Epping Forest District Council

Source Apportionment Assessment

November 2021

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Document Control Sheet

Identification	
Client	Epping Forest District Council
Document Title	Source Apportionment Study
Bureau Veritas Ref No.	AIR12173979

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Configuration				
Version	**Date**	**Author**	**Reason for Issue/Summary of Changes**	**Status**
1.0	11/10/21	D Clampin	Issued to client for comment	Draft
2.0	5/11/21	D Clampin	Inclusive of comments	First

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Executive Summary

Purpose of Assessment

Bureau Veritas has been commissioned by Epping Forest District Council (the Council) to complete a Detailed Modelling and Source Apportionment Assessment to support the update of their Air Quality Action Plan (AQAP). Currently there is one Air Quality Management Area (AQMA) within Epping Forest, declared in 2008 as a result of exceedances of the 40 µg/m^3 annual mean and 200 µg/m^3 1-hour objectives for Nitrogen Dioxide (NO_2). This AQMA is located near the B1393/Theydon Road junction at Epping, Bell Common. The aim of this Detailed Modelling Assessment is to increase the Councils' understanding of pollutant concentrations within the Epping Forest District AQMA, in order to provide technical input into their forthcoming AQAP.

The Detailed Modelling Assessment focusses on the road network within and around the Epping Forest AQMA to establish concentrations and determine the sources that contribute to pollutant concentrations within the AQMA. The area was modelled using the advanced atmospheric dispersion model ADMS-Roads (Version 5.0.0.1) and latest emissions from the Emissions Factors Toolkit (Version 10.1), with annual mean NO_2 concentration outputs produced at two discrete receptor locations, and across a receptor grid.

Assessment Findings

The highest annual mean concentration of NO_2 was recorded at R1 with a concentration of 52.2 µg/m^3. This is slightly higher than the adjacent recorded monitoring which recorded 48 µg/m^3 as a result of a slightly lower modelling height and its position relative to the road but still demonstrated an exceedance of the air quality objective limit of 40µg/m^3.

The empirical relationship given in LAQM.TG(16)[1] states that exceedances of the 1-hour mean objective for NO_2 is only likely to occur where annual mean concentrations are 60 µg/m^3 or above at a location of relevant exposure (Table 2-1). Given the NO_2 annual mean concentration recorded at all receptors is below 60 µg/m^3, exceedances of the hourly NO_2 AQS objective are unlikely.

PM_{10} and $PM_{2.5}$ concentrations have also been predicted as part of the modelling assessment. No modelled receptors recorded concentrations in exceedance of either of the annual mean objectives for these pollutants. The highest modelled PM_{10} concentration was 20.6 µg/m^3 at R1. The highest modelled $PM_{2.5}$ concentration was 12.9 µg/m^3 at R1.

Estimated Year of Compliance

Using the recommended method in TG(16), the estimated year of compliance within the AQMA, should no additional measures be put in place, is 2024 and will be below 10% of the AQO by 2026. It should be noted that this estimate is based on assumptions that were correct prior to the COVID-19 pandemic which is likely to affect behaviour and vehicle fleet predictions, so this result should be treated with some caution.

Source Apportionment

To help inform the development of measures as part of a future AQAP, a source apportionment exercise was undertaken to provide an understanding of any potential similarities in vehicle emission contributors within the AQMA. The source apportionment exercise has considered concentrations of oxides of Nitrogen (NO_x) and Particulate Matter measuring 10 microns and below (PM_{10}) and 2.5 microns and below ($PM_{2.5}$).

Petrol Cars were the most prevalent vehicles on the road within the AQMA, 46.6% of all vehicles were petrol cars. The fleet makeup, as determined by the ANPR survey, also indicated that vehicles using High Road Epping were made up of older vehicles than the default fleet assumption within the EFT derived from the National Air Emissions Inventory (NAEI).

The background concentrations show that for NO_x, motorway emissions account for around half of background concentrations.

The NO_x source apportionment exercise demonstrates Diesel Cars and Diesel Light Good Vehicles (LGVs) being the primary contributors to local road NO_x concentrations within the AQMA. The split between overall car, LGV and Heavy Good Vehicles (HGV) emissions was roughly equal with each contributing around a third to total road NOx.

An assessment of queueing traffic showed that, within the AQMA, congestion accounts for 81.9% of NO_x contributions from the road. This is to be expected as the receptors is located adjacent to traffic lights. Should any traffic smoothing measures such as replacing the lights with a roundabout be introduced, this is likely to reduce pollutant concentrations within the AQMA.

PM_{10} and $PM_{2.5}$ concentrations within the AQMA are largely made up of residual background sources. For both pollutants, the greatest road contributor was identified as being Diesel Cars, followed by Petrol cars and Diesel LGVs.

1 Introduction

Bureau Veritas has been commissioned by Epping Forest District Council (the Council) to complete a Source Apportionment Assessment to update their outdated Air Quality Action Plan (AQAP). Currently there is one Air Quality Management Area (AQMA) within Epping Forest, declared as a result of exceedances of the 40 µg/m^3 annual mean and 200 µg/m^3 1-hour objectives for Nitrogen Dioxide (NO_2). This AQMA is located near the B1393/Theydon Road junction at Epping, Bell Common.

In order to provide technical input into an updated AQAP that will cover the area within the existing AQMA boundary, the air quality modelling has been completed using 2019 traffic data, 2019 monitoring data and the latest Local Air Quality Management (LAQM) tools. This report details the findings of this updated analysis, and provides recommendation on matters related to NO_2 exceedances, in order to inform the update of the AQAP.

1.1 Scope of Assessment

It is the general purpose and intent of this assessment to determine, with reasonable certainty, the magnitude and geographical extent of any exceedances of the AQS objectives for NO_2, enabling the Council to provide for a focused consideration on updating measures as part of the revision of the AQAP.

The following are the objectives of the assessment:

- To assess the air quality at selected locations (“receptors”) representative of worst-case exposure relative to the averaging period of focus (i.e. annual objective - façades of the existing residential units), based on modelling of emissions from road traffic on the local road network;
- To establish the spatial extent of any likely exceedances of the UK annual mean NO_2 AQS objective limit, and to identify the spatial extent of any areas within 10%;
- To establish the required reduction in emissions to comply with the UK AQS objectives; and
- To determine the relative contributions of various source types to the overall pollutant concentrations within the new AQMA, through source apportionment, in order to inform an updated AQAP.

The approach adopted in this assessment to assess the impact of road traffic emissions on air quality utilised the atmospheric dispersion model ADMS-Roads version 5.0.0.1, focusing on emissions of oxides of nitrogen (NO_x), which comprise of nitric oxide (NO) and nitrogen dioxide (NO_2). Particulate Matter (PM_{10} and $PM_{2.5}$) emissions have also been considered for completeness.

In order to provide consistency with the Council’s own work on air quality, the guiding principles for air quality assessments, as set out in the latest guidance provided by Defra for air quality assessment (LAQM.TG(16))[1], have been used.

[1] LAQM Technical Guidance LAQM.TG(16) – April 2021. Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland.

2 Air Quality – Legislative Context

2.1 Air Quality Strategy

The importance of existing and future pollutant concentrations can be assessed in relation to the national air quality standards and objectives established by Government. The Air Quality Strategy[2] (AQS) provides the over-arching strategic framework for air quality management in the UK and contains national air quality standards and objectives established by the UK Government and Devolved Administrations to protect human health. The air quality objectives incorporated in the AQS and the UK Legislation are derived from Limit Values prescribed in the EU Directives transposed into national legislation by Member States.

The CAFE (Clean Air for Europe) programme was initiated in the late 1990s to draw together previous directives into a single EU Directive on air quality. The CAFE Directive[3] has been adopted and replaces all previous air quality Directives, except the 4th Daughter Directive[4]. The Directive introduces new obligatory standards for $PM_{2.5}$ for Government but places no statutory duty on local government to work towards achievement of these standards.

The Air Quality Standards (England) Regulations[5] 2010 came into force on 11 June 2010 in order to align and bring together in one statutory instrument the Government's obligations to fulfil the requirements of the new CAFE Directive.

The objectives for ten pollutants – benzene (C_6H_6), 1,3-butadiene (C_4H_6), carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter (PM_{10} and $PM_{2.5}$), ozone (O_3) and Polycyclic Aromatic Hydrocarbons (PAHs), have been prescribed within the AQS[2].

The AQS objectives apply at locations outside buildings or other natural or man-made structures above or below ground, where members of the public are regularly present and might reasonably be expected to be exposed to pollutant concentrations over the relevant averaging period. Typically, these include residential properties and schools/care homes for long-term (i.e. annual mean) pollutant objectives and high streets for short-term (i.e. 1-hour) pollutant objectives. Table 2-1 taken from LAQM TG(16)[1] provides an indication of those locations that may or may not be relevant for each averaging period.

This assessment focuses on NO_2 due to the significance this pollutant holds within the Council's administrative area - evidenced by the declared AQMA. Moreover, as a result of traffic pollution the UK has failed to meet the EU Limit Values for this pollutant by the 2010 target date. As a result, the Government has had to submit time extension applications for compliance with the EU Limit Values, which has since passed and its continued failure to achieve these limits is currently giving rise to infraction procedures being implemented. The UK is not alone as the challenge of NO_2 compliance at EU level includes many other Member States.

In July 2017, the Government published its plan for tackling roadside NO_2 concentrations[6], to achieve compliance with EU Limit Values. This sets out Government policies for bringing NO_2 concentrations within statutory limits in the shortest time period possible. Furthermore, the Clean Air Strategy was published in 2019, which outlines how the UK will meet international commitments

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[2] Defra (2007), The Air Quality Strategy for England, Scotland, Wales and Northern Ireland.

[3] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe.

[4] Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic hydrocarbons in ambient air.

[5] The Air Quality Standards Regulations (England) 2010, Statutory Instrument No 1001, The Stationary Office Limited.

[6] Defra, DfT (2017), UK plan for tackling roadside nitrogen dioxide concentrations

to significantly reduce emissions of five damaging air pollutants by 2020 and 2030 under the adopted revised National Emissions Ceiling Directive (NECD).

The AQS objectives for these pollutants are presented in Table 2-2.

Table 2-1 – Examples of where the Air Quality Objectives should apply

Averaging Period	Objectives should apply at:	Objectives should generally not apply at:
Annual mean	All locations where members of the public might be regularly exposed. Building facades of residential properties, schools, hospitals, care homes etc.	Building facades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term
24-hour mean and 8-hour mean	All locations where the annual mean objectives would apply, together with hotels. Gardens or residential properties[1].	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
1-hour mean	All locations where the annual mean and 24 and 8-hour mean objectives would apply. Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where the public might reasonably be expected to spend one hour or more. Any outdoor locations at which the public may be expected to spend one hour or longer.	Kerbside sites where the public would not be expected to have regular access.
15-minute mean	All locations where members of the public might reasonably be expected to spend a period of 15 minutes or longer.	

Note [1] For gardens and playgrounds, such locations should represent parts of the garden where relevant public exposure is likely, for example where there is seating or play areas. It is unlikely that relevant public exposure would occur at the extremities of the garden boundary, or in front gardens, although local judgement should always be applied.

Table 2-2 – Relevant AQS Objectives for the Assessed Pollutants in England

Pollutant	AQS Objective	Concentration Measured as:	Date for Achievement
Nitrogen dioxide (NO_2)	200 µg/m³ not to be exceeded more than 18 times per year	1-hour mean	31st December 2005
	40 µg/m³	Annual mean	31st December 2005
Particles (PM_{10})	50 µg/m³ not to be exceeded more than 35 times a year	24-hour mean	31st December 2004
	40 µg/m³	Annual Mean	31st December 2004
Particles ($PM_{2.5}$)	25 µg/m³	Annual Mean	2020

2.2 Local Air Quality Management (LAQM)

Part IV of the Environment Act 1995[7] places a statutory duty on local authorities to periodically review and assess air quality within their area, and determine whether they are likely to meet the AQS objectives set down by Government for a number of pollutants – a process known as Local Air Quality Management (LAQM). The AQS objectives that apply to LAQM are defined for seven pollutants: benzene, 1,3-butadiene, CO, Pb, NO_2, SO_2 and Particulate Matter.

Local Authorities were formerly required to report on all of these pollutants, but following an update to the regime in 2016, the core of LAQM reporting is now focussed around the objectives of three pollutants: NO_2, PM_{10} and SO_2. Where the results of the Review and Assessment process highlight that problems in the attainment of the health-based objectives pertaining to the above pollutants will arise, the authority is required to declare an AQMA – a geographic area defined by high concentrations of pollution and exceedances of health-based standards.

The areas in which the AQS objectives apply are defined in the AQS as locations outside (i.e. at the façade) of buildings or other natural or man-made structures above or below ground where members of the public are regularly present and might reasonably be expected to be exposed to pollutant concentrations over the relevant averaging period of the AQS objective.

Following any given declaration, the Local Authority is subsequently required to develop an Air Quality Action Plan (AQAP), which will contain measures to address the identified air quality issue and bring the location into compliance with the relevant objective as soon as possible.

One of the objectives of the LAQM regime is for local authorities to enhance integration of air quality into the planning process. Current LAQM Policy Guidance[8] recognises land-use planning as having a significant role in term of reducing population exposure to elevated pollutant concentrations. Generally, the decisions made on land-use allocation can play a major role in improving the health of the population, particularly at sensitive locations – such as schools, hospitals and dense residential areas.

[7] http://www.legislation.gov.uk/ukpga/1995/25/part/IV
[8] Local Air Quality Management Policy Guidance LAQM.PG(16). April 2016. Published by Defra in partnership with the Scottish Government, Welsh Assembly Government and Department of the Environment Northern Ireland.

3 Review and Assessment of Air Quality Undertaken by the Council

3.1 Local Air Quality Management

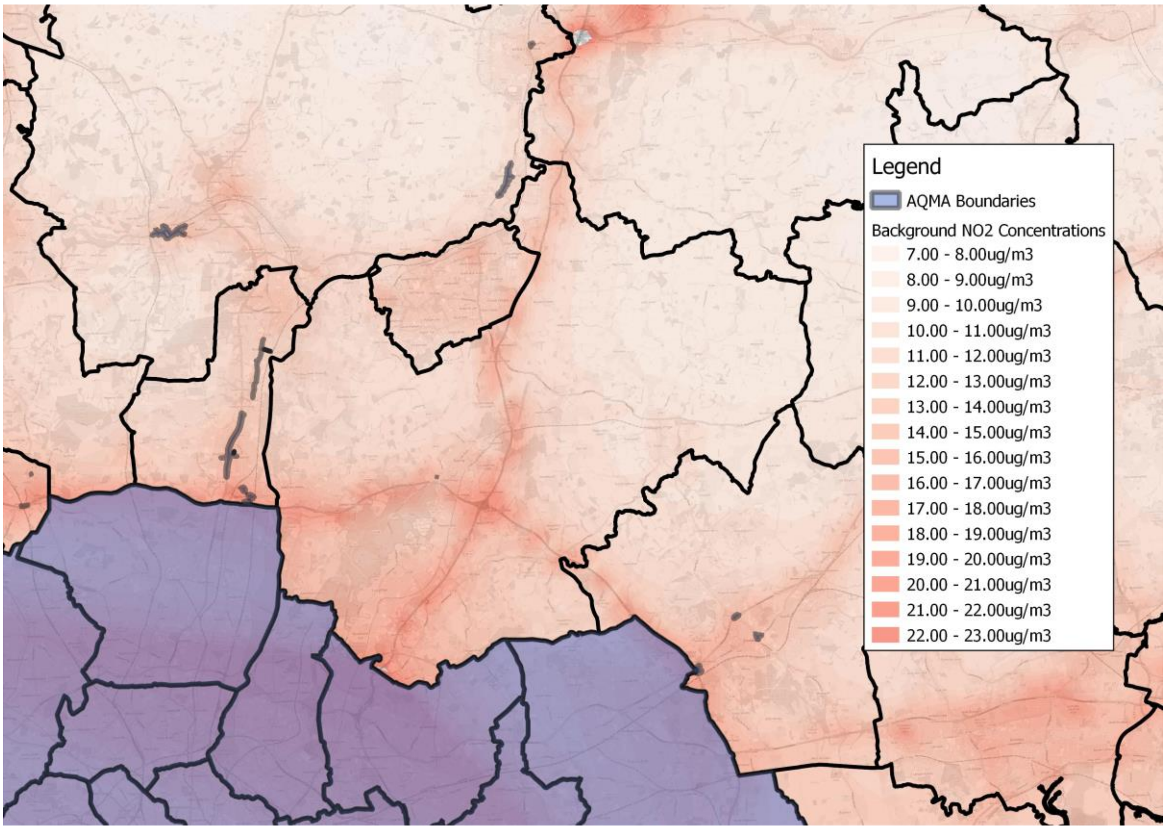
The Council currently has one AQMA (AQMA Epping Forest District Council No.2 2012), declared in 2008 for the exceedance of the NO_2 annual mean UK AQS objective of 40 µg/m^3 and 1-hour mean objective. The AQMA, as shown in Figure 3-2, is located near the B1393/Theydon Road junction at Epping, Bell Common.

