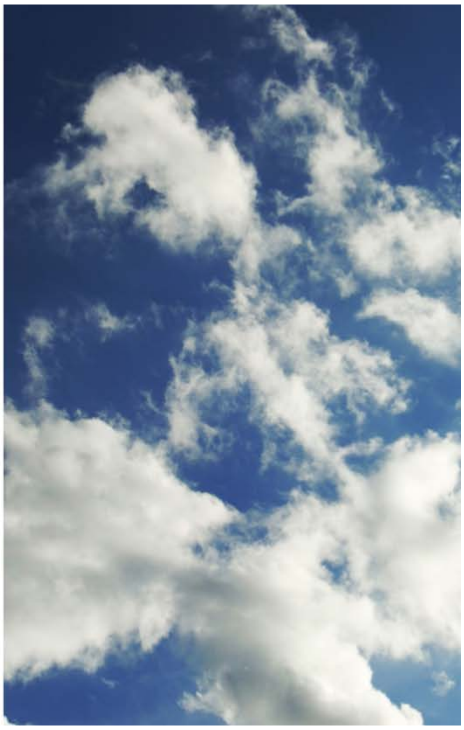
Woking Borough Council

Air Quality Further Assessment for Woking Borough Council

In Fulfilment of Part IV of the Environment Act 1995 Local Air Quality Management



Amec Foster Wheeler Environment & Infrastructure UK Limited

January 2015

Document Revisions

No.	Details	Date
1	Draft	23/01/15
2	Final	29/01/15

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Report for

Joseph Dutfield
Environment Officer
Neighbourhood Services
Woking Borough Council
Civic Office
Gloucester Square
Woking
Surrey
GU21 6YL

Main Contributors

Ben Warrern
Rachel Hicks

Issued by

....

Ben Warren

Approved by

....

Christine McHugh

Amec Foster Wheeler Environment & Infrastructure UK Limited

17 Angel Gate, City Road, London EC1V 2SH,
United Kingdom
Tel +44 (0) 207 843 1400
Fax +44 (0) 207 843 1410

Doc Reg No. 36175rr003i3

Executive Summary

Part IV of the Environment Act 1995 places a statutory duty on local authorities to review and assess air quality in their areas, and to determine whether or not the Air Quality Objectives (AQOs) are likely to be achieved.

This Further Assessment is required following the declaration of an Air Quality Management Area (AQMA) by Woking Borough Council (WBC) in January 2014 as a result of exceedences of the nitrogen dioxide (NO_2) annual mean AQO at the junction between Anchor Hill, Lower Guildford Road and Highclere Road.

This Further Assessment has been carried out to assess whether the declaration of the AQMA was justified and whether the appropriate geographical area has been included; to ascertain the sources contributing to the exceedence; and to calculate the magnitude of reduction in emissions required to achieve the objective. This Further Assessment used ambient monitoring data from 2013 and modelled concentrations for the same year.

The 2014 Local Air Quality Management (LAQM) Progress Report confirmed that one diffusion tube within the AQMA at Anchor Hill recorded an NO_2 concentration that exceeded the annual mean AQO. Detailed atmospheric dispersion modelling was carried out using the Cambridge Environmental Research Consultants Ltd (CERC) ADMS-Roads model (version 3.4.2). Concentrations of NO_2 were modelled at relevant receptor locations and monitoring locations within the vicinity of the assessment area.

It was concluded that the declaration of the AQMA for the NO_2 annual mean objective was justified and that it should remain at its current extent. The calculation of the likely sources of NO_2 concentrations within the AQMAs has also been undertaken as part of this Further Assessment. This has found that a largest proportion of NO_2 concentrations within the AQMAs are from local traffic in the area. Breaking down this local traffic proportion into the source of annual mean NO_2 concentrations, the contribution of diesel cars and LGVs was found to have a significant influence on total concentrations. The estimate of the NO_X emission reductions required is up to 17% which corresponds to a reduction of road NOx concentration of around 11 $\mu g\ m^{-3}$.

A prediction of when the annual mean NO_2 AQO will be achieved in the AQMA has also been undertaken. This has predicted that the annual mean NO_2 AQO will be achieved by 2017 assuming that predicted reductions in roadside NO_2 concentration as a result of fleet renewal actually occur. This prediction is based only on changes to the national fleet emissions and does not take into account any increase in traffic flows or congestion in the area.

