is considered to over-predict concentrations at the junction of Upper Stone Street, Knightrider Street, Mote Road and Lower Stone Street and slightly under-predict at the section of Upper Stone Street between Brunswick Street and Old Tovil Road. At the junction of Lower Stone Street, Mote Road and Upper Stone Street, exceedances have been predicted by the model where measured concentrations were below the objective in 2019 (specifically monitoring sites Maid98, Maid111 and Maid127). The over-prediction at this location is, in part, a result of the use of a conservative verification factor, described in Appendix A2. Similarly, the verification factor used incorporates the locations at which the model performs well, leading to an under-predictions at the locations where measured concentrations are highest, i.e., Upper Stone Street.

3.15 The high predicted and measured concentrations along sections of Upper Stone Street are likely to be due to limited dispersion within these areas due to the presence of street canyons and the effects of the uphill gradient on that road. Measured concentrations adjacent to this section of road in 2019 are above the objective at locations of relevant exposure. Concentrations at the majority of the roadside receptors adjacent to Upper Stone Street are predicted to exceed the objective in 2019.

3.16 Predictions and measurements suggest concentrations at some locations adjacent to Upper Stone Street are also above 60 μg/m$^3$ and therefore there is a risk of exceedances of the 1-hour mean objective along this road; indeed, the objective was exceeded in 2019 at monitor CM3[1].

### *AQMA Recommendation*

3.17 There is uncertainty surrounding both the measured and modelled concentrations. It is therefore recommended that any amendments to the AQMA include, as a minimum, all locations where measured and modelled concentrations exceed 36 μg/m$^3$ at specific locations of relevant exposure. This will reduce the possibility of having to extend the AQMA boundary as a result of annual variations in concentrations. The AQMA should, as a minimum, cover Upper Stone Street from the junction of the A429 to Old Tovil Road, as shown in Figure 13.

[1] See latest Annual Status Report for details.

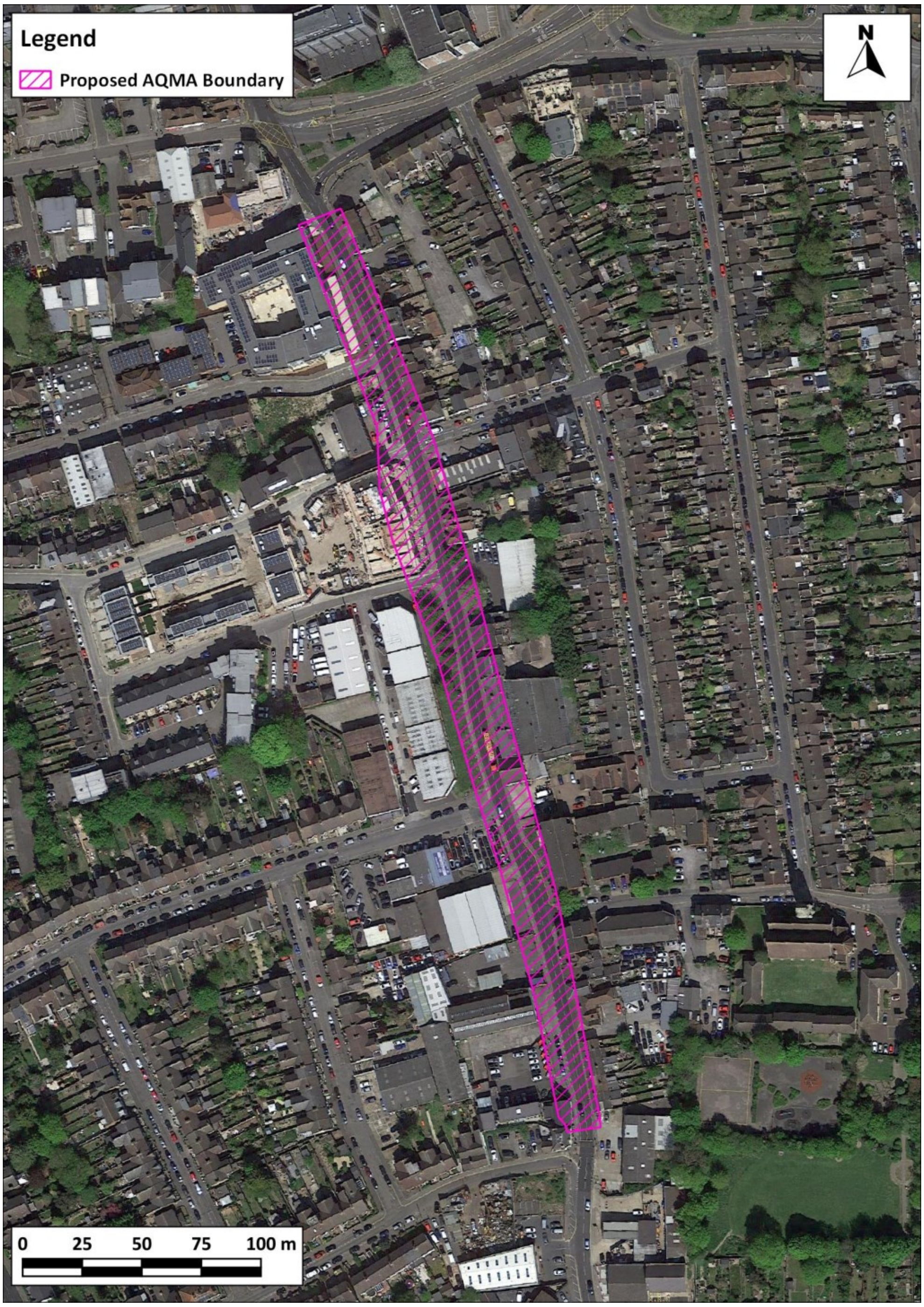


**Figure 13: Proposed AQMA Boundary**

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### *2022 Baseline Scenario*

3.18 Figure 14 shows modelled annual mean nitrogen dioxide concentrations at the lowest modelled height at the specific receptors in the 2022 Baseline. This indicates that the annual mean objective is exceeded at fewer receptors in 2022 than in 2019 adjacent to Upper Stone Street, without any intervention. In particular, several receptors to the north and south of Brunswick Street East and two receptors to the south of Waterloo Street are no longer predicted to exceed the objective. There are also fewer predicted exceedances of 60 µg/m³ between Brunswick Street East and the A429, and north of Old Tovil Road. In total, it is estimated that the annual mean nitrogen dioxide objective is exceeded at 27 receptors in the 2022 Baseline, of which an annual mean concentration of 60 µg/m³ is exceeded at approximately three.