The most recent AQAP for this AQMA was published in 2012. Monitoring within the borough has shown that concentrations of NO_2 are generally declining. In the most recently available Annual Status Report (ASR), the only monitored exceedance of the NO_2 annual mean AQS objective was within the existing AQMA.

Every local authority that has an active AQMA, is required under Part IV of the Environment Act 1995 and Part III of the Environment (NI) Order 2002 to provide an AQAP as a means to address the areas of poor air quality that have been identified within the AQMA. Nonetheless, the specifications for this tender only detail the requirement for source apportionment study to be undertaken. As a result, the proposal herein has focussed on the proposed scope for a source apportionment study.

From an initial review of background annual mean NO_2 concentrations as shown in Figure 3-1, the M25 and M11 corridors are key contributors to pollutant concentrations within the district as pictured below, the darker red highlighting the higher concentrations.

Figure 3-1 – Background NO_2 Concentrations in EFDC



3.2 Review of Air Quality Monitoring

3.2.1 Local Air Quality Monitoring

During 2019, the latest available year of baseline monitoring, the Council's non-automatic monitoring programme consisted of recording NO_2 concentrations using a network of passive diffusion tubes at 42 sites across Epping Forest District. No automatic (continuous) monitoring took place within the District during 2019.

Between 2015 and 2020 there have been exceedances of the annual mean AQS objective at Sites; 1, 3 and 11 as set out in the latest ASR available for EFDC[9]. During 2019, there was only one recorded exceedance of the annual mean AQS objective for NO_2 at Site 3: Bell Vue which monitored 48 µg/m³.

The details of the diffusion tube monitoring within Epping for 2019 used for the purpose of the modelling assessment are shown in Table 3-1, and monitored concentrations for 2015-2019 are presented in Table 3-2.

Table 3-1 – Epping Forest District Council LAQM Diffusion Tube Monitoring

Site ID	Site Location	Site Type	In AQMA	OS Grid Ref X	OS Grid Ref Y	Monitoring Height (m)
3	Epping: Bell Vue	Roadside	Y	544928	201281	2
33	Epping: Copped Hall, Bell Common	Roadside	N	544709	201139	2

Table 3-2 – Relevant Epping Forest District Council LAQM Diffusion Tube Monitoring

Site ID	Valid Data Capture for 2019 (%)	Annual Mean NO_2 Concentration (µg/m³)				
		2015	2016	2017	2018	2019
1	100.0	39	**48**	**45**	39	39
11	100.0	**45**	**42**	39	39	34
3	100.0	**63**	**64**	**64**	**55**	**48**
33	75.0	-	-	-	-	31
Notes All values reported are bias adjusted as required and represent the monitoring location (i.e. absence of distance correction calculations)						

The only monitored exceedance of the annual average NO_2 limit was at location 3 which has recorded an exceedance every year since 2015. Monitoring at site 33 commenced in 2019 so there are no historical data available for this site.

The empirical relationship given in LAQM.TG(16)[1] states that exceedances of the 1-hour mean objective for NO_2 is only likely to occur where annual mean concentrations are 60 µg/m³ or above at a location of relevant exposure (Table 2-1). This indicates that an exceedance of the 1-hour mean objective is unlikely to have occurred at these sites past 2017 at location 3.

Epping Forest District Council AQMA boundary and the relevant 2019 council-operated monitoring locations are presented in Figure 3-2.

[9] https://www.eppingforestdc.gov.uk/wp-content/uploads/2021/02/2020-Annual-Status-Report.pdf

Figure 3-2 – Epping Forest District Council AQMA Boundary

3.3 Defra Background Concentration Estimates

Defra maintains a nationwide model of existing and future background air pollutant concentrations at a 1 km x 1 km grid square resolution. This data includes annual average concentration for NO_x, NO_2, PM_{10} and $PM_{2.5}$, using a base year of 2018 (the year in which comparisons between modelled and monitoring are made)[10]. The model used to determine the background pollutant levels is semi-empirical in nature: it uses the National Atmospheric Emissions Inventory (NAEI) emissions to model the concentrations of pollutants at the centroid of each 1km grid square, but then calibrates these concentrations in relation to actual monitoring data.

Pollutant background concentrations used for the purposes of this assessment have been obtained from the Defra supplied background maps for the relevant 1 km x 1 km grid squares covering the modelled domain for the year 2019. The relevant annual mean background concentration will be added to the predicted annual mean road contributions in order to predict the total pollutant concentration at each receptor location. The total pollutant concentration can then be compared against the relevant AQS objective to determine the event of an exceedance.

The Defra mapped background concentrations for base year of 2019, which cover the modelled domain, are presented in Table 3-3. All of the mapped background concentrations presented are well below the respective annual mean AQS objectives.

Table 3-3 – Defra Background Pollutant Concentrations in the AQMA

Grid Square (E,N)	2019 Annual Mean Background Concentration (µg/m^3) [1]			
	Total Background NO_x	Total Background NO_2	Total Background PM_{10}	Total Background $PM_{2.5}$
544500, 201500	25.2	18.1	17.9	11.1
Note: [1] Values obtained from the 2019 Defra Mapped Background estimates for the relevant 1km x 1km grid squares covering the modelled domain				

[10] Defra Background Maps (2019), available at https://uk-air.defra.gov.uk/data/laqm-background-home

4 Assessment Methodology

To predict pollutant concentrations of road traffic emissions the atmospheric model ADMS Roads version 5.0.0.1 was used to model a 2019 baseline scenario. The guiding principles for air quality assessments as set out in the latest guidance and tools provided by Defra for air quality assessment (LAQM.TG(16)[1] have been used.

The approach used in this assessment has been based on the following:

- Prediction of NO_2 concentrations at the two existing receptors within the AQMA and comparison with the relevant AQS objectives;
- Quantification of relative NO_2 contribution of sources to overall NO_2 pollutant concentration; and
- Determination of the geographical extent of any potential exceedances in regard to the existing AQMA boundary.

4.1 Traffic Inputs

Traffic flows and vehicle class compositions for the 2019 baseline scenario were taken from the following sources:

- Epping High Road - Provided by Epping Forest District Council as ANPR data allowing for detailed understanding of vehicle splits at the junction of the AQMA for 2019.
- M25 - The Department for Transport (DfT) traffic count point database for traffic for 2019.

Traffic speeds were modelled at either the relevant speed limit for each road or, where available, monitored vehicle speeds provided. Where appropriate, vehicle speeds have been reduced in accordance with LAQM TG(16)[1] to simulate queues at junctions, traffic lights and other locations where queues or slower traffic are known to be an issue. Congestion has been modelled at the junction by the AQMA by modelling the traffic speed at 5 km/h.

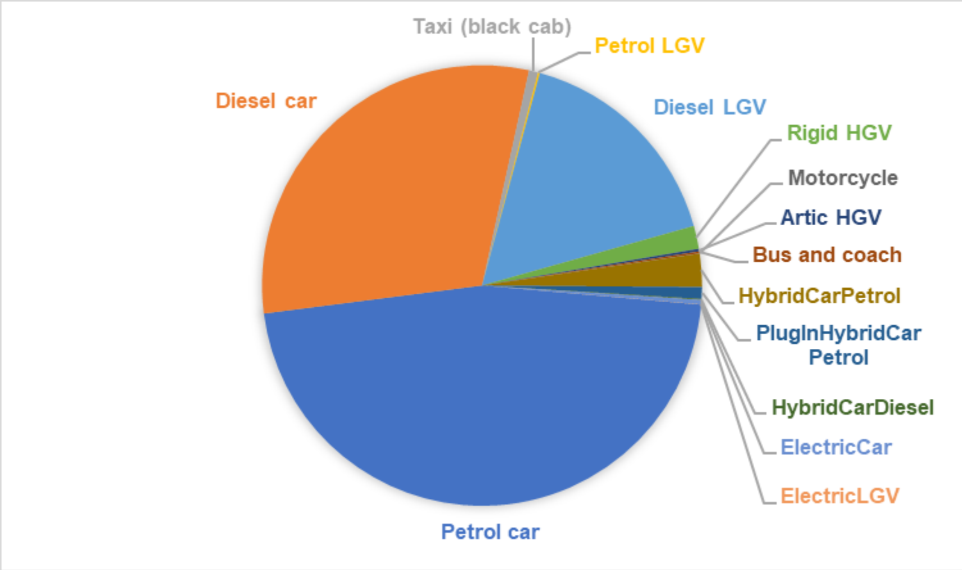
The Emissions Factors Toolkit (EFT) version 10.1 developed by Defra[11] has been used to determine vehicle emission factors for input into the ADMS-Roads model, based upon the traffic data inputs.

Details of the traffic flows used in this assessment including vehicle splits and Euro Class distribution are provided in Table B. 1 of the Appendices. The modelled road network is presented in Figure 4-4.

The traffic data provided by Aecom has been provided broken down by vehicle type and Euro class. The split of each vehicle type is shown in Figure 4-1below.

[11] Defra, Emissions Factors Toolkit. https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html

Figure 4-1 – Proportion of Vehicles on Epping High Road



A comparison of the observed Euro vehicles and the default UK fleet has been undertaken and is included below:

Figure 4-2 – Comparison of Observed ANPR data with UK Default Vehicle Fleet – Cars and LGVs

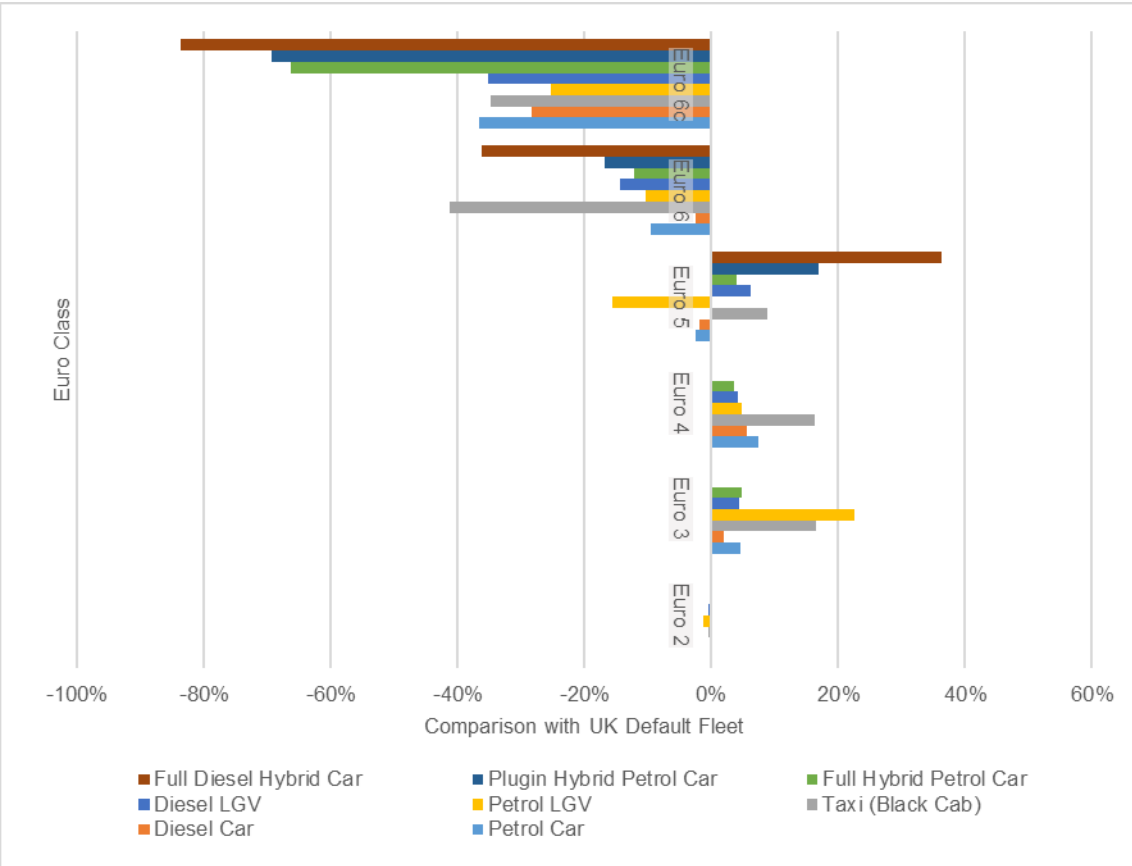
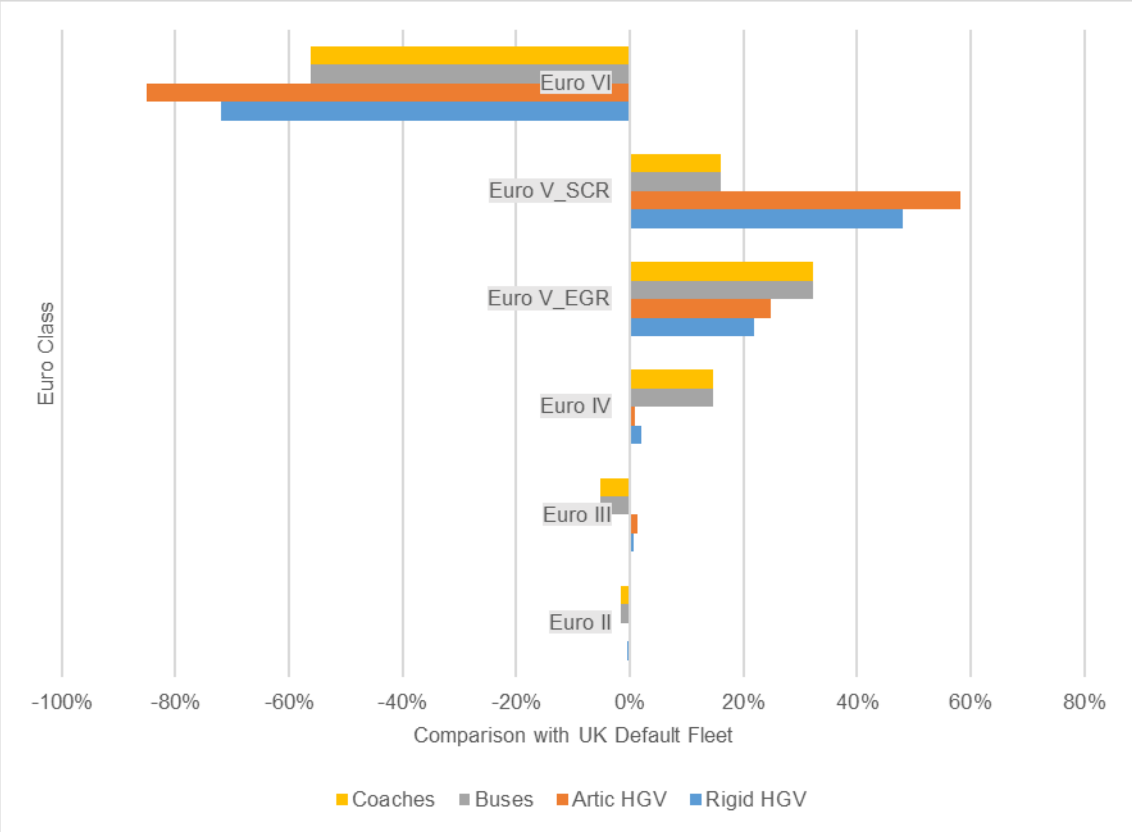


Figure 4-3 – Comparison of Observed ANPR data with UK Default Vehicle Fleet – HGVs



As shown above, the observed fleet typically contains more older vehicles (Euro 5 and below) than the default UK fleet and fewer new Euro 6 vehicles for all vehicle types.