WBC should also use the results of the source apportionment calculations and the reduction in NOx emissions calculations to inform development of an AQAP to achieve compliance with the AQO at an earlier date than would be the case if relying on fleet renewal alone. As WBC has no feasible mechanism for control over the proportion of diesel cars and LGVs in the fleet accessing the Anchor Hill junction, the most effective measures to tackle pollution in the AQMA would be those that reduce the total traffic volume, the amount of time that vehicles spend at the junction with their engines running and/or those that reduce acceleration across the junction.

Contents

1. Introduction

1.1 Project Background and Purpose of this Report

Amec Foster Wheeler Environment & Infrastructure UK Limited ('Amec Foster Wheeler') has been commissioned by Woking Borough Council (WBC) to undertake this Further Assessment based on the information provided by the local authority.

WBC declared an Air Quality Management Area (AQMA) at Anchor Hill in 2014 as a result of exceedences of the annual mean nitrogen dioxide (NO_2) air quality objective (AQO). A map of the AQMA is given in Appendix A. In 2013, the maximum recorded NO_2 concentration in the Anchor Hill AQMA was 41.5 μgm^{-3}.

A Further Assessment is now required to ensure that the declaration of this AQMA was a valid decision and to determine the likely sources of pollutants within the AQMA in order to support the development of an Air Quality Action Plan (AQAP).

1.2 Relevant Legislation

The legislative framework for air quality consists of legally enforceable EU Limit Values that are transposed into UK legislation as Air Quality Standards (AQS) that must be at least as challenging as the EU Limit Values. Action in the UK is then driven by the UK's Air Quality Strategy that sets the Air Quality Objectives (AQO).

The EU Limit Values are set by the European directive on air quality and cleaner air for Europe (2008/50/EC) and the European directive relating to arsenic, cadmium, mercury, nickel, and polycyclic aromatic hydrocarbons in ambient air (2004/107/EC), as the principal instruments governing outdoor ambient air quality policy in the EU. The Limit Values are legally binding levels for concentrations of pollutants for outdoor air quality.

The two European directives, as well as the Council's decision on exchange of information were transposed into UK Law via the Air Quality Standards Regulations 2010, which came into force in the UK on 11th June 2010, replacing the Air Quality Standards Regulations 2007. Air Quality Standards are concentrations recorded over a given time period, which are considered to be acceptable in terms of what is scientifically known about the effects of each pollutant on health and on the environment.

The Air Quality Strategy sets the Air Quality Objectives (AQO), which give target dates and some interim target dates to help the UK move towards achievement of the EU Limit Values. The AQOs are a statement of policy intentions or policy targets and as such, there is no legal requirement to meet these objectives except in as far as they mirror any equivalent legally binding Limit Values in EU legislation. The most recent UK Air Quality Strategy for England, Scotland, Wales and Northern Ireland was published in July 2007.

Table 1.1 sets out the air quality objectives that are relevant to this Further Assessment, and the dates by which they are to be achieved. The latest LAQM Technical Guidance (LAQM TG (09))[1] suggests that the relationship between monitored hourly and annual NO_2 concentrations is such that if the monitored annual mean of NO_2 is less than 60µg m^{-3}, exceedences of the hourly mean objective are unlikely.

Table 1.1 Summary of Relevant Air Quality Standards and Objectives

Pollutant	AQO (UK)	Averaging Period	Date to be Achieved and Maintained Thereafter (UK)
NO_2	40 µg m^{-3}	Annual mean	31.12.2005
NO_2	200 µg m^{-3} not to be exceeded more than 18 times a year	1-hour mean	31.12.2005

1.2.1 Local Air Quality Management

Part IV of the Environment Act 1995 places a statutory duty on local authorities to review and assess air quality in their areas under the Local Air Quality Management (LAQM) regime, and to determine whether or not the AQOs are likely to be achieved.

The Review and Assessment process is undertaken every three years. Local authorities undertake a USA at the start of each round of Review and Assessment to identify any significant changes that may have occurred since the last round. To ensure continuity in the LAQM process, Review and Assessment Progress Reports are prepared in the years between each Review and Assessment round.

Where exceedences for a certain pollutant are considered likely at a relevant location, the local authority is required to proceed to a Detailed Assessment for that pollutant. If the results of the Detailed Assessment confirm that an AQO is unlikely to be met, the local authority is required to declare an Air Quality Management Area (AQMA).