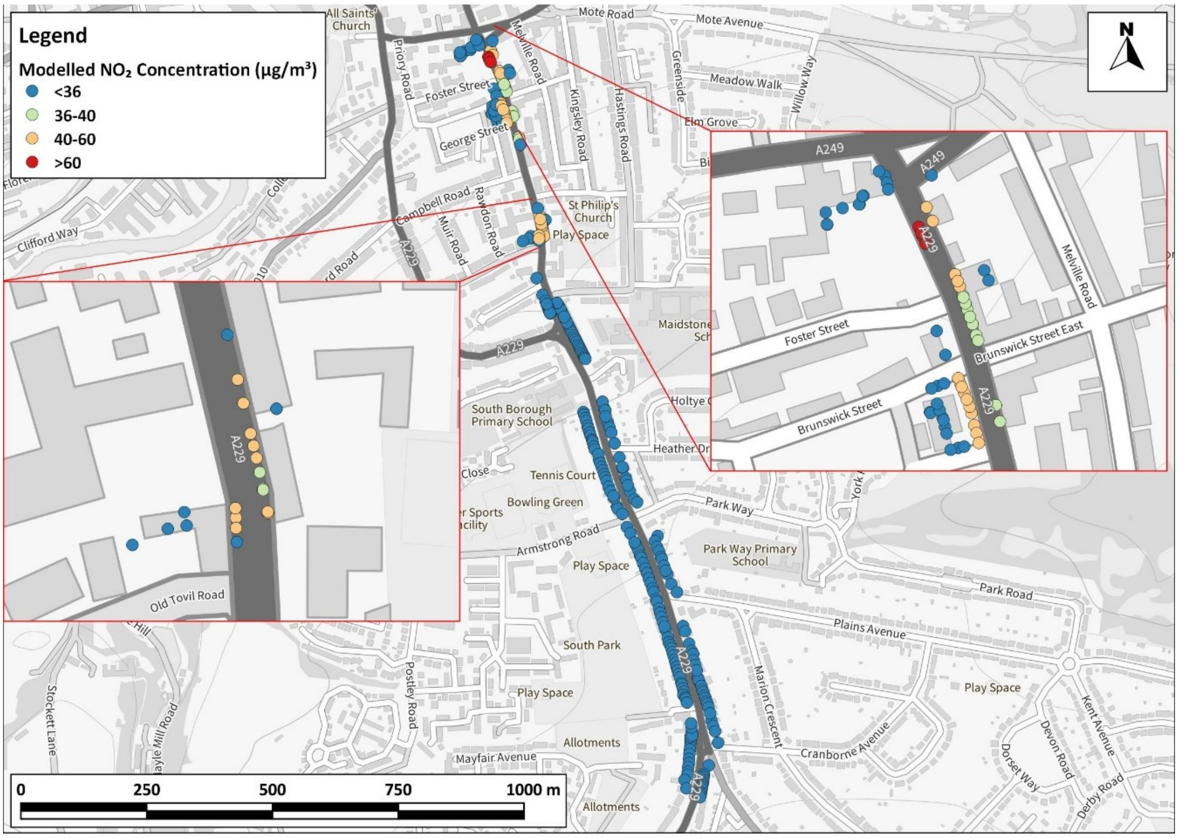


**Figure 14:** **Modelled Annual Mean Nitrogen Dioxide Concentrations at Specific Receptors in 2022 Baseline**



### *2022 Euro VI Bus Scenario*

3.19 Figure 15 shows modelled annual mean nitrogen dioxide concentrations at the specific receptors in the 2022 Euro VI Bus scenario. Compared to the 2022 Baseline scenario, the objective is predicted to be achieved at additional receptors to the south of Brunswick Street and to the south of Waterloo Street. Exceedances of the objective are predicted to remain to the north of Old Tovil Road, to the north of George Street, opposite and north of Foster Street. Concentrations exceeding 60 µg/m³ are predicted north of Foster Street. In total, is it estimated that the annual mean nitrogen dioxide objective is exceeded at 15 receptors in the 2022 Euro VI Bus Scenario, of which an annual mean concentration of 60 µg/m³ is exceeded at approximately three.

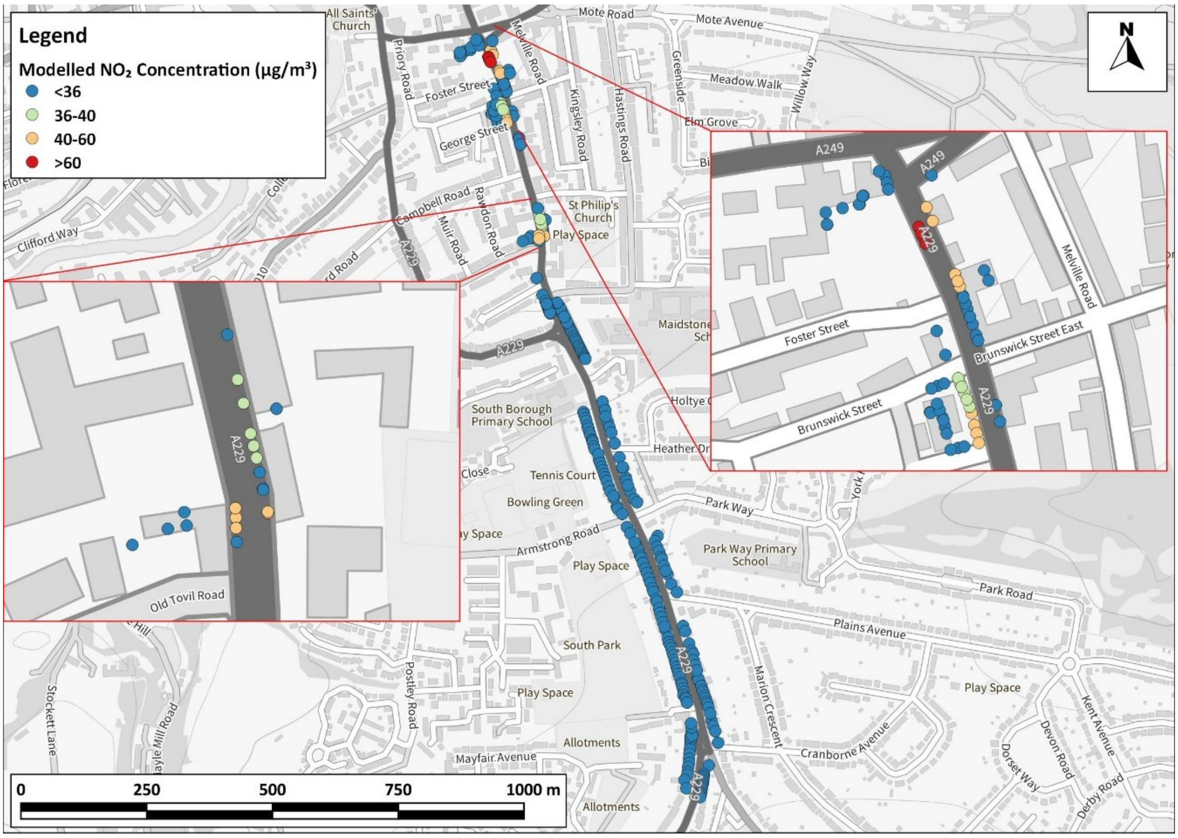


**Figure 15: Modelled Annual Mean Nitrogen Dioxide Concentrations at Specific Receptors in 2022 Euro VI Bus Scenario**



### *2022 EV Bus Scenario*

3.20 Figure 16 shows modelled annual mean nitrogen dioxide concentrations at the specific receptors in the 2022 EV Bus scenario. There is no difference between the 2022 Euro VI Bus and 2022 EV Bus scenarios, in terms of how many exceedances of the objective and of 60 µg/m³ are predicted to occur.