The AQMA is located within 250 m of Bell Common Tunnel on the M25. Emissions from this tunnel will be considered using the Roads Tunnel module within ADMS Roads.

4.2 Sensitive Receptors

A total of two discrete receptors were included within the assessment to represent locations of relevant exposure at the two properties within the AQMA. Details of the receptors are presented within Table 4-1 and their locations are illustrated in Figure 4-5.

A receptor was included at ground floor at both properties within the AQMA.

Concentrations were also modelled across a regular gridded area, at a standardised ‘breathing zone’ height of 1.5 m, covering the full extent of the model domain. The intelligent gridding option was applied to the ADMS-roads model meaning additional points were added at locations close to the roads for greater output resolution.

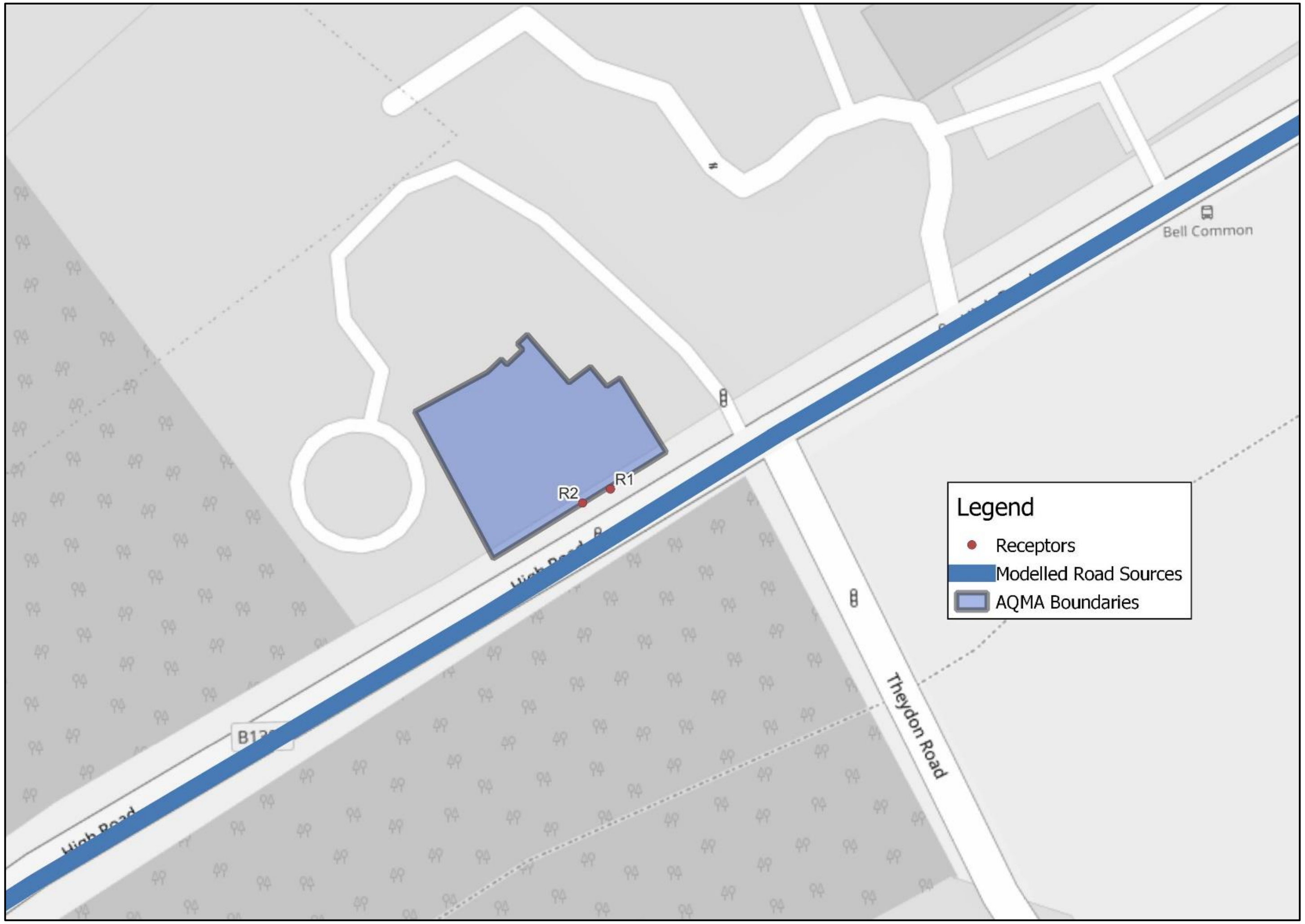
Table 4-1 – Discrete Receptor Locations

Receptor ID	X	Y	Height
R1	544928	201281	1.5
R2	544925	201279	1.5

Figure 4-4 – Modelled Road Network

Base map and data from OpenStreetMap and OpenStreetMap Foundation (CC-BY-SA). © https://www.openstreetmap.org and contributors.

Figure 4-5 – Modelled Receptors



4.3 General Model Inputs

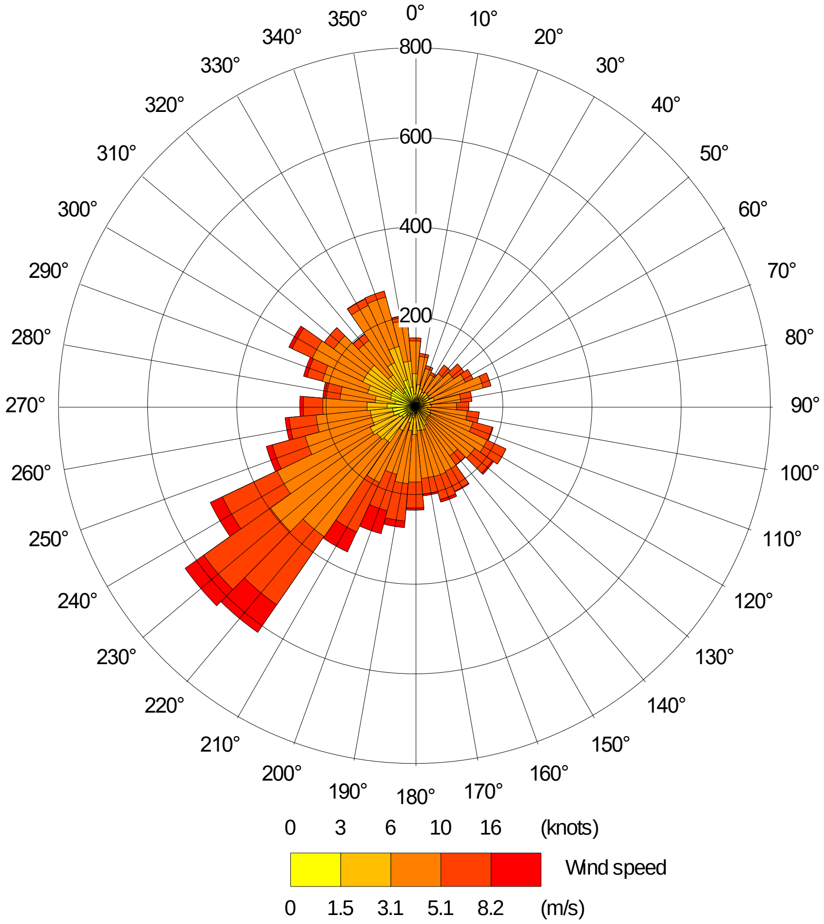
A site surface roughness value of 0.5 m was entered into the ADMS-roads model, consistent with the parkland/open suburbia. In accordance with CERC's ADMS Roads User Guide[12], a minimum Monin-Obukhov length of 10 m was used for the ADMS Road model to reflect the topography of the model domain.

One year of hourly sequential meteorological data from a representative synoptic station is required by the dispersion model. 2019 meteorological data from Stansted Airport weather station has been used in this assessment. The station is located approximately 23 km north of the AQMA and is considered representative of the meteorological conditions experienced throughout the borough. A surface roughness value of 0.5 m was used for the area surrounding the meteorological station, representative of the Stansted airfield location and surrounding buildings.

Within the modelled domain a review of topography was undertaken to establish whether it was required to include modelled road gradients. Following this review, it was considered to not be required.

A wind rose for this site for the year 2019 is shown in Figure 4-6.

Figure 4-6 – Wind rose for Stansted Data 2019



[12] CERC (2020), ADMS-Roads User Guide Version 5

Most dispersion models do not use meteorological data if they relate to calm winds conditions, as dispersion of air pollutants is more difficult to calculate in these circumstances. ADMS-Roads treats calm wind conditions by setting the minimum wind speed to 0.75 m/s. It is recommended in LAQM.TG(16)[1] that the meteorological data file be tested within a dispersion model and the relevant output log file checked, to confirm the number of missing hours and calm hours that cannot be used by the dispersion model. This is important when considering predictions of high percentiles and the number of exceedances. LAQM.TG(16)[1] recommends that meteorological data should have a percentage of usable hours greater than 85%. If the data capture is less than 85% short-term concentration predictions should be expressed as percentiles rather than as numbers of exceedances. The 2019 meteorological data from Stansted includes 8,666 lines of usable hourly data out of the total 8,760 for the year, i.e. 98.9% usable data. This is therefore suitable for the dispersion modelling exercise.

4.4 Bell Common Tunnel

To account for the emissions from Bell Common Tunnel, the Road Tunnel Module within ADMS has been used. This involves creating an additional input file to account for emissions from both the entrance and exit of the Tunnel. The inputs for Bell Common Tunnel are included below. This has been completed in line with the CERC ADMS User Guide[12].This module has been validated using monitoring data gathered at Bell Common tunnel.

Table 4-2 – Additional Input File Tunnel Inputs

Name	Bell Common Tunnel
X1	544555.3
Y1	201054.4
X2	545066.2
Y2	200992.4
NumTrafficDir	2
BoreDepth1	8
PortalBaseElev1	0
OutflowRoad1	M25 E of BCT
OutflowWidth1	32
OutflowWall1	No
BoreDepth2	8
PortalBaseElev2	0
OutflowRoad2	M25 W of BCT
OutflowWidth2	32
OutflowWall2	No

4.5 Model Outputs

The background pollutant values discussed in Section 3.3 have been used in conjunction with the concentrations predicted by the ADMS-Roads model to calculate predicted total annual mean concentrations of NO_x.

For the prediction of annual mean NO_2 concentrations for the modelled scenarios, the output of the ADMS-Roads model for road NO_x contributions has been converted to total NO_2 following the methodology in LAQM.TG(16)[1], using the NO_x to NO_2 conversion tool developed on behalf of Defra. This tool also uses the total background NO_x and NO_2 concentrations. This assessment has used version 8.1 (August 2020) of the NO_x to NO_2 conversion tool[13]. The road contribution is then added to the appropriate NO_2 background concentration value to obtain an overall total NO_2 concentration.

The same process has been applied to provide annual mean concentrations for PM_{10} and $PM_{2.5}$. As no Particulate Matter monitoring was available within the study area, the verification factor used for NO_2 has been applied.

In addition to annual mean concentrations, NO_x source apportionment was carried out for the following vehicle classes:

- Cars
- Taxis
- Light-Goods Vehicles (LGVs);
- Rigid Heavy-Goods Vehicles (HGVs)
- Articulated HGVs;
- Bus and Coaches;
- Motorcycles;
- Full Hybrid Petrol Cars;
- Plug-in Hybrid Petrol Cars;
- Full Hybrid Diesel Cars;
- Battery Electric Vehicle (EV) Cars; and,
- Battery EV LGVs.

Verification of the ADMS-Roads assessment has been undertaken using a number of local authority diffusion tube monitoring locations. All NO_2 results presented in the assessment are those calculated following the process of model verification. Full details of the verification process are provided in Appendix A – ADMS Model Verification.

[13] Defra NO_x to NO_2 Calculator (2020), available at https://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc

4.6 Uncertainty

Due to the number of inputs that are associated with the modelling of the study area there is a level of uncertainty that has to be taken into account when drawing conclusions from the predicted concentrations of NO_2. The predicted concentrations are based upon the inputs of traffic data, background concentrations, emission factors, street canyon calculations, meteorological data, modelling terrain limitations and the availability of monitoring data from the assessment area(s).

4.7 Uncertainty in NO_x and NO_2 Trends

Recent studies have identified historical monitoring data within the UK that shows a disparity between measured concentration data and the projected decline in concentrations associated with emission forecasts for future years[14]. Ambient concentrations of NO_x and NO_2 have shown two distinct trends over the past twenty-five years: (1) a decrease in concentrations from around 1996 to 2002/04, followed by (2) a period of more stable concentrations from 2002/04 rather than the further decline in concentrations that was expected due to the improvements in vehicle emissions standards.

The reason for this disparity is related to the actual on-road performance of vehicles, in particular diesel cars and vans, when compared with calculations based on the Euro emission standards. Preliminary studies suggest the following:

- NO_x emissions from petrol vehicles appear to be in line with current projections and have decreased by 96% since the introduction of 3-way catalysts in 1993;
- NO_x emissions from diesel cars, under urban driving conditions, do not appear to have declined substantially, up to and including Euro 5. There is limited evidence that the same pattern may occur for motorway driving conditions; and
- NO_x emissions from HDVs equipped with Selective Catalytic Reduction (SCR) are much higher than expected when driving at low speeds.

This disparity in the historical national data highlights the uncertainty of future year projections of both NO_x and NO_2.

Defra and the Devolved Administrations have investigated these issues and have since published updated versions of the EFT that utilise COPERT 5 emission factors, which may go some way to addressing this disparity, but it is considered likely that a gap still remains. This assessment has used the latest EFT version 10.1 and associated tools published by Defra to help minimise any associated uncertainty when forming conclusions from the results.

All tools used within the modelling process and baseline year of assessment used are based on assumptions prior to the COVID-19 pandemic. All assumptions made are based on the best understanding at the time of writing but there is the potential for behaviours to change in future as a result of a shift towards more flexible working or changes in uptake of newer vehicles.

[14] Carslaw, D, Beevers, S, Westmoreland, E, Williams, M, Tate, J, Murrells, T, Steadman, J, Li, Y, Grice, S, Kent, Aand Tsagatakis, I. 2011, Trends in NO_x and NO_2 emissions and ambient measurements in the UK, prepared for Defra, July 2011.

5 Results

5.1 Modelled Concentrations

5.1.1 Baseline 2019 NO_2 Concentrations

The assessment has considered emissions of NO_2 from road traffic at the two existing receptor locations within the AQMA.

Table 5-1 provides a summary of the modelled receptors.

Table 5-1 – Summary of 2019 Modelled Receptor Results NO_2

Receptor ID	Modelled Annual Mean Concentration		
	NO_2	PM_{10}	$PM_{2.5}$
R1	52.2	20.6	12.9
R2	50.5	20.5	12.9
AQO	**40**	**40**	**20**

The modelled NO_2 results are slightly higher than the monitored concentration as a result of the difference in heights modelled and their positions relative to the road. The monitoring is located at 2 m height and the receptors at 1.5 m to represent typical ground floor windows.

Modelled concentrations of both PM_{10} and $PM_{2.5}$ are below the relevant national objectives.

Short Term

The empirical relationship given in LAQM.TG(16)[1] states that exceedances of the 1-hour mean objective for NO_2 is only likely to occur where annual mean concentrations are 60 µg/m^3 or above at a location of relevant exposure (Table 2-1). Given the NO_2 annual mean concentration recorded at all receptors is below 60 µg/m^3, exceedances of the hourly NO_2 AQS objective are unlikely.