Once a local authority has declared an AQMA, a remedial AQAP must be prepared and implemented to improve air quality within that area. Within 12 months of the AQMA declaration, a Further Assessment is required to provide local authorities with an opportunity to supplement the information they have already gathered from their earlier Review and Assessment work. The findings of the Further Assessment can be used to improve air quality and feed into the local authority's Action Plan.

A local authority is also required to submit a Detailed Assessment in order to revoke an AQMA. The Detailed Assessment should outline the evidence for changes in the likelihood of exceedence of objectives occurring and demonstrate the cause of these changes.

[1] Defra (2009). *Local Air Quality Management: Technical Guidance*. London: Defra Publications. (LAQM.TG(09))

1.3 Summary of Previous Rounds of Review and Assessment

Table 1.2 summarises the outcomes of WBC's previous rounds of Review and Assessment.

Table 1.2 Previous Rounds of Review and Assessment

Date(s)	Summary
2006 Updating and Screening	The Council did not identify a risk of the air quality objectives for carbon monoxide, benzene, 1,3-butadiene, lead, sulphur dioxide or PM_{10} being exceeded by the relevant years anywhere in the Council's area. Thus, the Council did not need to proceed beyond the Updating and Screening Assessment for these pollutants. An exceedence of the annual mean NO_2 objective was measured at Anchor Hill, Knaphill. As a consequence, the Council proceeded to a Detailed Assessment for this area.
2007 Detailed Assessment	A detailed modelling assessment was undertaken due to an exceedence of the annual mean objective for NO_2 identified by the diffusion tube monitoring at Anchor Hill, Knaphill. The modelling predicted that the highest levels of NO_2 were close to facades of houses on the north side of Anchor Hill, with concentrations just below the annual mean objective (by less than 1µg/m3). Predictions for 2010 indicated that concentrations at all facades and at the diffusion tube sites would not exceed the objective. As a result it was concluded that an Air Quality Management Area did not need to be designated in the area. The diffusion tube monitoring in this area was subsequently extended to include two additional locations.
2008 Progress Report	Monitoring data indicated that air quality objectives for NO_2 were not exceeded at locations of relevant public exposure across the borough.
2009 Updating and Screening Assessment	Monitoring within the borough confirmed that the annual mean NO_2 objective was exceeded at three locations: the kerbside sites at Anchor Hill in Knaphill; Victoria Way in Woking; and the bridge over the M25. These sites did not represent relevant exposure. All other sites in the borough monitored for nitrogen dioxide and benzene met the relevant annual mean objectives. No potential or actual exceedences at relevant locations were established, and so it was not necessary to proceed to a Detailed Assessment.
2010 Progress Report	Monitoring data indicated that air quality objectives for NO_2 were being met at locations of relevant public exposure across the borough. Therefore, it was not necessary to proceed to a Detailed Assessment for any location.
2011 Progress Report	Passive monitoring results highlighted seven areas in the borough with NO_2 levels exceeding the annual mean objectives. Two of these areas were representative of public exposure. The site at Anchor Hill (AH1) for which a Detailed Assessment had previously been carried out in 2007. This tube was not considered to be representative of nearby properties close to the road as it was not positioned at a location of relevant exposure. The Council planned to undertake additional monitoring at locations of relevant exposure and if exceedences were recorded, carry out a Detailed Assessment. The site on Monument Road recorded an exceedence for the first time. Further monitoring was recommended to determine if a Detailed Assessment was required.
2012 Updating Screening and Assessment	Additional monitoring at Anchor Hill identified exceedences of the annual mean objective for NO_2 at sites of relevant exposure. It was recommended that the Council proceed to a new Detailed Assessment for this junction. Additional monitoring was recommended for the area around Constitution Hill. All other monitoring recorded levels below the air quality objectives.
2012 Detailed Assessment	Due to monitored and modelled exceedences of the annual mean objective for NO_2 along Anchor Hill the Council look into declaring an AQMA and install some further monitoring in the area.
2013 Progress Report	The results from both monitoring and assessment of sources in the borough indicated that outside the planned Anchor Hill AQMA the air quality objectives were being met and will continue to be met in the future. No Detailed Assessments were required.
AQMA Declaration January 2014	The Council declared the Anchor Hill AQMA.