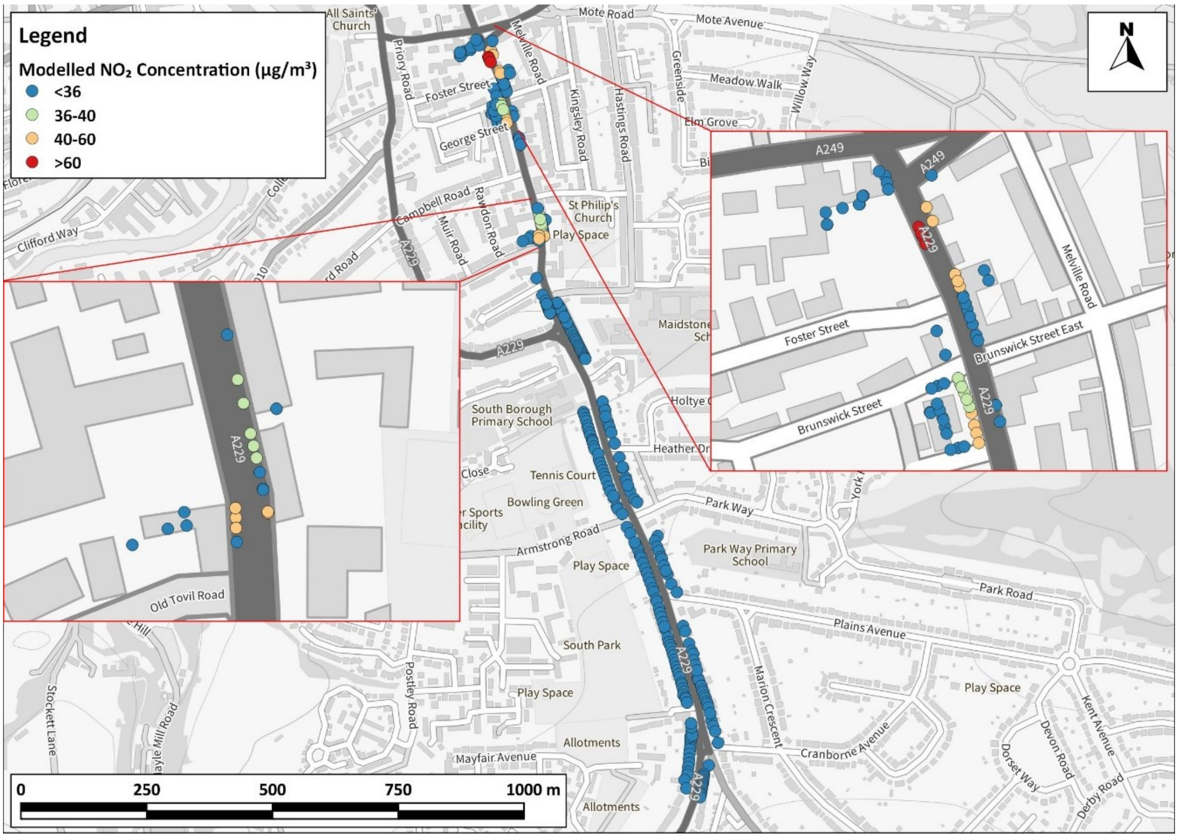


**Figure 16:** **Modelled Annual Mean Nitrogen Dioxide Concentrations at Specific Receptors in 2022 EV Bus Scenario**



## Source Apportionment on Upper Stone Street

3.21 Defra's EFT has been used to provide an indication of the proportion of road traffic emissions on Upper Stone Street from each vehicle and Euro class type in 2019. Emissions of particulate matter from each vehicle type have been included for information.

3.22 Figure 17 and Table 4 show the percentage of emissions by vehicle type. This has been calculated using the total modelled annual emissions on Upper Stone Street in 2019 and the Source Apportionment option within the EFT. The results indicate that the majority of road NOx emissions in 2019 were produced by Diesel Cars (33.0%), followed by Buses/Coaches (20.4%), Rigid Heavy Goods Vehicles (HGVs) (17.5%), and Diesel Light Goods Vehicles (LGVs) (17.4%). For particulate matter emissions ($PM_{10}$ and $PM_{2.5}$), the contribution from Petrol Cars is proportionally much higher than for NOx.

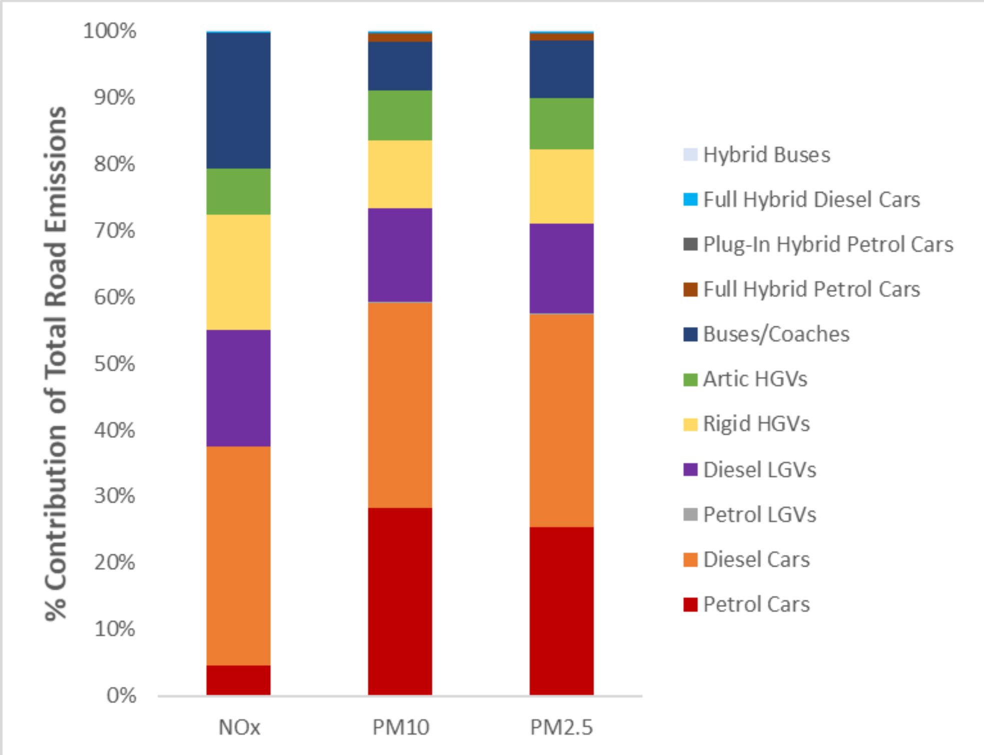


**Figure 17: Percentage Contribution of Total Road Emissions by Vehicle Type (2019 Baseline)**

**Table 4: Percentage Contribution of Total Road Emissions by Vehicle Type (2019)**

| Vehicle Type | NOx (%) | $PM_{10}$ (%) | $PM_{2.5}$ (%) |
|---|---|---|---|
| **Petrol Cars** | 4.5 | 28.3 | 25.3 |
| **Diesel Cars** | 33.0 | 30.7 | 32.1 |
| **Petrol LGVs** | 0.0 | 0.2 | 0.2 |
| **Diesel LGVs** | 17.4 | 14.0 | 13.6 |
| **Rigid HGVs** | 17.5 | 10.2 | 11.2 |
| **Artic HGVs** | 6.9 | 7.5 | 7.6 |
| **Buses/Coaches** | 20.4 | 7.4 | 8.7 |
| **Full Hybrid Petrol Cars** | 0.1 | 1.1 | 1.0 |
| **Plug-In Hybrid Petrol Cars** | 0.0 | 0.3 | 0.3 |
| **Full Hybrid Diesel Cars** | 0.2 | 0.2 | 0.2 |
| **FCEV LGVs** | 0.0 | 0.0 | 0.0 |
| **CNG Buses** | 0.0 | 0.0 | 0.0 |
| **Hybrid Buses** | 0.1 | 0.1 | 0.1 |
| **FCEV Buses** | 0.0 | 0.0 | 0.0 |

3.23 Figure 18, Figure 19, Table 5 and Table 6 show the percentage contribution of NOx emissions by vehicle Euro class for Light Duty Vehicles (LDVs) and Heavy Duty Vehicles (HDVs; HGVs and

Buses/Coaches), respectively. The proportions have been calculated based on the annual emissions from all modelled roads using the EFT's Euro Emissions Standards Summary for NOx.