Contour Plots

Modelled contour plots for total NO_2, PM_{10} and $PM_{2.5}$ annual mean concentrations are included below inclusive of both road and background concentrations at the modelled study area. Where there are exceedances of the relevant objective for NO_2 these areas are highlighted in green.

The contour plot is representative of gridded output from the ADMS model showing how the model has dispersed pollutants based on the sources input. This shows the spatial extent of pollutant concentrations as assumed in the model. The contour plots are inclusive of the model outputs and background concentrations and are subject to the same assumptions around verification and conversion from NO_x to NO_2.

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Figure 5-1 – Annual Mean NO_2 Concentration Isopleth

Figure 5-2 – Annual Mean PM_{10} Concentration Isopleth

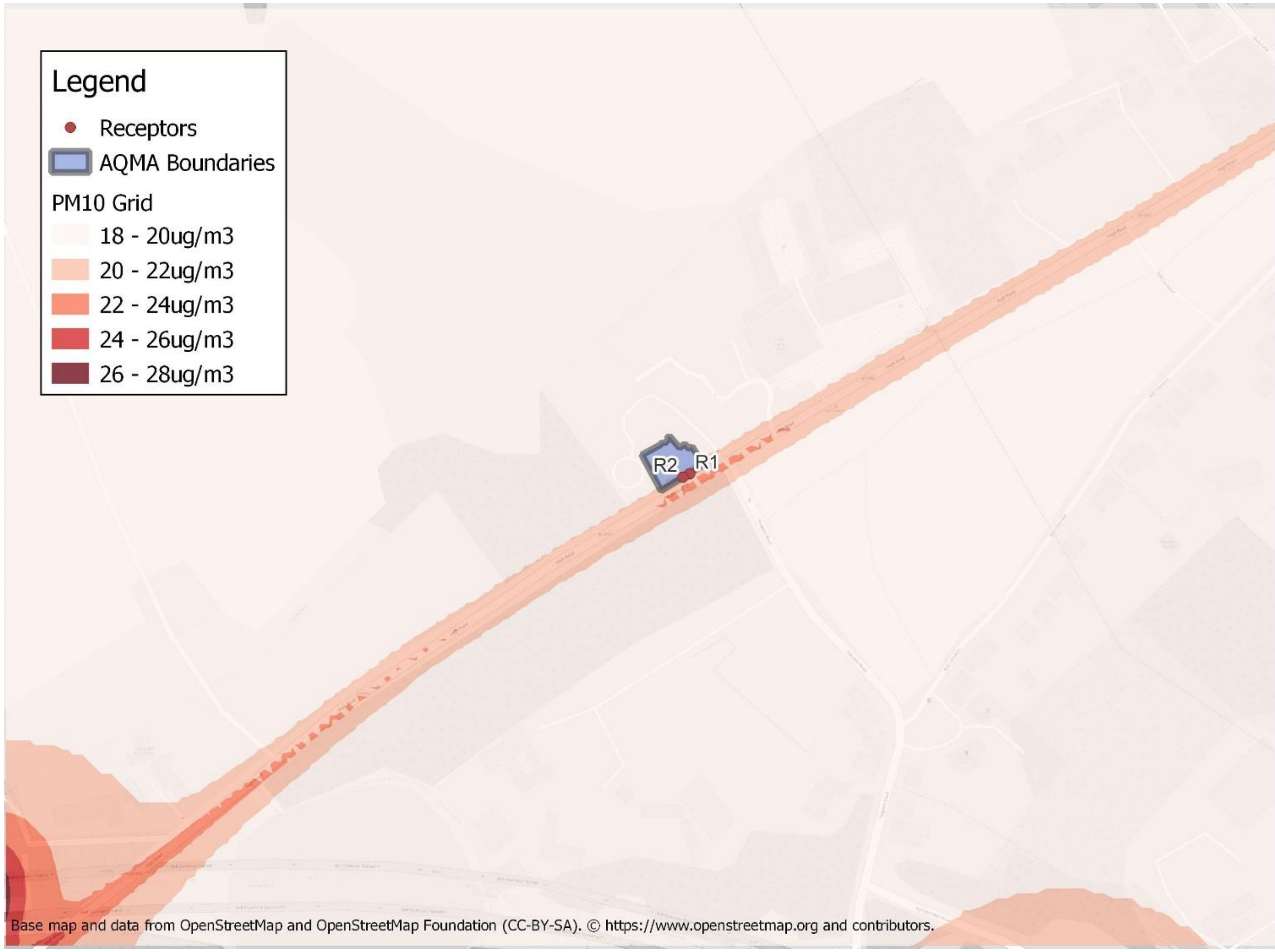


Figure 5-3 – Annual Mean $PM_{2.5}$ Concentration Isopleth

5.1.2 Required Reduction in Emissions

In line with the methodology presented in Box 7.6 of TG(16)[1], the necessary reduction in Road NO_x and NO_2 emissions required to bring the current AQMA into compliance is calculated below, as shown in Table 5-2. This has been completed at the maximum annual mean concentration location, either monitored or modelled, for the existing AQMA. The TG(16) procedure calculates the required reduction of road NO_x to achieve a total NO_2 concentration of 40 µg/m^3.

Table 5-2 – Required Reduction in NO_x and NO_2

Metric	Value (Concentrations as µg/m^3)
Worst-Case Relevant Exposure NO_2 Concentration	52.2
Equivalent NO_x Concentration	99.1
Background NO_x	25.2
Background NO_2	18.1
Road NO_x - Current	73.9
Road NO_2 - Current	34.1
Road NO_x - Required (to achieve NO_2 concentration of 39.9 µg/m^3)	44.5
Road NO_2 - Required (to achieve NO_2 concentration of 39.9 µg/m^3)	21.8
Required Road NO_x Reduction	29.4
Required Road NO_2 Reduction	12.3
Required % Reduction NOx	39.8%

5.2 Estimated Year of Compliance

Following the identification of exceedances of the AQS objectives, it is useful to provide an estimate of the year by which concentrations at the identified locations of exceedances will become compliant with the relevant AQS objective. This is initially provided below assuming only the trends for future air quality, as currently predicted by Defra, are realised which should be treated with caution as it is expected that these will change as a result of the COVID-19 pandemic. The implementation of specific intervention measures to mitigate the local air quality issues, as are currently being developed by the Council within a revised AQAP, would then be considered most likely to bring forwards the estimated date of compliance.

Following the methodology outlined in LAQM.TG(16)[1] paragraph 7.70 onward, the year by which concentrations at the identified locations of exceedances will become compliant with the NO_2 annual mean AQS objective has been estimated. This has been completed using the predicted modelled NO_2 concentrations from the 2019 Base scenario.

As a worst-case approach, the projection is based upon the monitoring from 2019 predicted as having the maximum annual mean NO_2 concentration at R1. The appropriate roadside NO_2 projection factors, as provided on the LAQM Support website[15], are then applied to this

[15] https://laqm.defra.gov.uk/tools-monitoring-data/roadside-no2-projection-factor.html

concentration value to ascertain the estimated NO_2 annual mean reduction per annum, and hence the anticipated year of compliance. In this case, roadside projection factors for 'Rest of UK (HDV <10%)' have been applied, consistent with the receptor location.

The projected NO_2 annual mean concentrations following the above approach are presented in Table 5-3.

Table 5-3 – Projected Annual Mean NO_2 Concentrations

Receptor 1							
2019 Annual Mean Concentration (µg/m^3)	Predicted Annual Mean Concentration (µg/m^3)						
	2020	2021	2022	2023	2024	2025	2026
52.2	**49.6**	**46.8**	**44.2**	**41.9**	39.7	37.6	35.8

In **bold**, exceedance of the NO_2 annual mean AQS objective of 40µg/m^3
Vehicle Adjustment Factor = Rest of UK (HDV <10%)

Table 5-3 indicates that the first year by which Receptor 1 will be exposed to a concentration below the annual mean NO_2 AQS objective will be 2024 at the very earliest. Concentrations are expected to be below 10% of the annual mean NO_2 AQS objective at the very earliest by 2026.

It should be noted that these calculations are made based on assumptions which were correct prior to the COVID-19 pandemic and so the results should be treated with caution.

5.3 Source Apportionment

5.3.1 Background Source Apportionment

The Defra maps provide high level source apportionment for a number of different emissions sources. For the background map square within which the AQMA is located the breakdown of sources is shown below for NO_x, PM_{10} and $PM_{2.5}$.

'Other' sources are defined as per the Background Maps user guide as 'ships, off-road and other emissions. 'Point Sources' are those which come are defined as emissions of a known amount from a known location (e.g. a power station) but do not fall under the 'Industry' source category.

Secondary PM is defined as any inorganic and organic aerosol sources of particulate matter and 'Residual + Salt is inclusive of Sea Salt, calcium and iron rich dusts and regional primary PM and residual non-characterised sources.

Table 5-4 – NO_x Background Source Apportionment

	Motorway	Trunk Road	Primary Road	Minor Road	Industry	Domestic	Aircraft	Rail	Other	Point Sources	Rural
NO_x Concentration (µg/m³)	11.0	<0.1	1.6	1.5	1.1	1.4	<0.1	<0.1	0.4	0.6	7.7
Percent of Background NO_x	43.4	0.1	6.2	6.1	4.3	5.5	<0.1	0.2	1.5	2.2	30.5

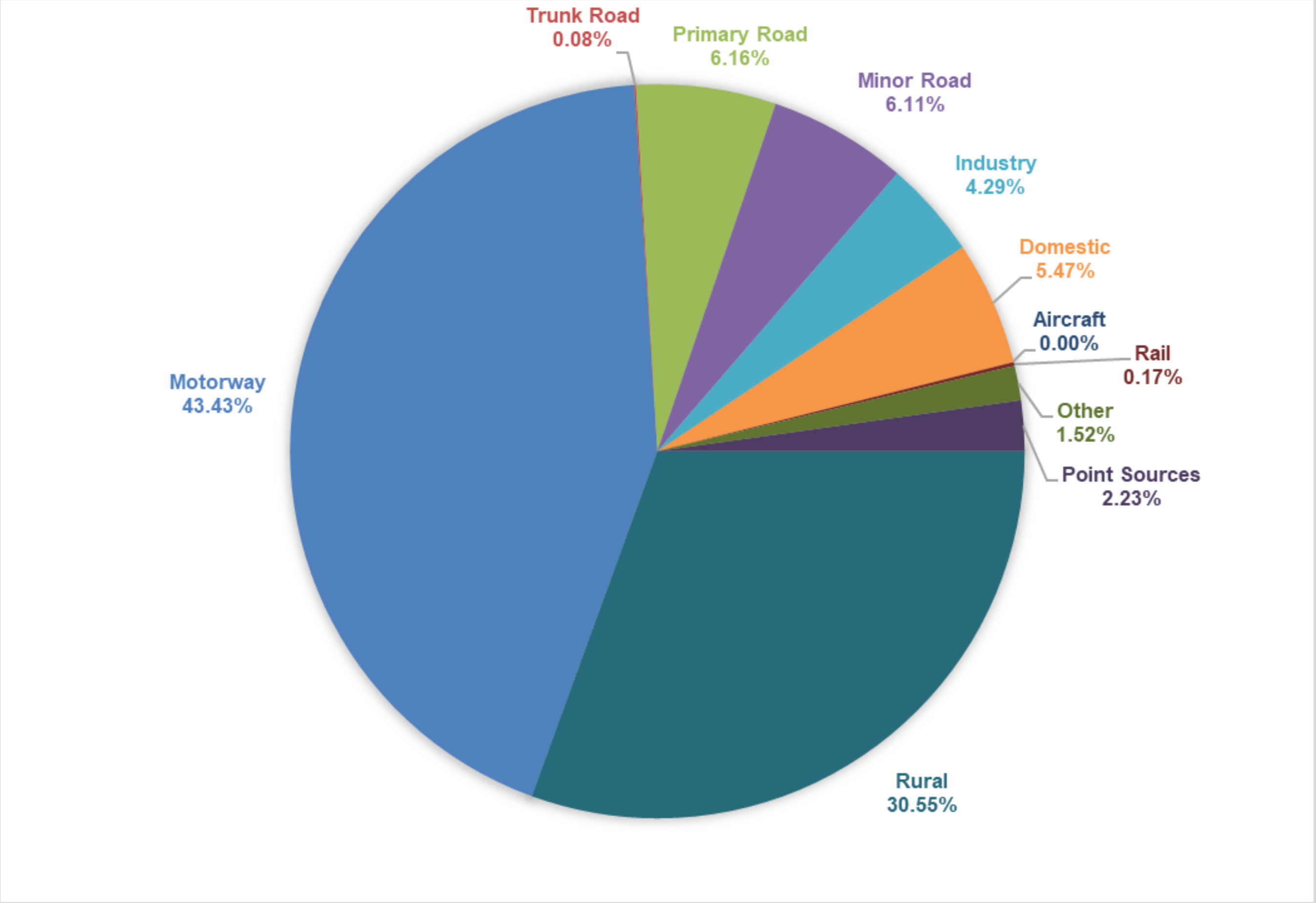
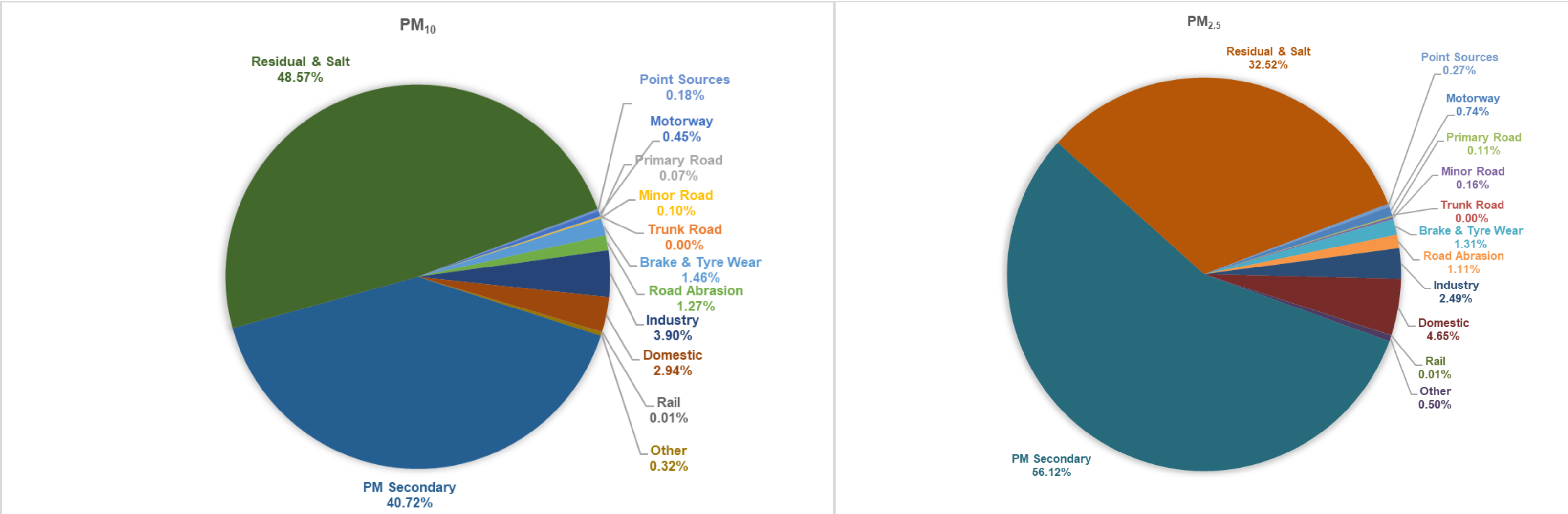


Table 5-5 – PM_{10} and PM_{25} Background Source Apportionment

	Motorw ay	Trunk Road	Primary Road	Minor Road	Brake & Tyre Wear	Road Abrasion	Industry	Domestic	Rail	Other	PM Secondary	Residual & Salt	Point Sources
PM_{10} Concentration (µg/m³)	<0.1	<0.1	<0.1	<0.1	0.3	0.2	0.7	0.5	<0.1	<0.1	7.3	8.7	<0.1
Percent of Background PM_{10}	0.5	<0.1	<0.1	<0.1	1.5	1.3	3.9	2.9	<0.1	0.3	40.7	48.6	0.2
$PM_{2.5}$ Concentration (µg/m³)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.5	<0.1	<0.1	6.2	3.6	<0.1
Percent of Background $PM_{2.5}$	0.7	<0.1	<0.1	0.2	1.3	1.1	2.5	4.7	<0.1	0.5	56.1	32.5	0.3



As shown above, the motorway makes up around 43% of the background NO_x concentration within the grid square containing the AQMA. PM_{10} and $PM_{2.5}$ concentrations are mainly made up of Residual and secondary emissions.