Table 1.3 (continued) Previous Rounds of Review and Assessment

Date(s)	Summary
Progress Report 2014	The results from both monitoring and assessment of sources in the borough indicated that with the exception of the Anchor Hill AQMA and an air quality "hot spot" at Constitution Hill the air quality objectives area were being met, and it was assessed that they will continue to be met in the future. Given the elevated NO_2 concentrations observed in 2013 and the limited number of diffusion tubes in the area known as Constitutional Hill, the Council intended to undertake additional diffusion tube monitoring at locations of relevant exposure. Should these diffusion tubes indicate exceedences of the annual average air quality objective, a Detailed Assessment will be undertaken to determine the magnitude and the geographical extent of the exceedence.

1.4 Purpose of this Report

The purpose of this report is to inform WBC whether the declaration of an AQMA at Anchor Hill was a valid decision and to determine the likely sources of pollutants within the AQMA in order to support the Action Planning process.

2. Methodology

2.1 Introduction

The methodology for undertaking the Further Assessment is outlined below. This methodology follows the guidance given in LAQM TG (09) in relation to undertaking a Further Assessment. The Further Assessment is expected to consider the following;

- Confirm the original assessment, including the verification of the detailed modelling, and thus ensure the AQMA designation and geographical scope of the AQMAs were based on robust information;
- Calculate more accurately what improvement in air quality, and corresponding reduction in emissions, would be required to attain the air quality objectives in the AQMA;
- Refine knowledge of the sources of pollution so the air quality Action Plan may be appropriately targeted;
- Ensure any new local developments that were not fully considered within earlier Review and Assessment work are considered *e.g.*, new transport schemes; and
- Use any additional monitoring which may have taken place since the Detailed Assessment to support the conclusions of the AQMA.

2.2 Dispersion Model Set-Up

Assessing the need for an AQMA was undertaken with detailed atmospheric dispersion modelling using the Cambridge Environmental Research Consultants Ltd (CERC) ADMS-Roads model (version 3.2.4.0). Key features of the atmospheric dispersion modelling system are summarised in Appendix B.

The modelling was used in order to predict NO_2 concentrations over a wider area than is possible with monitoring. The modelling encompassed the area from the High Street up to Anchor Hill and the junctions at Highclere Road and Lower Guildford Road.

Receptors were selected at the façades of buildings near the modelled road links. The receptors selected represent relevant exposure with respect to the NO_2 annual mean AQO. This includes locations where members of the public might be regularly exposed such as residential properties, schools and hospitals. Google Street View was used in conjunction with information supplied by WBC to find the locations and heights of receptors and monitoring sites. The receptors modelled in the assessment are given in Table 2.1 and are shown in Appendix C.