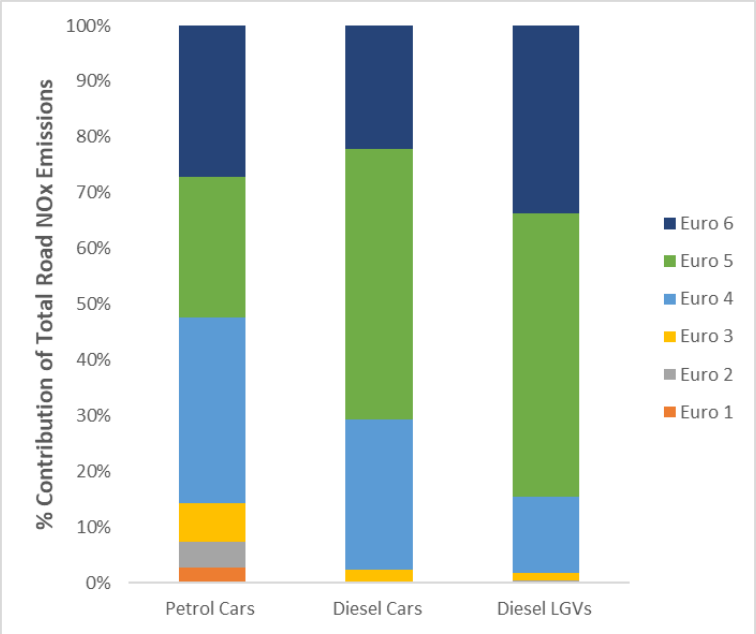


**Figure 18: Percentage Contribution of Total Road NOx Emissions from Light Duty Vehicles by Euro Class Type (2019 Baseline)**

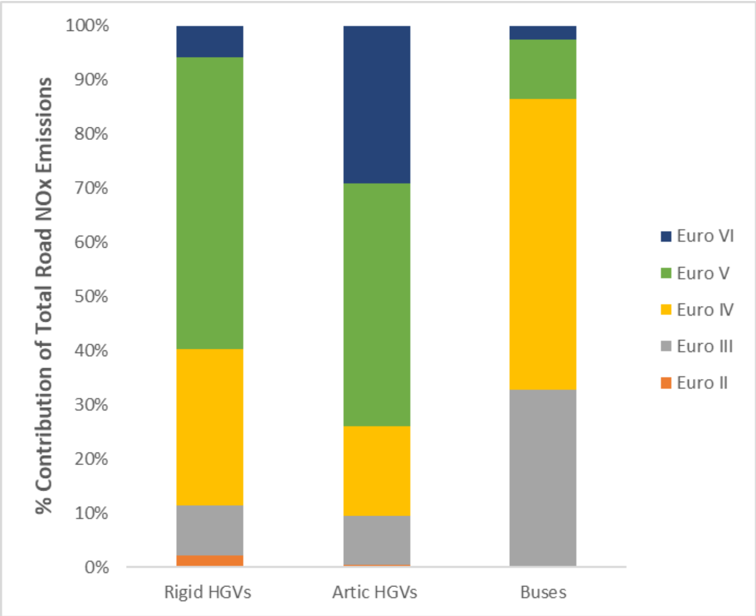


**Figure 19: Percentage Contribution of Total Road NOx Emissions from Heavy Duty Vehicles by Euro Class Type (2019 Baseline)**

**Table 5: Percentage Contribution of Total Road Emissions from Light Duty Vehicles by Euro Class Type (2019)**

| Euro Standard | Petrol Cars (%) | Diesel Cars (%) | Diesel LGVs (%) |
|---|---|---|---|
| Euro 1 | 2.7 | 0.1 | 0.0 |
| Euro 2 | 4.7 | 0.1 | 0.5 |
| Euro 3 | 6.9 | 2.1 | 1.2 |
| Euro 4 | 33.3 | 27.0 | 13.8 |
| Euro 5 | 25.3 | 48.5 | 50.8 |
| Euro 6 | 27.1 | 22.2 | 33.7 |

**Table 6: Percentage Contribution of Total Road Emissions from Heavy Duty Vehicles by Euro Class Type (2019)**

| Vehicle Type | Rigid HGVs | Artic HGVs | Buses |
|---|---|---|---|
| Euro II | 2.1 | 0.5 | 0.3 |
| Euro III | 9.3 | 9.0 | 32.5 |
| Euro IV | 28.8 | 16.7 | 53.7 |
| Euro V | 53.9 | 44.9 | 11.0 |
| Euro V | 5.8 | 29.0 | 2.5 |
| Euro VI | 2.1 | 0.5 | 0.3 |

3.24 Figure 18 and Table 5 indicate that the majority of NOx emissions from Petrol Cars in 2019 are from Euro 4 vehicles (33.3%), while for Diesel Cars and LGVs, Euro 5 vehicles emit the highest proportion of NOx (48.5% and 50.8%, respectively). In terms of HDVs, Figure 19 and Table 6 indicate that the majority of NOx emissions from Rigid and Artic HGVs in 2019 are from Euro V vehicles (53.9% and 44.9%, respectively), while for Buses/Coaches, the majority of emissions are from Euro IV vehicles (53.7%).

3.25 The ANPR data (after manual assignment of Euro classes as described in Paragraph A2.1) show that approximately 18% of the bus fleet within Maidstone centre in 2021 are Euro III vehicles and 43% are Euro IV vehicles. This is taken to indicate an older than average bus fleet, although this assumption should be treated with some caution (see Paragraph A2.1).

3.26 It should be noted that these proportions are calculated based on a series of assumptions (as described in Paragraph A2.1), and are estimated for 2019 using Defra's EFT, based on ANPR data collected in 2021, corrected to 2019 where possible.

# 4 Summary

4.1 Detailed modelling on Upper Stone Street has shown that the predicted annual mean nitrogen dioxide concentrations in 2019 exceed the objective on the one-way section of that road, but not at locations of relevant exposure elsewhere. The majority of road NOx emissions on Upper Stone Street in 2019 can be attributed to diesel vehicles; primarily cars, followed by buses and coaches, rigid HGVs and LGVs.

4.2 Based on an analysis of the monitoring data within Maidstone between 2015 and 2019, and a modelling study covering central Maidstone and the A229, it is recommended that the extent of the AQMA is reduced to cover Upper Stone Street only. It is considered that the AQMA can be revoked in northern Maidstone and the M20 in that area, Barming and west Maidstone, and Loose Road, Sutton Road and Sheal's Crescent in central Maidstone.

4.3 Future (2022) modelling scenarios show that predicted annual mean nitrogen dioxide concentrations continue to fall within the study area without any intervention to reduce road NOx emissions, however, exceedances of the annual mean nitrogen dioxide objective are predicted to persist adjacent to Upper Stone Street. Assuming that all buses and coaches either meet Euro VI emission standard, or that all buses and coaches are converted to electric vehicles, further reduces the predicted concentrations and the number of exceedances, but not to the extent that all receptors are predicted to meet the objective.

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# 6 Glossary

| | |
|---|---|
| **AADT** | Annual Average Daily Traffic |
| **ADMS-Roads** | Atmospheric Dispersion Modelling System model for Roads |
| **ANPR** | Automatic Number Plate Recognition |
| **ASR** | Annual Status Report |
| **AQC** | Air Quality Consultants |
| **AQMA** | Air Quality Management Area |
| **Defra** | Department for Environment, Food and Rural Affairs |
| **DfT** | Department for Transport |
| **EFT** | Emission Factor Toolkit |
| **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 |
| **HGV** | Heavy Goods Vehicle |
| **IAQM** | Institute of Air Quality Management |
| **kph** | Kilometres Per hour |
| **LAQM** | Local Air Quality Management |
| **LDV** | Light Duty Vehicles (<3.5 tonnes) |
| **LGV** | Light Goods Vehicle |
| **MBC** | Maidstone Borough Council |
| **µg/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 |

| | |
|---|---|
| **OGV** | Other Goods Vehicle |
| **Standards** | A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal |
| **TEMPro** | Trip End Model Presentation Program |

# 7 Appendices

# A1 Professional Experience

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

Dr Beattie is an Associate Director with AQC, with more than 20 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. She has led on the air quality inputs into Clean Air Zone feasibility studies and has provided support to local authorities on the integration of air quality considerations into Local Transport Plans and planning policy processes. 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 carried out numerous assessments for new residential and commercial developments, including the negotiation of mitigation measures where relevant. She has also acted as an expert witness for both residential and commercial developments. She has carried out BREEAM assessments covering air quality for new developments. Dr Beattie has also managed contracts on behalf of Defra in relation to allocating funding for the implementation of air quality improvement measures. She is a Member of the Institute of Air Quality Management, Institution of Environmental Sciences and is a Chartered Scientist.