5.3.2 Vehicle Type and Age

To help inform the development of measures as part of the action plan stage of the project, a NO_x source apportionment exercise was undertaken for the following vehicle classes:

- Cars
- Taxis
- Light-Goods Vehicles (LGVs);
- Rigid Heavy-Goods Vehicles (HGVs)
- Articulated HGVs;
- Bus and Coaches;
- Motorcycles;
- Full Hybrid Petrol Cars;
- Plug-in Hybrid Petrol Cars;
- Full Hybrid Diesel Cars;
- Battery Electric Vehicle (EV) Cars; and,
- Battery EV LGVs.

This will provide vehicle emission proportions of NO_x that will allow the Council to design specific AQAP measures targeting a reduction in emissions from specific vehicle types.

It should be noted that emission sources of NO_2 are dominated by a combination of direct NO_2 (f-NO_2) and oxides of nitrogen (NO_x), the latter of which is chemically unstable and rapidly oxidised upon release to form NO_2. Reducing levels of NO_x emissions therefore reduces levels of NO_2. As a consequence, the source apportionment study has considered the emissions of NO_x which are assumed to be representative of the main sources of NO_2.

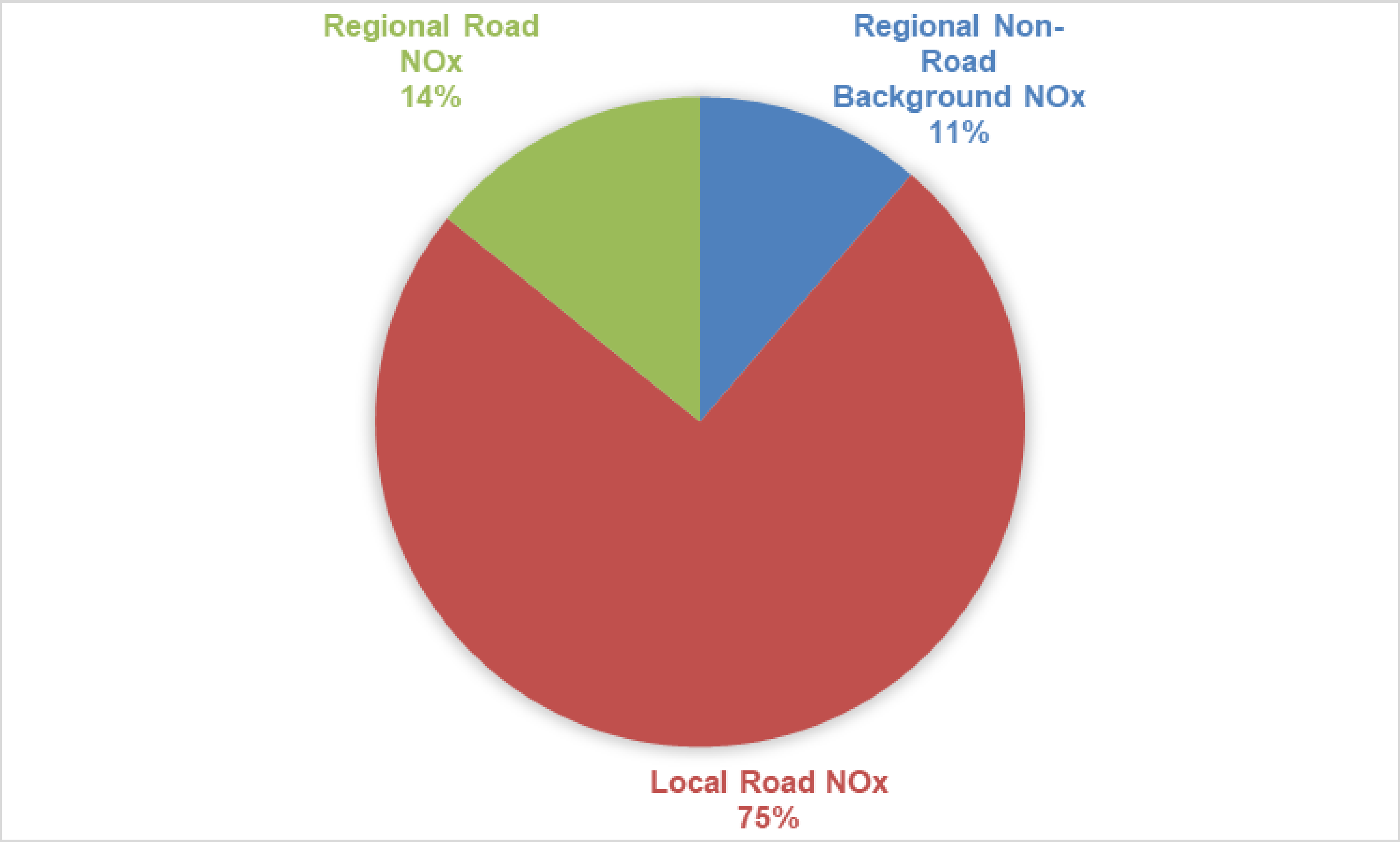
The source apportionment study has also included PM_{10} and $PM_{2.5}$.

The age of vehicles has been determined by accounting for the 'Euro Class' they are assigned.

Table 5-6 – Detailed Source Apportionment of NO_x Concentrations at R1

Results	All Vehicles	Petrol Car	Diesel Car	Taxis	Petrol LGV	Diesel LGV	Rigid HGV	Artic HGV	Buses/ Coaches	Motorcycle	Full Hybrid Petrol Cars	Plug-in Hybrid Petrol Cars	Full Hybrid Diesel Cars	Battery EV Cars	Battery EV LGVs	Background
NO_x Concentration (µg/m^3)	73.9	3.3	21.1	0.8	<0.1	23.0	19.7	4.1	1.9	<0.1	0.1	<0.1	0.1	0.0	0.0	25.2
Percentage of Total NO_x	74.5%	3.3%	21.3%	0.8%	<0.1%	23.2%	19.8%	4.2%	1.9%	<0.1%	0.1%	<0.1%	0.1%	0.0%	0.0%	25.5%
Percentage Contribution to Road NO_x	100%	4.4%	28.5%	1.1%	<0.1%	31.1%	26.6%	5.6%	2.5%	<0.1%	0.1%	<0.1%	0.1%	0.0%	0.0%	

Figure 5-4 – Source Apportionment of NO_x Concentrations – High Level



‘Regional Road’ – Emissions from roads not included in the model
‘Local Road’ – Emissions from roads included within the model
‘Regional Non-Road’ – All other emissions

Figure 5-5 – Detailed Source Apportionment of NO_x Concentrations – All Sources

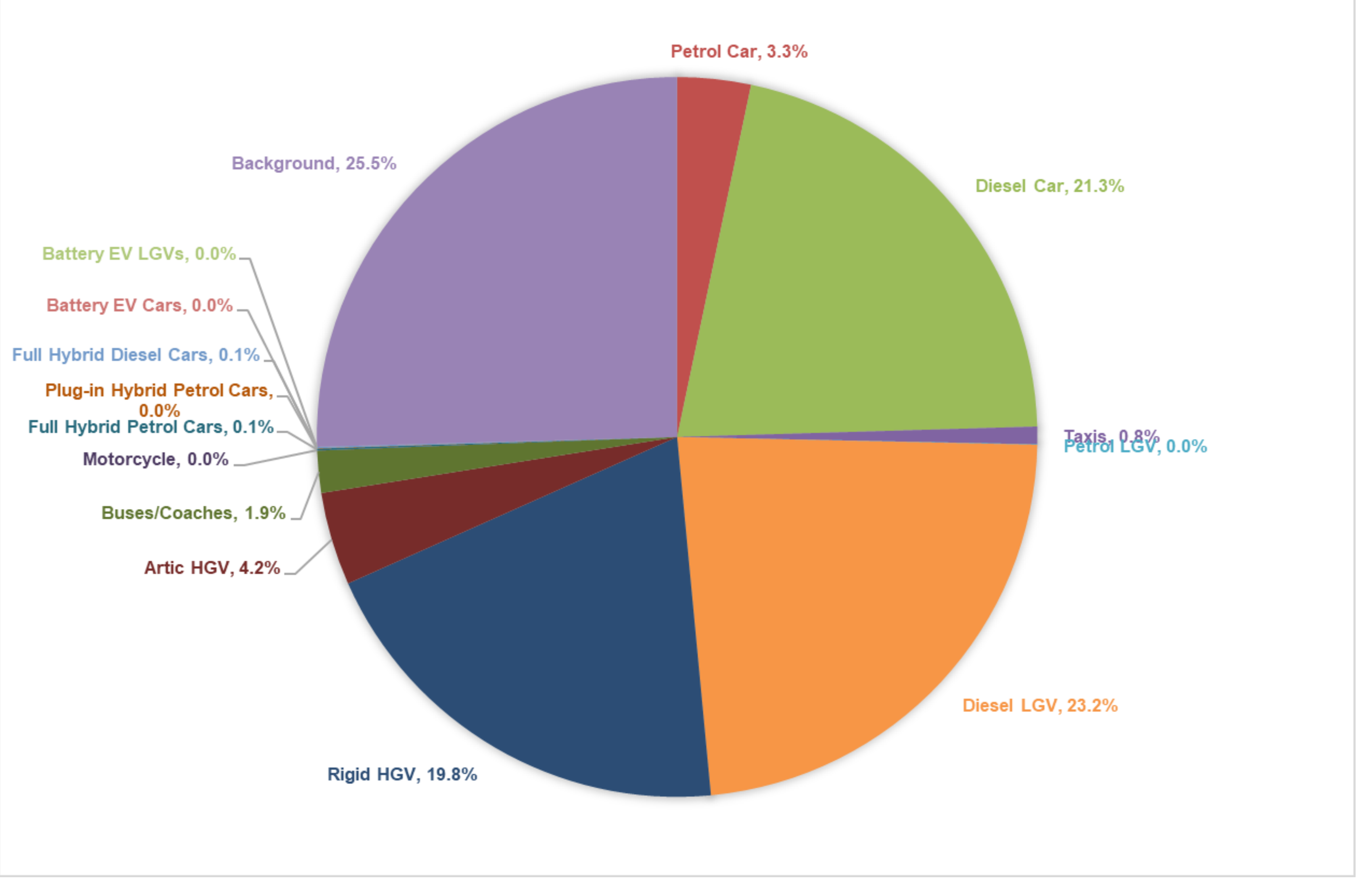


Figure 5-6 – Detailed Source Apportionment of NO_x Concentrations – Road Sources

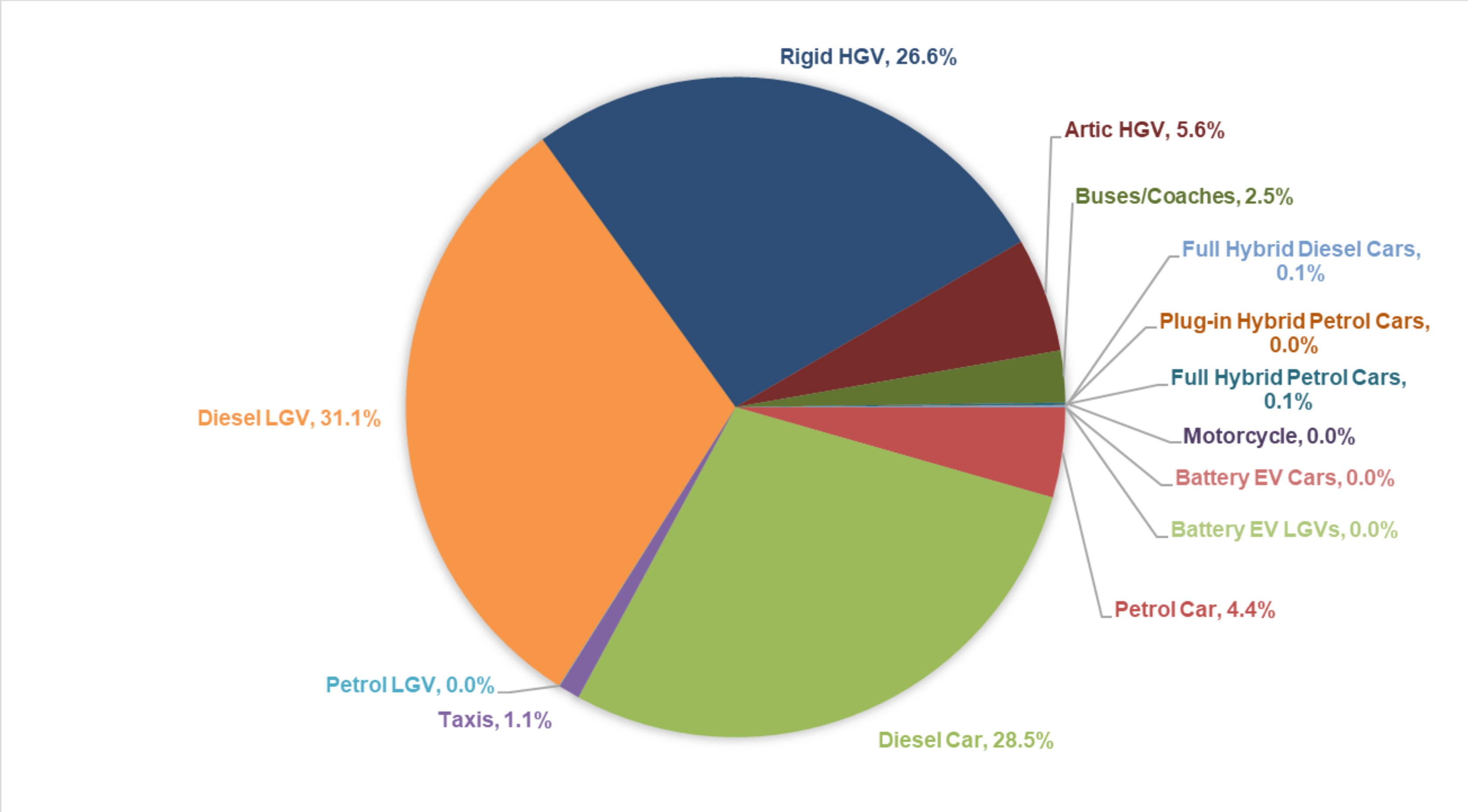


Table 5-7 – Detailed Source Apportionment of PM_{10} Concentrations at R1

Results	All Vehicles	Petrol Car	Diesel Car	Taxis	Petrol LGV	Diesel LGV	Rigid HGV	Artic HGV	Buses/Coaches	Motorcycle	Full Hybrid Petrol Cars	Plug-in Hybrid Petrol Cars	Full Hybrid Diesel Cars	Battery EV Cars	Battery EV LGVs	Background
PM_{10} Concentration (µg/m^3)	2.7	0.8	0.8	<0.1	<0.1	0.6	0.3	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17.9
Percentage of Total PM_{10}	13.2%	4.0%	3.8%	0.1%	<0.1%	2.9%	1.2%	0.7%	0.1%	<0.1%	0.2%	0.1%	<0.1%	<0.1%	<0.1%	86.8%
Percentage Contribution to Road PM_{10}	100%	30.1%	28.9%	0.9%	0.2%	22.1%	9.3%	5.5%	0.7%	<0.1%	1.5%	0.5%	0.1%	0.2%	<0.1%	