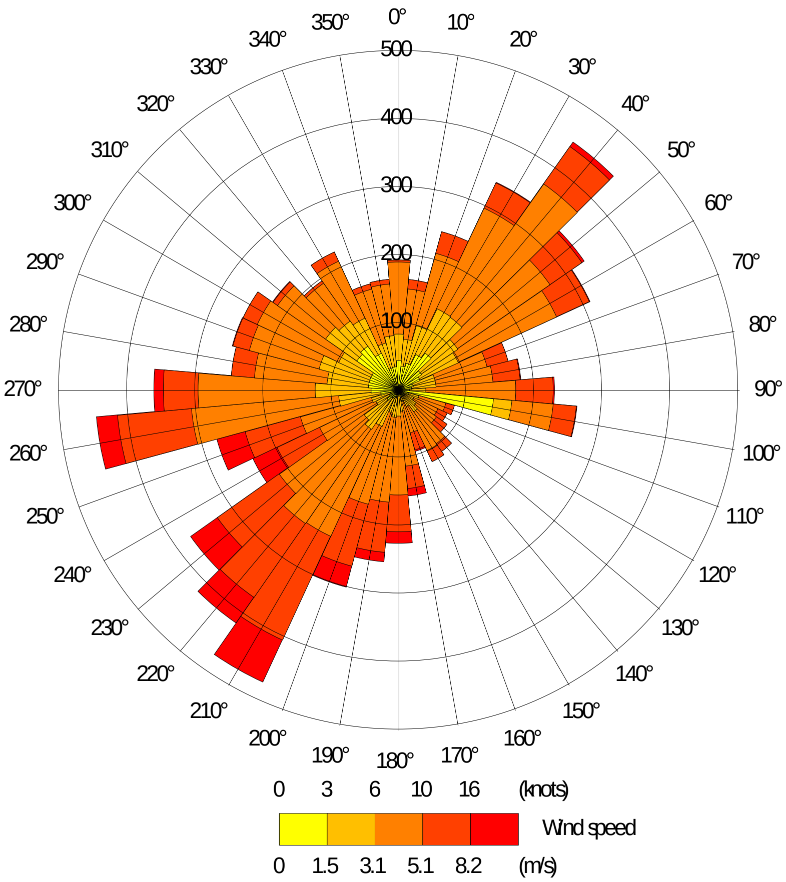
Table 2.1 Modelled Receptors

Receptor ID	Receptor Location	X (m)	Y (m)	Z (m)	Within AQMA?
R1	Cleve Court	496644	158713	1.5	Yes
R2	Residential	496623	158721	1.5	Yes
R3	Aragon Court	496628	158700	1.5	Yes
R4	Residential	496606	158701	1.5	Yes
R5	Tudor Court (north-side)	496609	158685	1.5	Yes
R6	Highclere Dental Practice	496593	158693	1.5	Yes
R7	Tudor Court (south-side)	496607	158668	1.5	Yes
R8	Residential	496564	158694	1.5	No
R9	The Anchor Pub (east-side)	496594	158642	1.5	No
R10	Pets Kingdom Shop	496567	158681	1.5	No
R11	The Anchor Pub (north-side)	496580	158658	1.5	No
R12	Knaphill Food & Wine Convenience Store	496550	158668	1.5	No

2.2.1 Meteorological Data

Meteorological data from Heathrow Airport weather station for 2013 was used in the model. The wind rose for Heathrow Airport is shown as Figure 2.1.

Figure 2.1 2013 Heathrow Airport Wind Rose



As illustrated by the wind rose, the prevailing winds are typical for the south of England, being dominated by winds from the south-westerly sectors.