## Dr Kate Wilkins, BSc (Hons) MSc PhD MIEnvSc MIAQM

Dr Wilkins is a Senior Consultant with AQC with eight years' postgraduate and work experience in the field of Environmental and Earth Sciences. Since joining AQC in January 2018, she has undertaken numerous air quality impact assessments for road traffic, combustion plant and construction dust throughout the UK for both standalone assessments and for EIAs, and has also prepared local authority reports and literature reviews. She has contributed her technical skills in programming and specialist software to a range of large-scale projects, including the third runway at Heathrow airport. Previously, Kate completed a PhD at the University of Bristol, researching atmospheric dispersion modelling and satellite remote sensing of volcanic ash. Prior to her PhD she spent a year working at the Environment Agency in Flood Risk Management. She is a Member of both the Institute of Air Quality Management and the Institution of Environmental Sciences.

## George Chousos, BSc MSc AMIEnvSc AMIAQM

Mr Chousos is an Assistant Consultant with AQC, having joined in May 2019. Prior to joining AQC, he completed an MSc in Air Pollution Management and Control at the University of Birmingham, specialising in air pollution control technologies and management, and data processing using R. He also holds a degree in Environmental Geoscience from the University of Cardiff, where he undertook a year in industry working in the field of photo-catalytic technology. He is now gaining experience in the field of air quality monitoring and assessment.

## Helen Pearce, BSc (Hons) MSc

Miss Pearce is an Assistant Consultant with AQC, having joined in September 2021. Prior to joining AQC she was based at the University of Birmingham, completing a BSc in Geography, MSc in Applied Meteorology and Climatology, and is currently awaiting her PhD examination. Her PhD research specialised in air quality modelling where she developed a range of tools to estimate real-time pollutant concentrations on Birmingham's road network, and to quantify the impacts of Low Traffic Neighbourhoods on residential population exposure. Additionally, she provided the air quality modelling expertise on the NERC-funded project, 'GI4RAQ' (Green Infrastructure for Roadside Air Quality), to quantitively assess the impacts of 'green' interventions in street environments. She is now gaining experience in the field of air quality monitoring and assessment.

## Joe Rondel

Mr Rondel is an Environmental Monitoring Technician with AQC, having joined the Company in 2021. Prior to joining AQC he gained a degree in Geography from the University of Manchester, specialising in biological science and economics. He is now gaining experience in the field of air quality monitoring, including passive and active sampling techniques.

# A2 Modelling Methodology

## Assumptions

A2.1 It is necessary to make a number of assumptions when carrying out an air quality assessment; in order to account for some of the uncertainty in the approach, as described in Section 3, assumptions made have generally sought to reflect a realistic worst-case scenario. Not least, 2019 was used as the modelled year to provide a worst-case approach. Key assumptions made in carrying out this assessment include:

- a high proportion of the bus/coach vehicle category within the ANPR dataset does not have a Euro class assigned. Intelligent Data, who collected the data, have advised that the Euro status data is derived from the Motor Vehicle Registration Information System (MVRIS; a database of new vehicle registration details in the UK for cars and commercial vehicles <6 t gross vehicle weight). For commercial vehicles and buses/coaches of 6 t gross vehicle weight and over, this data service launched in 2016, thus for heavy vehicles registered before 2016, there are a high proportion of missing Euro class records in DVLA database. This will have skewed the Euro mix for these vehicles towards later classes. To mitigate this effect, classes for bus/coach, OGV1 and OGV2 vehicles have been assigned based on the vehicle registration date (where available) where no Euro class is already defined. Where no registration date is available, where possible, classes have been assigned based on the vehicle model and make;
- the vehicle categories for HGVs used within the ANPR dataset do not match the definitions within the EFT; EFT uses Rigid and Articulated HGV categories, while the ANPR separates HGVs by Other Goods Vehicles groups (OGV1; rigid vehicles >3.5 tonnes with two or three axles, and OGV2; rigid vehicles with four or more axles and articulated vehicles). Based on the proportions of these vehicles within the default EFT fleet mix, it is considered appropriate to assume that all OGV1 vehicles represent Rigid HGVs and OGV2 vehicles represent Articulated HGVs within the modelling;
- within the EFT, it has been assumed that that all electric and electric/hybrid petrol cars are petrol cars and all electric/hybrid diesel cars are diesel cars;
- it has been assumed that the EFT fleet projections for 2019 and 2022 are representative of those years, based on ANPR data collected in 2021;
- all buses and coaches have been removed from the fleet in the 2022 EV Bus scenario to simulate all buses having been converted to EVs;
- Mote Road, Upper Stone Street and Loose Road are on gradients;
- it has been assumed that the East Malling meteorological monitoring station appropriately represents conditions in the study area (this is discussed further in Paragraph A2.8); and

- sections of Upper Stone Street are located within street canyons (this is discussed further Paragraph A2.7).

## Background Concentrations

A2.2 Background concentrations have been defined using Defra's 2018-based background maps (Defra, 2021b), calibrated against local measurements made at the Maid45 background diffusion tube monitoring site. The measured nitrogen dioxide concentrations at this site in 2019 was 1.10 times higher than the 2019 Defra mapped background concentrations. All mapped nitrogen dioxide background concentrations for the grid squares covering the study area have therefore been adjusted by applying a factor of 1.10.

## Model Inputs

A2.3 Predictions have been carried out using the ADMS-Roads dispersion model (v5). 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 height and porosity, where relevant). Vehicle emissions have been calculated based on vehicle flow, composition and speed data using the EFT (Version 11.0) published by Defra.

A2.4 Vehicle fleet composition data have been based on ANPR data, provided by Intelligent Data, which were collected on Upper Stone Street between 29 September and 5 October 2021. The dataset provides traffic counts and a breakdown of vehicles by type and Euro class. This information has been used together with modelled traffic flows for 2019 in the area (provided by KCC), to estimate traffic flows, fleet composition and speed across the area of focus in 2019. Defra's EFT has been used to estimate vehicle emissions using the Fleet Projection Tool to factor the 2021 ANPR fleet mix by Euro class back to the 2019 baseline year. Traffic counts for Sheal's Crescent have been based on counts provided by DfT (2021). The 2019 AADT flows have been factored forwards to the future assessment year of 2022 using growth factors derived using the TEMPro System v7.2 (DfT, 2017). Speeds have been based on those provided by KCC, with some having been adjusted based on professional judgement, taking account of the road layout, speed limits and the proximity to junctions.

A2.5 The traffic data used in this assessment are summarised in Table A2.1. The diurnal flow profile for the traffic has been derived using the ANPR data, and the monthly flow profile has been derived from the national profiles published by DfT (2020).