Figure 5-7 – Detailed Source Apportionment of PM_{10} Concentrations – All Sources

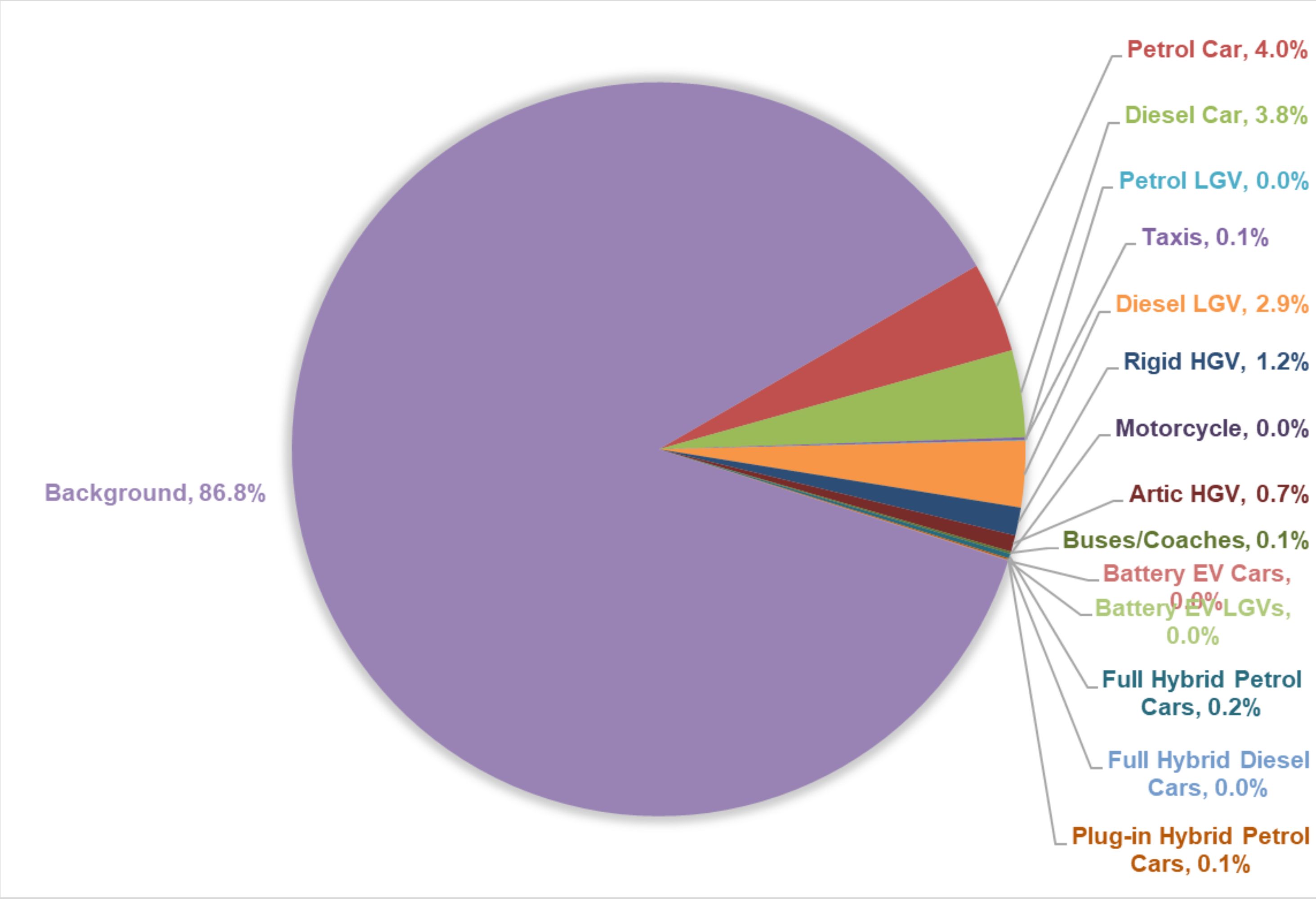


Figure 5-8 – Detailed Source Apportionment of PM_{10} Concentrations – Road Sources

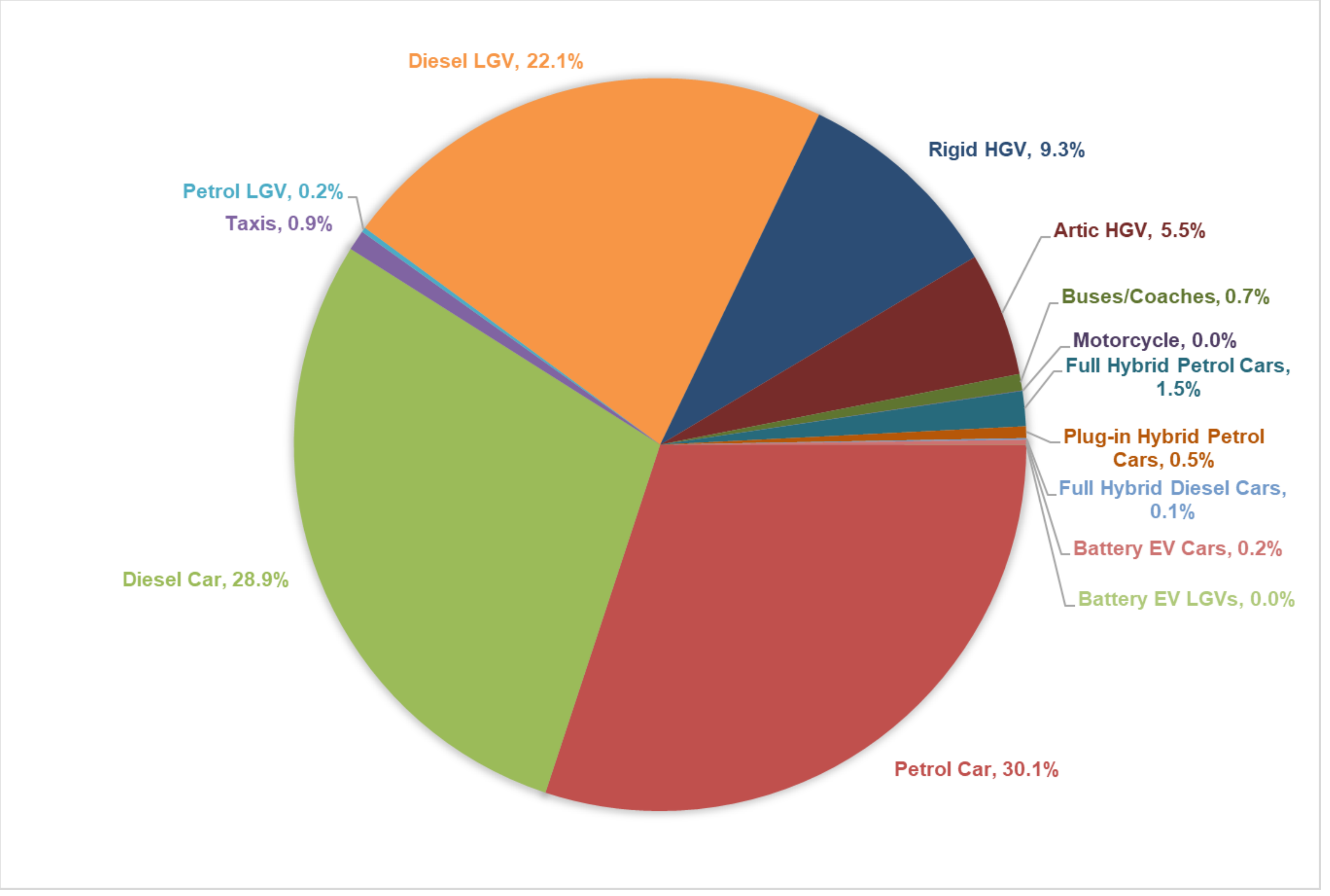


Table 5-8 – Detailed Source Apportionment of $PM_{2.5}$ Concentrations at R1

Results	All Vehicles	Petrol Car	Diesel Car	Taxis	Petrol LGV	Diesel LGV	Rigid HGV	Artic HGV	Buses/Coaches	Motorcycle	Full Hybrid Petrol Cars	Plug-in Hybrid Petrol Cars	Full Hybrid Diesel Cars	Battery EV Cars	Battery EV LGVs	Background
$PM_{2.5}$ Concentration (µg/m^3)	1.8	0.5	0.6	<0.1	<0.1	0.4	0.2	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	11.1
Percentage of Total $PM_{2.5}$	14.3%	3.8%	4.3%	0.2%	<0.1%	3.4%	1.5%	0.8%	0.1%	<0.1%	0.2%	0.1%	<0.1%	<0.1%	<0.1%	85.7%
Percentage Contribution to Road $PM_{2.5}$	100%	26.3%	30.1%	1.1%	0.2%	23.7%	10.2%	5.4%	0.8%	<0.1%	1.4%	0.4%	0.1%	0.2%	<0.1%	

Figure 5-9 – Detailed Source Apportionment of $PM_{2.5}$ Concentrations – All Sources

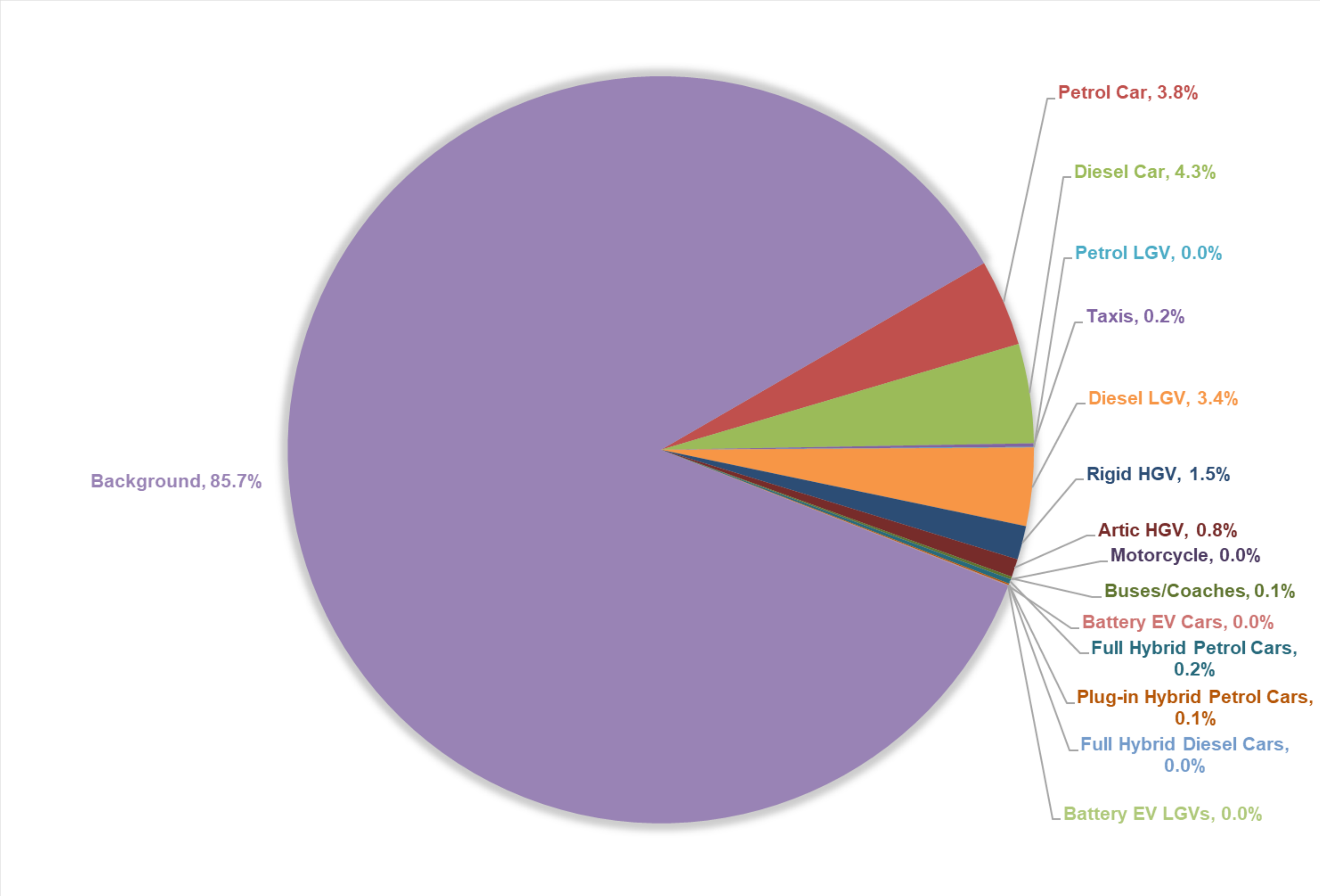
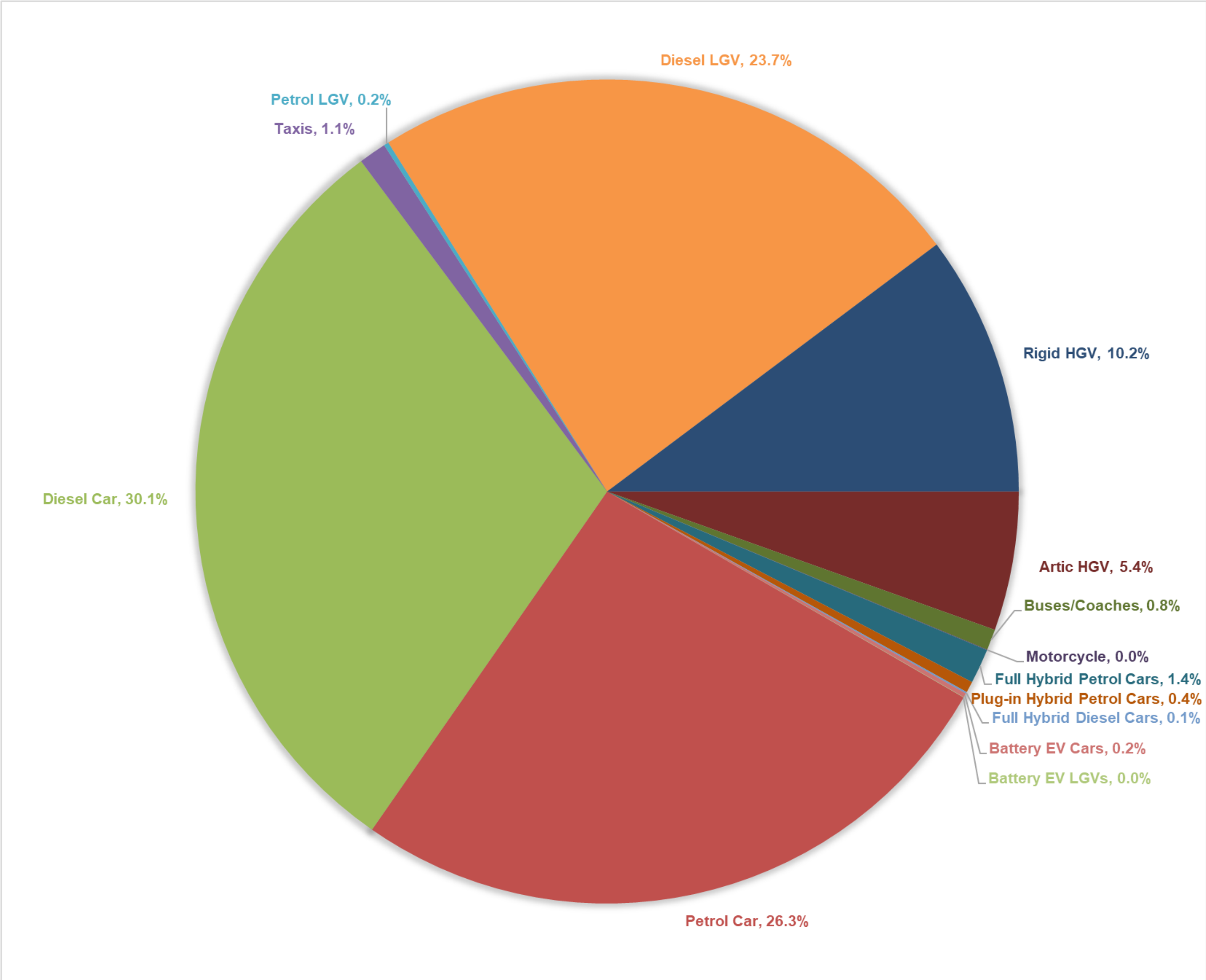


Figure 5-10 – Detailed Source Apportionment of $PM_{2.5}$ Concentrations – Road Sources



NO_x

The following observations can be made:

- Road traffic accounts for 73.9 µg/m³ (74.5%) of total NO_x (99.1 µg/m³), with background accounting for 25.2 µg/m³ (25.5%);
- Of the total road NO_x, the contribution of Petrol and Diesel Cars (32.%), Petrol and Diesel LGVs (31.1%) and Rigid and Artic HGVs including Buses and Coaches (34.8%) are split fairly evenly making up the total road NO_x;
- Of the cars included in the model, Diesel cars account for 28.5% of Road NO_x where Petrol cars account for only 4.4% and Taxis 1.1%;
- Of the LGVs, Diesel LGVs account for 31.1% of road NO_x emissions and Petrol LGVs >0.1%;
- Rigid HGVs account for 26.6% of Road NOx compared to Articulated HGVs which account for only 5.6% and Buses/Coaches only 2.5%
- Motorcycles are found to contribute <1%; and
- Hybrid Vehicles account for only 0.2% of Road NO_x.