**Table A2.1: Summary of Traffic Data used in the Assessment**

| Road Link | AADT | % Petrol Car | % Diesel Car | % LGV | % Rigid HGV | % Artic HGV | % Bus/ Coach | % Motor Cycle |
|---|---|---|---|---|---|---|---|---|
| **2019 Baseline** | | | | | | | | |
| Lower Stone Street | 11,983 – 18,803 | 44.0 - 44.5 | 36.1 - 36.5 | 13.4 - 13.6 | 2.3 - 2.8 | 1.7 - 2.1 | 1.4 - 1.7 | 0.0 |
| Knightrider Street | 4,923 – 5,646 | 44.8 | 36.6 - 36.7 | 13.6 | 2.1 | 1.5 - 1.6 | 1.3 | 0.0 |
| Mote Road (A249) | 1,098 – 6,115 | 44.8 - 47 | 36.7 - 38.5 | 13.6 - 14.3 | 0.1 - 2.1 | 0.0 - 1.5 | 0.0 - 1.3 | 0.0 |
| Wat Tyler Way (A249) | 2,545 – 5,247 | 44.6 - 45.6 | 36.5 - 37.3 | 13.6 - 13.9 | 1.4 - 2.3 | 1.0 - 1.7 | 0.8 - 1.4 | 0.0 |
| Upper Stone Street (A229) – west of Mote Road | 11,007 | 43.6 | 35.7 | 13.3 | 3.2 | 2.4 | 1.9 | 0.0 |
| Upper Stone Street (A229) – south of Mote Road | 13,329 – 17,300 | 44.0 - 44.4 | 36.0 - 36.4 | 13.4 - 13.5 | 2.4 - 2.8 | 1.8 - 2.1 | 1.5 - 1.7 | 0.0 |
| Loose Road (A229) – north of Sheal's Crescent | 13,329 – 15,544 | 44.3 - 44.7 | 36.3 - 36.6 | 13.5 - 13.6 | 2.2 - 2.5 | 1.6 - 1.8 | 1.3 - 1.5 | 0.0 |
| Sheal's Crescent | 12,434 | 44.1 | 36.1 | 12.9 | 2.5 | 1.9 | 1.5 | 1.0 |
| Loose Road (A229) – north of Park Way | 10,494 – 18,165 | 43.3 - 43.7 | 35.5 - 35.8 | 13.2 - 13.3 | 3.1 - 3.4 | 2.3 - 2.5 | 1.9 - 2.1 | 0.0 |
| Loose Road (A229) – north of Sutton Road (A274) | 22,360 – 24,443 | 44.1 - 44.3 | 36.1 - 36.3 | 13.4 - 13.5 | 2.5 - 2.7 | 1.9 - 2.0 | 1.5 - 1.6 | 0.0 |
| Loose Road (A229) – west of Sutton Road (A274) | 13,752 | 44.4 | 36.4 | 13.5 | 2.4 | 1.8 | 1.5 | 0.0 |
| Sutton Road (A274) | 13,920 | 44.8 | 36.7 | 13.7 | 2.0 | 1.5 | 1.2 | 0.0 |
| **2022 Baseline & 2022 Euro VI Bus** | | | | | | | | |
| Lower Stone Street | 12,534 – 19,668 | 44.0 - 44.5 | 36.1 - 36.5 | 13.4 - 13.6 | 2.3 - 2.8 | 1.7 - 2.1 | 1.4 - 1.7 | 0.0 |
| Knightrider Street | 5,150 – 5,906 | 44.8 | 36.6 - 36.7 | 13.6 | 2.1 | 1.5 - 1.6 | 1.3 | 0.0 |
| Mote Road (A249) | 1,149 – 6,397 | 44.8 - 47 | 36.7 - 38.5 | 13.6 - 14.3 | 0.1 - 2.1 | 0.0 - 1.5 | 0.0 - 1.3 | 0.0 |
| Wat Tyler Way (A249) | 2,662 – 5,488 | 44.6 - 45.6 | 36.5 - 37.3 | 13.6 - 13.9 | 1.4 - 2.3 | 1.0 - 1.7 | 0.8 - 1.4 | 0.0 |
| Upper Stone Street (A229) – west of Mote Road | 11,514 | 43.6 | 35.7 | 13.3 | 3.2 | 2.4 | 1.9 | 0.0 |
| Upper Stone Street (A229) – south of Mote Road | 13,942 – 18,095 | 44.0 - 44.4 | 36.0 - 36.4 | 13.4 - 13.5 | 2.4 - 2.8 | 1.8 - 2.1 | 1.5 - 1.7 | 0.0 |
| Loose Road (A229) – north of Sheal's Crescent | 13,942 – 16,259 | 44.3 - 44.7 | 36.3 - 36.6 | 13.5 - 13.6 | 2.2 - 2.5 | 1.6 - 1.8 | 1.3 - 1.5 | 0.0 |
| Sheal's Crescent | 13,005 | 44.1 | 36.1 | 12.9 | 2.5 | 1.9 | 1.5 | 1.0 |
| Loose Road (A229) – north of Park Way | 10,977 – 19,001 | 43.3 - 43.7 | 35.5 - 35.8 | 13.2 - 13.3 | 3.1 - 3.4 | 2.3 - 2.5 | 1.9 - 2.1 | 0.0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Loose Road (A229) – north of Sutton Road (A274)** | 23,388 – 25,568 | 44.1 - 44.3 | 36.1 - 36.3 | 13.4 - 13.5 | 2.5 - 2.7 | 1.9 - 2.0 | 1.5 - 1.6 | 0.0 |
| **Loose Road (A229) – west of Sutton Road (A274)** | 14,385 | 44.4 | 36.4 | 13.5 | 2.4 | 1.8 | 1.5 | 0.0 |
| **Sutton Road (A274)** | 14,560 | 44.8 | 36.7 | 13.7 | 2.0 | 1.5 | 1.2 | 0.0 |
| **2022 EV Bus** | | | | | | | | |
| **Lower Stone Street** | 12,534 – 19,668 | 44.8 - 45.2 | 36.7 - 37 | 13.6 - 13.8 | 2.3 - 2.8 | 1.7 - 2.1 | 0.0 | 0.0 |
| **Knightrider Street** | 5,150 – 5,906 | 45.3 - 45.4 | 37.1 | 13.8 | 2.1 | 1.6 | 0.0 | 0.0 |
| **Mote Road (A249)** | 1,149 – 6,397 | 45.4 - 47.0 | 37.1 - 38.5 | 13.8 - 14.3 | 0.1 - 2.1 | 0.0 - 1.6 | 0.0 | 0.0 |
| **Wat Tyler Way (A249)** | 2,662 – 5,488 | 45.2 - 45.9 | 37 - 37.6 | 13.8 - 14.0 | 1.4 - 2.3 | 1.0 - 1.7 | 0.0 | 0.0 |
| **Upper Stone Street (A229) – west of Mote Road** | 11,514 | 44.4 | 36.4 | 13.5 | 3.2 | 2.4 | 0.0 | 0.0 |
| **Upper Stone Street (A229) – south of Mote Road** | 13,942 – 18,095 | 44.8 - 45.1 | 36.7 - 36.9 | 13.6 - 13.7 | 2.4 - 2.8 | 1.8 - 2.1 | 0.0 | 0.0 |
| **Loose Road (A229) – north of Sheal's Crescent** | 13,942 – 16,259 | 45.0 - 45.3 | 36.9 - 37.1 | 13.7 - 13.8 | 2.2 - 2.5 | 1.7 - 1.9 | 0.0 | 0.0 |
| **Sheal's Crescent** | 13,005 | 44.8 | 36.6 | 13.1 | 2.6 | 1.9 | 0.0 | 1.0 |
| **Loose Road (A229) – north of Park Way** | 10,977 – 19,001 | 44.2 - 44.5 | 36.2 - 36.4 | 13.5 - 13.6 | 3.1 - 3.5 | 2.3 - 2.6 | 0.0 | 0.0 |
| **Loose Road (A229) – north of Sutton Road (A274)** | 23,388 – 25,568 | 44.8 - 45 | 36.7 - 36.9 | 13.7 | 2.5 - 2.7 | 1.9 - 2.0 | 0.0 | 0.0 |
| **Loose Road (A229) – west of Sutton Road (A274)** | 14,385 | 45.1 | 36.9 | 13.7 | 2.4 | 1.8 | 0.0 | 0.0 |
| **Sutton Road (A274)** | 14,560 | 45.4 | 37.2 | 13.8 | 2.1 | 1.5 | 0.0 | 0.0 |

A2.6 Figure A2.1 shows the road network included within the model, along with the speed at which each link was modelled.


**Figure A2.1: Modelled Road Network & Speed**

Imagery ©2021 Google, Imagery ©2021 Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies

A2.7 For the purposes of modelling, it has been assumed that sections of Upper Stone Street are within street canyons formed by buildings. This road has a number of 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. Sections of Upper Stone Street have, therefore, been modelled as street canyons using ADMS-Roads' advanced canyon module, with appropriate input parameters determined from local mapping. The advanced canyon module has been used, the input data for which have been published by Cambridge Environmental Research Consultants (CERC, 2016), who developed the ADMS models. The modelled canyons are shown in Figure A2.2.


**Figure A2.2: Modelled Canyons**

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A2.8 Hourly sequential meteorological data in sectors of 10 degrees from East Malling for 2019 have been used in the model. The East Malling meteorological monitoring station is located 5.5 km to the northwest of Maidstone. It is deemed to be the nearest monitoring station representative of meteorological conditions in the vicinity of Maidstone; both are located at inland locations in the south-east of England, where they will be influenced by the effects of inland meteorology. A wind rose for the site for the year 2019 is provided in Figure A2.3. The station is operated by the UK Met Office. Raw data were provided by the Met Office and processed by AQC for use in ADMS. Meteorological model input parameters are summarised in Table A2.2.

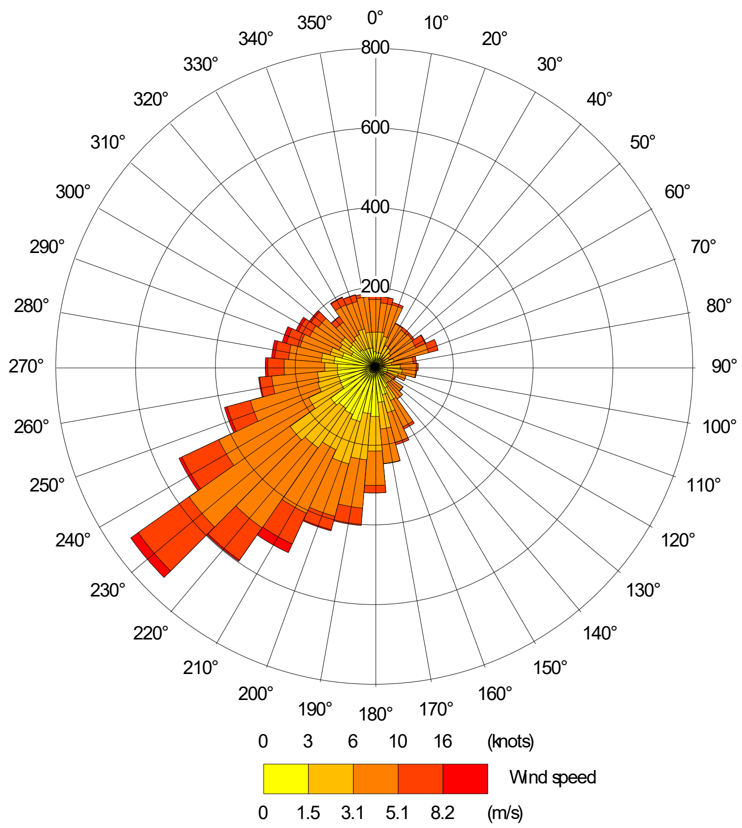


**Figure A2.3: East Malling 2019 Wind Rose**

**Table A2.2: Summary Model Inputs**

| Model Parameter | Value Used |
|---|---|
| **Terrain Effects Modelled?** | Yes – 6 km x 6 km Cartesian grid at 50m resolution |
| **Variable Surface Roughness File Used?** | Yes – 6 km x 6 km Cartesian grid at 50m resolution |
| **Urban Canopy Flow Used?** | No |
| **Gradients Modelled?** | Yes |
| **Advanced Street Canyons Modelled?** | Yes |
| **Noise Barriers Modelled?** | No |
| **Meteorological Monitoring Site** | East Malling |
| **Meteorological Data Year** | 2019 |
| **Dispersion Site Surface Roughness Length (m)** | Variable |
| **Dispersion Site Minimum MO Length (m)** | 30 |
| **Met Site Surface Roughness Length (m)** | 0.1 |
| **Met Site Minimum MO Length (m)** | 1 |

## Model Verification

A2.9 In order to ensure that ADMS-Roads accurately predicts local concentrations, it is necessary to verify the model against local measurements. The model has been run to predict the annual mean concentrations during 2019 at the CM3 automatic monitor, and Maid19, Maid53, Maid56, Maid81, Maid96, Maid98, Maid111, Maid122, Maid123, Maid127 and Maid132 diffusion tube monitoring sites. The locations of the monitoring sites are shown in Figure 3.

A2.10 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 + $NO_2$).

A2.11 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 8.1) available on the Defra LAQM Support website.

A2.12 The unadjusted model has under predicted the road-NOx contribution at several monitoring locations; this is a common experience with this and most other road traffic emissions dispersion models. 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 A2.4). The calculated adjustment factor of **2.0792** has been applied to the modelled road-NOx concentration for each receptor to provide adjusted modelled road-NOx concentrations.

A2.13 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 A2.5 compares final adjusted modelled total $NO_2$ at each of the monitoring sites to measured total $NO_2$.