The NO_x source apportionment exercise demonstrates Diesel Cars and LGVs being the primary contributors to road NO_x concentrations within the AQMA.

PM_{10} and $PM_{2.5}$

PM_{10} and $PM_{2.5}$ concentrations within the AQMA are largely made up of residual background sources. For both pollutants, the greatest road contributor was identified as being Diesel Cars, followed by Petrol cars and Diesel LGVs.

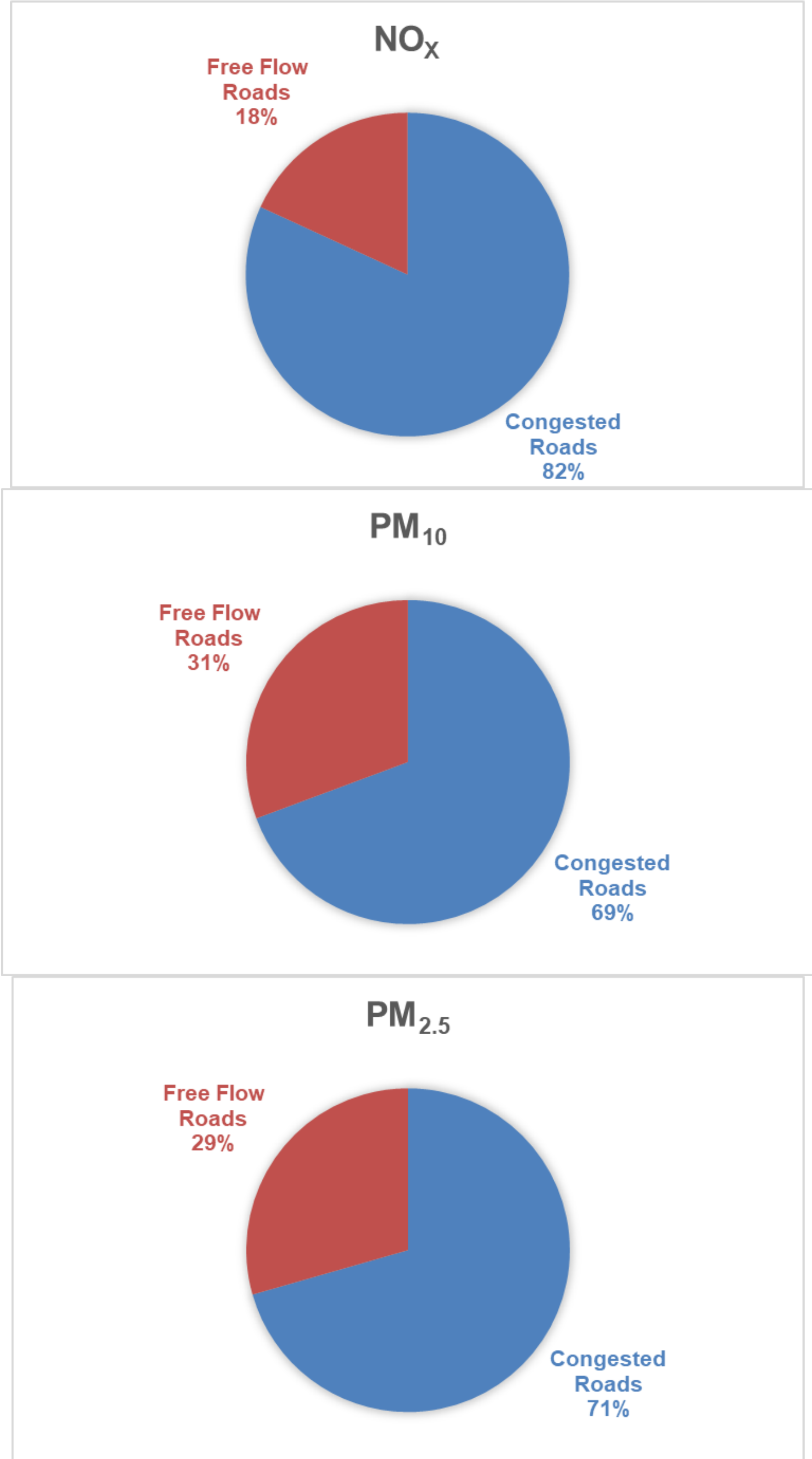
5.3.3 Congestion in AQMA

To achieve a verified model, the link within the AQMA has been modelled at 5 km/h in line with TG(16) to be representative of congestion and queueing traffic at this junction where vehicles are stopped as a result of traffic lights. The contribution from those links which have been modelled at slower speeds as a result of congestion and those with free-flowing traffic are compared below.

Pollutant		Congested Roads	Free Flowing Roads
NO_x	Total Road NO_x (µg/m³)	60.5	13.4
	Percent of Total Road NO_x	81.9	18.1
PM_{10}	Total Road PM_{10} (µg/m³)	1.10	0.49
	Percent of Total Road PM_{10}	69.3	30.7
$PM_{2.5}$	Total Road $PM_{2.5}$ (µg/m³)	0.76	0.32
	Percent of Total Road $PM_{2.5}$	70.6	29.4

It should be noted that the receptor used as representative of the worst-case location within the AQMA is located closest to a road with congestion, so it is to be expected that this would account for the majority of contributions to the total concentration.

Figure 5-11 – Source Apportionment of Road Congestion



6 Conclusions

The dispersion modelling exercise undertaken has provided the following updated perspective on NO_2 challenges within the Epping Forest AQMA.

6.1 Predicted Concentrations

All of receptors reporting NO_2 annual mean concentrations to be above or within 10% of the AQS objective limit are either located within the existing AQMA or are concentrated to roadside locations of junctions where key arterial roads meet and form the main transportation network within the region.

The highest annual mean concentration of NO_2 was recorded at R1 with a concentration of 52.2 µg/m^3. This is slightly higher than the adjacent recorded monitoring which recorded 48 µg/m^3 as a result of a slightly lower modelling height and its position relative to the road.

The empirical relationship given in LAQM.TG(16)[1] states that exceedances of the 1-hour mean objective for NO_2 is only likely to occur where annual mean concentrations are 60 µg/m^3 or above at a location of relevant exposure. Given the NO_2 annual mean concentration recorded at all receptors is below 60 µg/m^3, exceedances of the hourly NO_2 AQS objective are unlikely.

PM_{10} and $PM_{2.5}$ concentrations have also been predicted as part of the modelling assessment. No modelled receptors recorded concentrations in exceedance of either of the annual mean objectives for these pollutants. The highest modelled PM_{10} concentration was 20.6 µg/m^3 at R1. The highest modelled $PM_{2.5}$ concentration was 12.9 µg/m^3 at R1.

6.2 Estimated Year of Compliance

Using the recommended method in TG(16), the estimated year of compliance within the AQMA should no additional measures be put in place is 2024 and will be below 10% of the AQO by 2026.

6.3 Source Apportionment

To help inform the development of measures as part of a future AQAP, a NO_x source apportionment exercise was undertaken to provide an understanding of any potential similarities in vehicle emission contributors within the AQMA.

Petrol Cars were the most prevalent vehicles on the road within the AQMA, 46.6% of all vehicles were petrol cars. The fleet makeup, as determined by the ANPR survey, also indicated that vehicles using High Road Epping were made up of older vehicles than the default fleet assumption within the EFT derived from the National Air Emissions Inventory (NAEI).

The NO_x source apportionment exercise demonstrates Diesel Cars and Diesel LGVs being the primary contributors to road NO_x concentrations within the AQMA. The split between overall car, LGV and HGV emissions was roughly equal with each contributing around a third to total road NO_x.

An assessment of queueing traffic showed that, within the AQMA, congestion accounts for 81.9% of NO_x contributions from the road. Should any traffic smoothing measures be introduced, this is likely to reduce pollutant concentrations within the AQMA.

PM_{10} and $PM_{2.5}$ concentrations within the AQMA are largely made up of residual background sources. For both pollutants, the greatest road contributor was identified as being Diesel Cars, followed by Petrol cars and Diesel LGVs..

Appendices

Appendix A – ADMS Model Verification

The ADMS-Roads dispersion model has been widely validated for this type of assessment and is specifically listed in the Defra's LAQM.TG(16)[1] guidance as an accepted dispersion model.

Model validation undertaken by the software developer (CERC) will not have included validation in the vicinity of the AQMA. It is therefore necessary to perform a comparison of modelled results with local monitoring data at relevant locations. This process of verification attempts to minimise modelling uncertainty and systematic error by correcting modelled results by an adjustment factor to gain greater confidence in the final results.

The predicted results from a dispersion model may differ from measured concentrations for a large number of reasons, including uncertainties associated with:

- Background concentration estimates;
- Source activity data such as traffic flows and emissions factors;
- Monitoring data, including locations; and
- Overall model limitations.

Model verification is the process by which these and other uncertainties are investigated and where possible minimised. In reality, the differences between modelled and monitored results are likely to be a combination of all of these aspects.

Model setup parameters and input data were checked prior to running the models in order to reduce these uncertainties. The following were checked to the extent possible to ensure accuracy:

- Traffic data;
- Distance between sources and monitoring as represented in the model;
- Speed estimates on roads;
- Background monitoring and background estimates; and
- Monitoring data.

The traffic data for this assessment has been collated using a combination of data provided by the highways department at GCC and DfT traffic count data, as outlined in Section 4.1.

The details of the LAQM monitoring sites considered for the purposes of model verification are presented in Table A.1 below.

Table A.1 – Local Monitoring Data Available for Model Verification

Site ID	OS Grid Reference		2019 Annual Mean NO_2 Concentration (µg/m^3)	2019 Data Capture (%)
	X	Y		
3	544928	201281	48.0	100
33	544709	201139	31.0	100

NO_2 Verification Calculations

The verification of the modelling output was performed in accordance with the methodology provided in Chapter 7 of LAQM.TG(16)[1]. For the verification and adjustment of NO_x/NO_2, the 2019 monitoring data presented in Table A.1 was used.

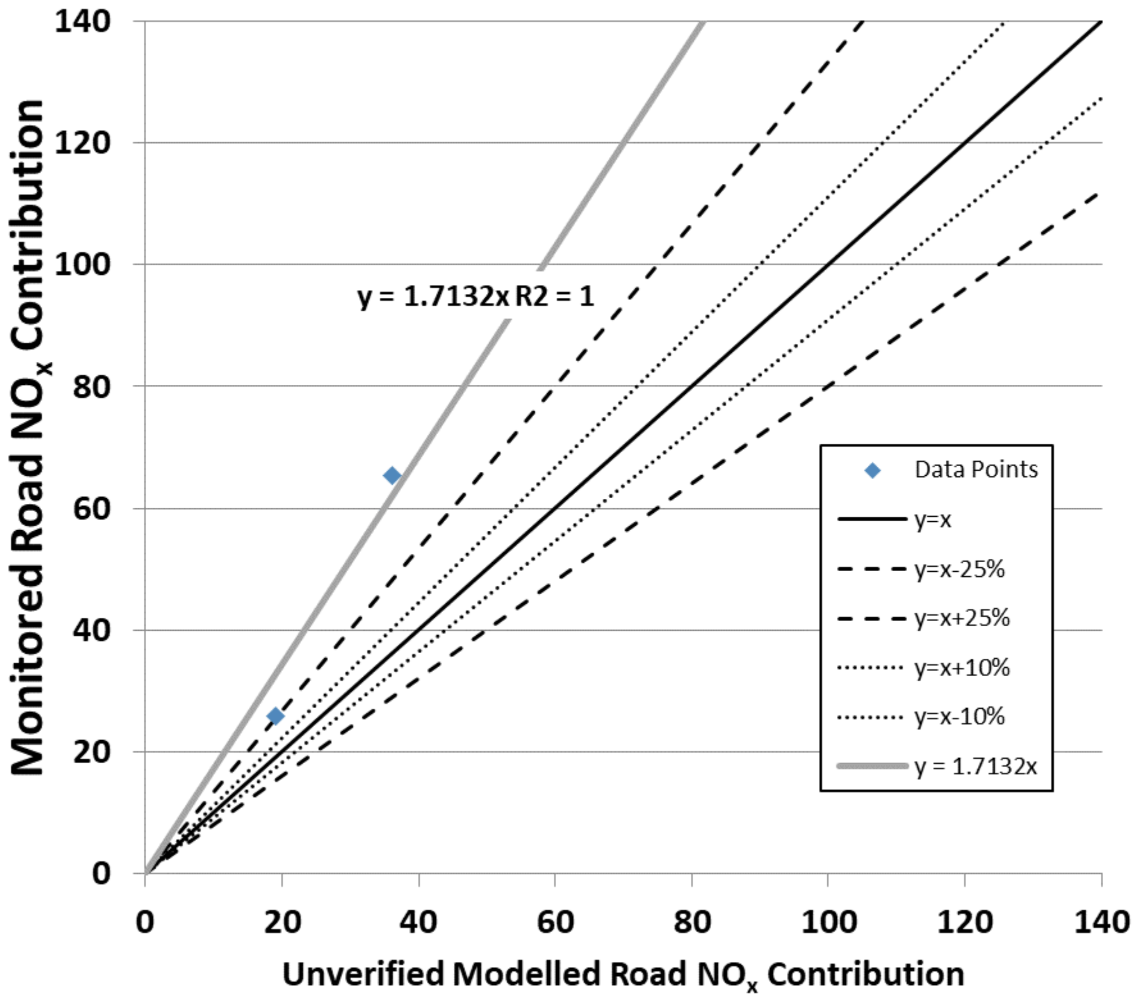
Verification was completed using the 2019 (2018 reference year) Defra background mapped concentrations for the relevant 1 km x 1 km grid squares within Epping Forest (i.e. those within which the model verification locations are located), as displayed in Table 3-3.

Table A.2 below shows an initial comparison of the monitored and unverified modelled NO_2 results for the year 2019, in order to determine if verification and adjustment was required. Figure A-1 shows this data graphically.

Table A.2 – Comparison of Unverified Modelled and Monitored NO_2 Concentrations

Site ID	Background NO_2	Monitored total NO_2 (µg/m³)	Unverified Modelled total NO_2 (µg/m³)	Difference (modelled vs. monitored) (%)
3	15.3	48.0	36.1	-24.8
33	15.3	31.0	28.0	-9.8

Figure A-1 – Unverified Comparison of the Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x



The data in the table above show that the model was under predicting at both verification points, with the highest under prediction between the modelled and monitored concentrations observed at Site 3 (-24.8 %). At this stage all model inputs were checked to ensure their accuracy, this includes road and monitoring sire geometry, traffic data, link emission rates, 2019 monitoring results, background concentrations and modelling features such as street canyons. Following a level of QA/QC completed upon the model, no further improvement of the modelled results could be obtained on this occasion. The difference between modelled and monitored concentrations was almost 25% at the monitoring location within the AQMA, therefore adjustment of the results was necessary. The relevant data was then gathered to allow the adjustment factor to be calculated.