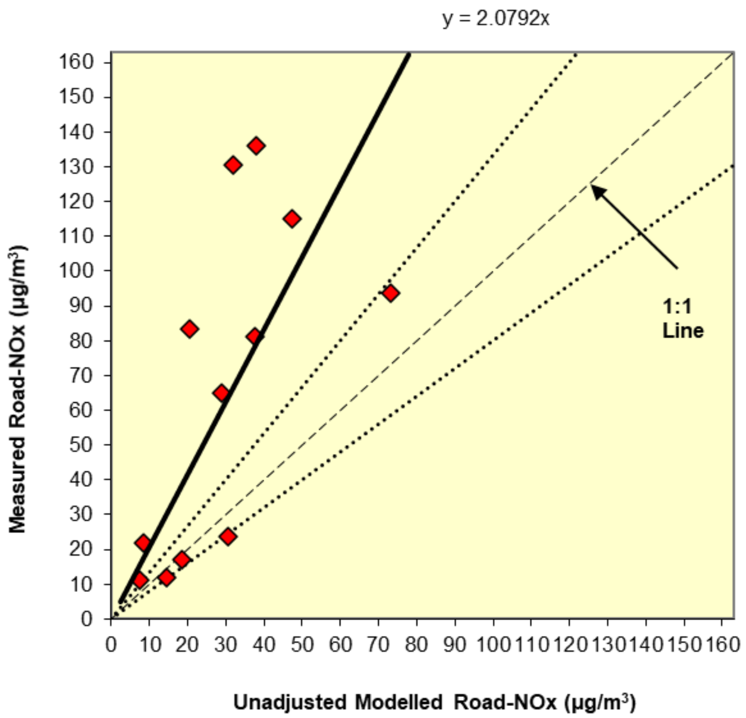


**Figure A2.4: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations. The dashed lines show ± 25%.**

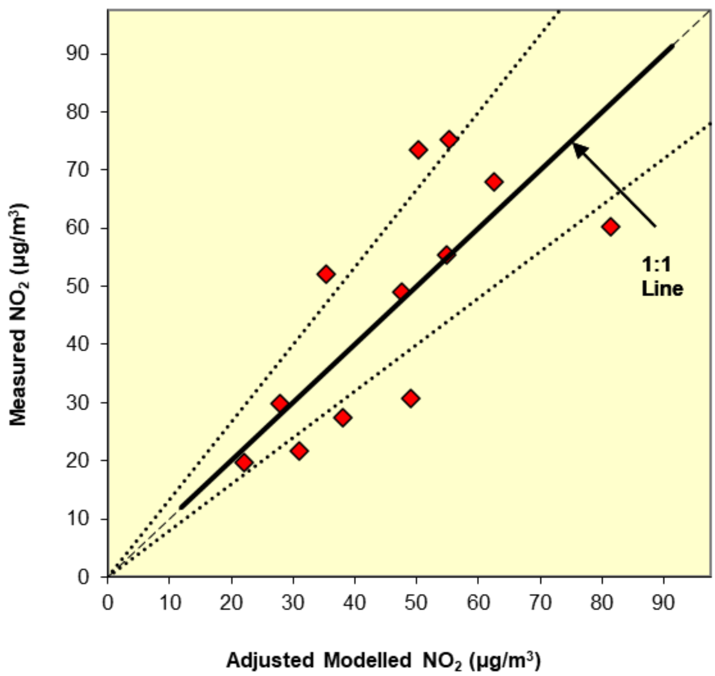


**Figure A2.5: Comparison of Measured Total $NO_2$ to Final Adjusted Modelled Total $NO_2$ Concentrations. The dashed lines show ± 25%.**

A2.14 Table A2.3 shows the statistical parameters relating to the performance of the model, as well as the 'ideal' values (Defra, 2021a). There is a large degree of scatter within the model results, as demonstrated by the high RMSE presented in Table A2.3. This is likely to be due to the uncertainty in the traffic data used within the model. However, the fractional bias is close to zero, indicating that the overall adjustment factor is appropriate for this data set.

**Table A2.3: Statistical Model Performance**

| Statistical Parameter | Model-Specific Value | 'Ideal' Value |
|---|---|---|
| **Correlation Coefficient** [a] | 0.72 | **1** |
| **Root Mean Square Error (RMSE)** [b] | 13.65 | **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/m$^3$). TG16 (Defra, 2021a) outlines that, ideally, a RMSE value within 10% of the air quality objective (4 μg/m$^3$) would be derived. If RMSE values are higher than 25% of the objective (10 μg/m$^3$) 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.

## Post-processing

A2.15 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. The traffic mix within the calculator has been set to "All other urban UK traffic", which is considered suitable for the study area. The calculator predicts the component of $NO_2$ based on the adjusted road-NOx and the background $NO_2$.

# A3 Review of 20 mph Speed Limits

A3.1 One option being discussed for Upper Stone Street is a 20 mph speed limit. Because the changes are unlikely to have a large impact on overall average speed, but instead impact on stop start traffic, modelling using ADMS and average speed emission factors is unlikely to provide a robust assessment. An assessment could be undertaken using a microsimulation traffic model, however, at this stage it is considered that a better use of budget would be to undertake a brief literature review of all peer reviewed studies which have been undertaken to look at the impacts of 20 mph speed limits on emissions in different settings. This is provided below.

A3.2 Previous applications and assessments of 20 mph speed limits in other UK locations have focused on reporting the wider implications of such schemes, such as reduced fatal injuries (Bornioli et al., 2020; Grundy et al., 2009), increased modal shift to active travel alternatives (Pilkington et al., 2018; Cairns et al., 2014; Warrington Borough Council, 2010), and decreased health inequalities (Dorling, 2014). The following paragraphs are, however, focused specifically on implications for road traffic emissions due to changes in the speed limit, and no other traffic calming methods.

A3.3 There are numerous ways to estimate emissions from a fleet of vehicles including modelling and measurements. Those discussed here are based on modelling, and can be summarised by the umbrella terms of: average-speed based models and instantaneous (or modal) models.

A3.4 The UK National Atmospheric Emissions Inventory (NAEI) provides the relationship between speed and emission factor for both NOx and $PM_{2.5}$, available at: https://naei.beis.gov.uk/data/ef-transport, which are based on relationships within COPERT[2]. This method is based on the measurement of emissions over both pre-determined drive-cycles in a laboratory, and real-world driving emission measurements, the average speed of which is determined, and corresponding tailpipe emission rate assigned. The drive-cycles are completed for multiple vehicle types, Euro classes, and fuels. Using an average-speed method, for example in models used for Local Air Quality Management, such as this study, would always predict larger emissions by lowering the speed limit from 30 mph to 20 mph due to a decrease in operational engine efficiency. However, this assumes that vehicles are already travelling relatively freely at 30 mph, and would subsequently travel freely at 20 mph, which is unlikely to be the case in an urban environment.

A3.5 Research has shown that prior to the implementation of 20 mph limits in other UK locations, vehicles were, on average, travelling below the 30 mph speed limit, for example, 25.1 mph in Calderdale (Calderdale Council, 2018). After 20 mph limits (sign only) were in place, typically measured speeds only reduced by an incremental amount: 2.7 mph in Bristol (Pilkington et al., 2018), 1.9 mph in Calderdale (Calderdale Council, 2018), and 1.4 mph in Birmingham (Birmingham City Counil, 2018).

[2] COPERT is a software tool developed by the European Environment Agency and is used widely to calculate national emissions from road transport in Europe

A3.6 Furthermore, the average-speed approach neglects driving dynamics, such as short-lived acceleration and deceleration events where large proportions of emissions occur. Direct measurements of vehicle speeds and exhaust emissions have found that acceleration and deceleration events are reduced in magnitude in 20 mph (European equivalent) limit zones, and therefore emissions of NOx and $PM_{2.5}$ reduce (Casanova and Fonseca, 2012).

A3.7 Changes in such dynamics cannot be assessed by the average-speed methodology, but can be by instantaneous emissions models which account for vehicle specific power and engine load. AQC (2014) and Williams and North (2013) applied the AIRE emissions model to assess the potential impacts of 20 mph speed limits. Both studies suggest that lower speed limits have the potential to reduce NOx emissions from road transport through smoother vehicle flows and less overall speed variation, the opposite conclusion than that of the average-speed based methodology.

A3.8 Other local factors are also likely to have an influence on the net change in emissions due to the introduction of a 20 mph speed limit. Most previous studies have used passenger cars to measure or model outcomes, but if the fleet is dominated by HGVs these vehicles are likely to have a different emissions profile with changes to speed and acceleration. Additionally, road gradients also play an important role in vehicle emissions (Kean et al., 2003), but are yet to be fully investigated in relation to changes at lower speeds. Gradient is likely to be a major contributing factor on Upper Stone Street.

A3.9 Overall, it still remains uncertain whether a 20 mph limit is likely to reduce road transport emissions. It is generally accepted that approaches which account for the impacts on overall vehicle flow and frequency of acceleration and deceleration events are likely to be more representative of real-world driving patterns than the average-speed approach (Davis, 2018). However, local factors such as the fleet mix and road gradient are also likely to play an important role in determining net emissions.

A3.10 Therefore, for Upper Stone Street, although there is not clear evidence around the impacts of a 20 mph speed limit, it is judged that it is not likely to worsen air quality, and may provide some benefits, although these are unlikely to be measurable through monitoring.