Model adjustment needs to be undertaken based on NO_x and not NO_2. For the Council operated monitoring results used in the calculation of the model adjustment, NO_x was derived from NO_2; these calculations were undertaken using a spreadsheet tool available from the LAQM website[16].

[16] http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc

Verification (AQMA)

Table A.3 provides the relevant data required to calculate the model adjustment based on regression of the modelled and monitored road source contribution to NO_x.

Figure A-2 provides a comparison of the Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x, and the equation of the trend line based on linear regression through zero. The Total Monitored NO_x concentration has been derived by back-calculating NO_x from the NO_x/NO_2 empirical relationship using the spreadsheet tool available from Defra's website. The equation of the trend lines presented in gives an adjustment factor for the modelled results of 1.713.

Table A.3 – Data Required for Adjustment Factor Calculation

Site ID	Monitored total NO2 (µg/m3)	Monitored total NOx (µg/m3)	Background NO2 (µg/m3)	Background NOx (µg/m3)	Monitored road contribution NO2 (total - background) (µg/m3)	Monitored road contribution NOx (total - background) (µg/m3)	Modelled road contribution NOx (excludes background) (µg/m3)
3	48.0	90.6	18.1	25.2	29.9	65.4	36.1
33	31.0	51.1	18.1	25.2	12.9	25.9	19.1

Figure A-2 – Comparison of the Modelled Road Contribution NO_x versus Monitored Road Contribution NO_x

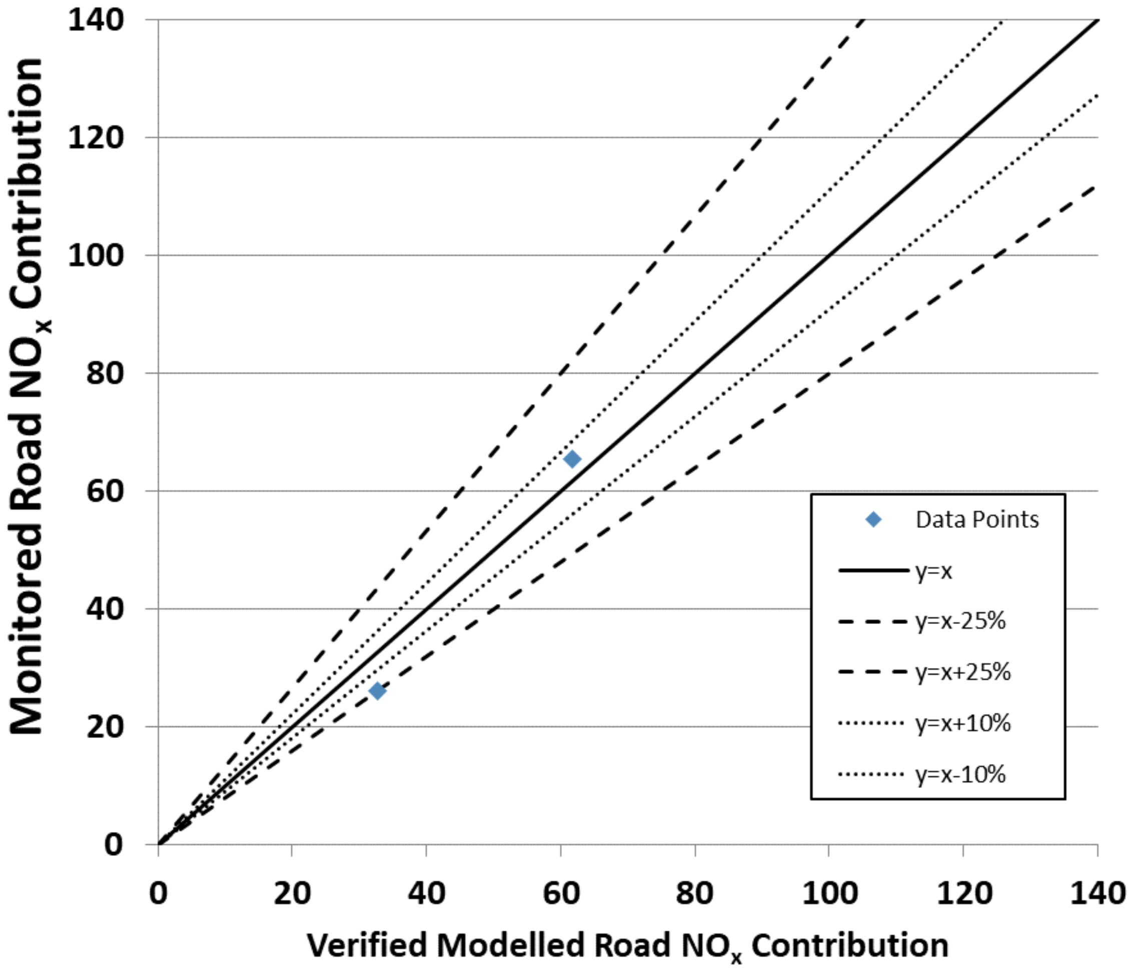


Table A.4 – Adjustment Factor and Comparison of Verified Results against Monitoring Results

Site ID	Ratio of monitored road contribution NO_x / modelled road contribution NOx	Adjustment factor for modelled road contribution NO_x	Adjusted modelled road contribution NO_x (µg/m^3)	Adjusted modelled total NO_x (including background NO_x) (µg/m^3)	Modelled total NO_2 (based upon empirical NO_x / NO_2 relationship) (µg/m^3)	Monitored total NO_2 (µg/m^3)	Difference (adjusted modelled NO_2 vs. monitored NO_2) (%)
3	1.81	1.713	61.8	87.0	47.3	48.0	-1.4
33	1.36		32.7	57.9	34.5	31.0	11.4

Figure A-3 – Comparison of the Verified Modelled Total NO2 versus Monitored NO2

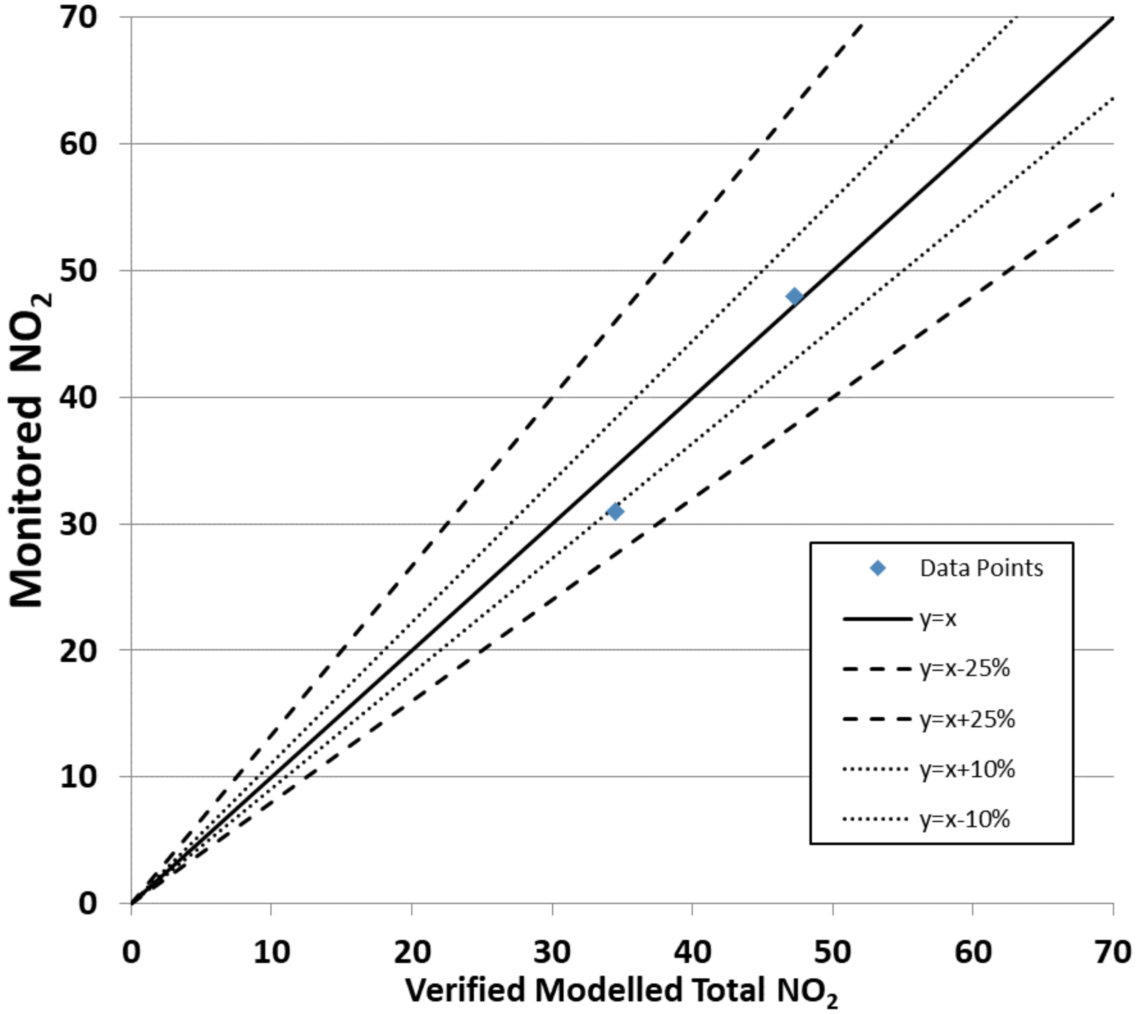


Table A.4 and Figure A-3 show the ratios between monitored and modelled NO_2 for each monitoring location after using the calculated adjustment factor. LAQM.TG(16)[1] states that:

"In order to provide more confidence in the model predictions and the decisions based on these, the majority of results should be within 25% of the monitored concentrations, ideally within 10%."

The sites show good agreement between the ratios of monitored and modelled NO_2, It can be seen that the verification point within the AQMA is within ±10% tolerance as detailed in LAQM.TG(16). and is less than 1% different. Monitoring at Site 33 is just outside of 10% difference and within the acceptable 25% tolerance.

A factor of 1.713 reduces the Root Mean Square Error (RMSE) from a value of 40.4 to 2.5, which is in line with the guidance value of 4 µg/m^3 as stated within LAQM.TG(16).

The adjustment factor was applied to the road contribution NO_x and PM concentrations predicted by the model to arrive at the final NO_2 concentrations in the AQMA.

Appendix B – Traffic Inputs

Table B. 1 – Traffic Data used in the Detailed Assessment - ANPR Data provided by AECOM for High Road Epping

Modelled Road Link	AADT	% Petrol Car	% Diesel Car	% Taxi (black cab)	% LGV	% Rigid HGV	% Artic HGV	% Bus and Coach	% Motorcycle	% Full Hybrid Petrol Cars	% Plug-In Hybrid Petrol Cars	% Full Hybrid Diesel Cars	% Battery EV Cars	% Battery EV LGV	Speed (km/h)
High Rd Epping Sth	25237	46.58	30.47	0.67	16.54	1.69	0.20	0.14	0.01	2.43	0.86	0.08	0.32	0.02	64
High Rd Epping Sth SD	25237	46.58	30.47	0.67	16.54	1.69	0.20	0.14	0.01	2.43	0.86	0.08	0.32	0.02	5
High Rd Epping Nth	25237	46.58	30.47	0.67	16.54	1.69	0.20	0.14	0.01	2.43	0.86	0.08	0.32	0.02	64
High Rd Epping Nth SD	25237	46.58	30.47	0.67	16.54	1.69	0.20	0.14	0.01	2.43	0.86	0.08	0.32	0.02	5

Notes

Traffic speeds were modelled at either the relevant speed limit for each road or where available monitored vehicle speeds

Where appropriate, vehicle speeds have been reduced to simulate queues at junctions, traffic lights and other locations where queues or slower traffic are known to be an issue – in accordance with LAQM TG(16)[1]

Table B. 2 – Traffic Data used in the Detailed Assessment – Euro Compositions on High Road Epping

Cars & LGVs	Pre-Euro 1	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5	Euro 6	Euro 6c
Petrol Car	-	-	0.00	0.09	0.22	0.25	0.44	-
Diesel Car	-	-	-	0.04	0.16	0.33	0.46	-
Taxi (Black Cab)	-	-	-	0.19	0.29	0.40	0.12	-
Petrol LGV	-	-	-	0.29	0.20	0.14	0.37	-
Diesel LGV	-	-	-	0.07	0.17	0.36	0.40	-
Full Hybrid Petrol Car	-	-	-	0.05	0.08	0.21	0.67	-
Plugin Hybrid Petrol Car	-	-	-	-	-	0.24	0.76	-
Full Diesel Hybrid Car	-	-	-	-	-	0.42	0.58	
E85 Bioethanol Car	-	-	0.00	0.04	0.15	0.27	0.17	0.37
LPG Car		-	0.00	0.04	0.15	0.27	0.17	0.37
Full Hybrid Petrol LGV					0.17	0.32	0.24	0.27
Plug-In Hybrid Petrol LGV	-					0.39	0.29	0.33
E85 Bioethanol LGV	-	-	0.01	0.06	0.15	0.30	0.22	0.25
LPG LGV		-	0.01	0.06	0.15	0.30	0.22	0.25

HGVs and Buses	Pre-Euro I	Euro I	Euro II	Euro III	Euro IV	Euro V_EGR	Euro V_SCR	Euro VI
Rigid HGV	-	-	-	0.05	0.07	0.27	0.62	
Artic HGV	-	-	-	0.02	0.02	0.28	0.68	
Buses	-	-	-	0.03	0.22	0.39	0.36	
Coaches	-	-	-	0.03	0.22	0.39	0.36	
B100 Rigid HGV			0.01	0.04	0.05	0.05	0.14	0.72
B100 Artic HGV			0.00	0.01	0.01	0.03	0.10	0.85
Biodiesel Buses		-	0.02	0.08	0.08	0.07	0.20	0.56
Biodiesel Coaches		-	0.02	0.08	0.08	0.07	0.20	0.56
Hybrid Buses - Single Decker					-	0.20	0.61	0.19
Hybrid Buses - Double Decker					-	0.20	0.61	0.19
Hybrid Buses - Articulated					-	0.20	0.61	0.19

Motorcycles	Pre-Euro 1	Euro 1	Euro 2	Euro 3	Euro 4	Euro 5
0-50cc	-	-	0.33	0.67	-	-
2-stroke - 50-100cc	-	-	0.33	0.67	-	-
4-stroke - 50-150cc	-	-	0.33	0.67	-	-

4-stroke - 150-250cc	-	-	0.33	0.67	-	-
4-stroke - 250-750cc	-	-	0.33	0.67	-	-
4-stroke - >750-cc	-	-	0.33	0.67	-	-

Table B. 3 – Traffic Data used in the Detailed Assessment – M25 data sourced from DfT

Modelled Road Link	AADT	% Car	% LGV	% HGV	% Bus and Coach	% Motorcycle	Speed(kph)
M25 W of BCT	140908	64.7	20.3	14.6	0.2	0.3	112
M25 E of BCT	140908	64.7	20.3	14.6	0.2	0.3	112.00
Bell Common Tunnel	140908	64.7	20.3	14.6	0.2	0.3	112.00

Notes

Traffic speeds were modelled at either the relevant speed limit for each road or where available monitored vehicle speeds

Where appropriate, vehicle speeds have been reduced to simulate queues at junctions, traffic lights and other locations where queues or slower traffic are known to be an issue – in accordance with LAQM TG(16)[1]

Euro Compositions along the M25 are based on the default included within the EFT