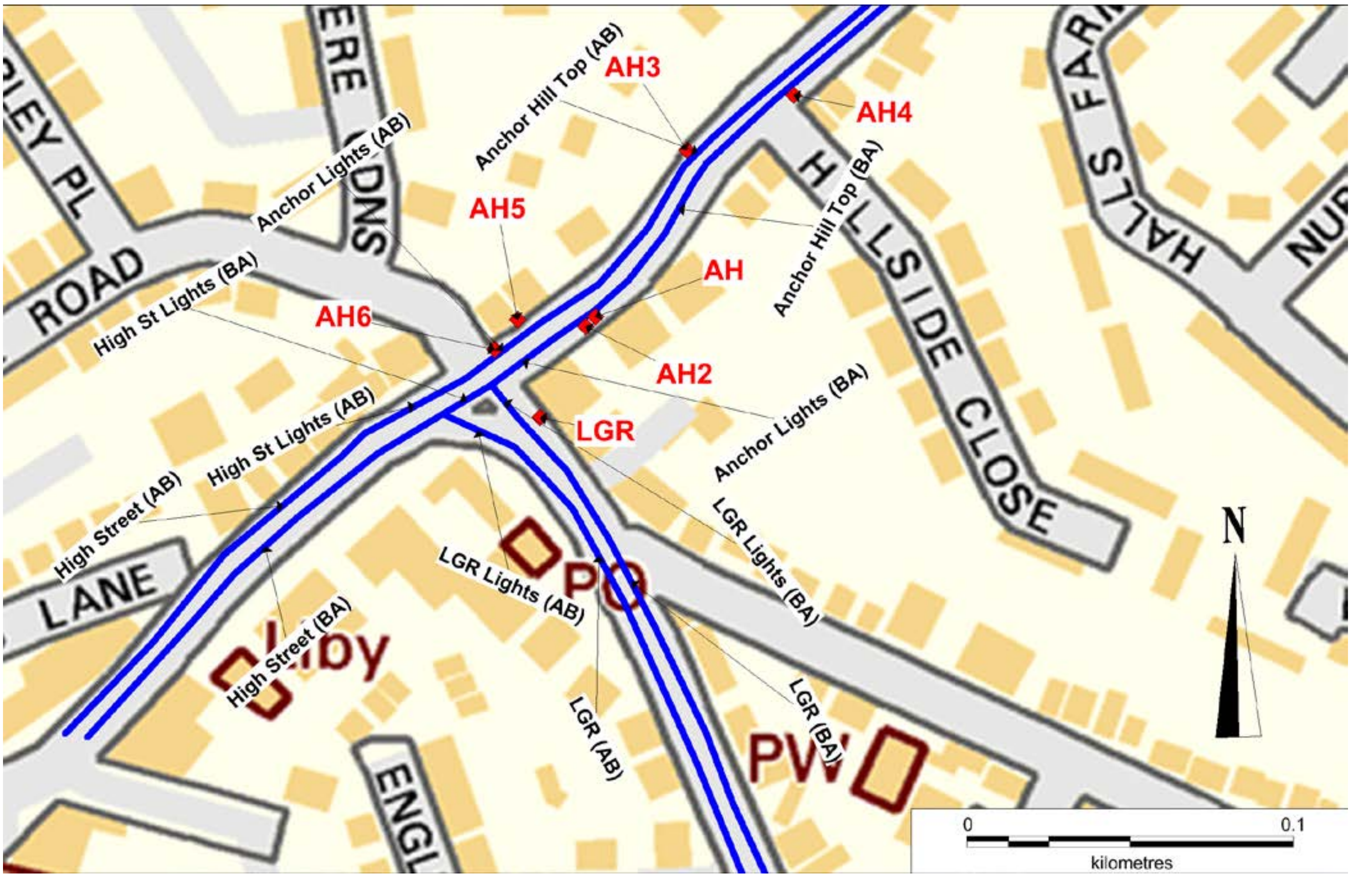
2.2.2 Traffic Data

Automatic Traffic Count (ATC) surveys were carried out in September 2014 for both directions of the following roads:

- Anchor Hill (between the junctions for Lower Guildford Road (LGR) and Hillside Close);
- LGR (between Queens Road and Victoria Road);and
- Anchor Hill (between Englefield Road and LGR).

From this data, average hourly traffic flows, class splits, and speeds for traffic flowing in each direction, were derived for each road. This information was used in the Defra Emissions Factor Toolkit (version 6.0.1) to derive hourly NO_X emission profiles for each road for weekdays, Saturday and Sunday traffic. The Toolkit uses NO_X emission factors from the European Environment Agency (EEA) COPERT 4 (version 8.1) emission calculation tool. The emission factors are available for three different road types outside London: ‘urban’, ‘rural’ and 'motorway'. For this assessment 'urban' was selected to represent the road links. Speeds were modified to account for increased emissions at the traffic lights, in accordance with LAQM.TG(09). The speed for traffic at the junction was reduced to 15 kph to represent the queuing at lights on the junction on Anchor Hill. The traffic data used in the assessment are summarised in Appendix D. Figure 2.2 shows the roads modelled.

Figure 2.2 Map Showing the Roads Modelled at Anchor Hill and Air Quality Monitoring Sites



Legend

Diffusion Tubes

ADMS Road Sources

2.2.3 Other Model Inputs

In this study, street canyons, noise barriers, buildings and complex terrain were not modelled. The ADMS-Roads link to MapInfo was used to enter source geometry.

2.2.4 Other Model Parameters

The surface roughness is a model parameter that is related to the height of features, such as buildings and trees. The value of 0.5 m is recommended in the ADMS models to represent open suburbia therefore a surface roughness value of 0.5 m was used to represent the nature of the surface features in the vicinity.

A value of 30 m, suitable for cities and large towns, was used for the minimum Monin-Obukhov length. This model parameter is used to account for the urban heat island effect where city buildings and surfaces are hotter than the surrounding air due to heating or release of heat absorbed. The urban heat island effect is most significant at night.

2.3 Model Verification

Model verification enables an estimation of uncertainty and systematic errors associated with the dispersion modelling components of the air quality assessment to be considered. There are many explanations for these errors, which may stem from uncertainty in the modelled number of vehicles, speeds and vehicle fleet composition. Defra has provided guidance in terms of preferred methods for undertaking dispersion model verification[1]. Model verification involves the comparison of modelled concentrations and local NO_X / NO_2 monitoring data.

Full details of the model verification procedure are provided in Appendix E. The verification process concluded that a model adjustment factor of 2.6 was required. All modelled concentrations with respect to this assessment area have been adjusted using the adjustment factor of 2.6. The modelled results are discussed in Section 4

3. Baseline Information

3.1 Air Quality Monitoring

3.1.1 Automatic Monitoring

There are no continuous monitoring sites located within Woking Borough.

3.2 Non-Automatic Monitoring

WBC undertook diffusion tube monitoring at 24 locations in 2013, seven of which are in the assessment area. All seven of the diffusion tubes are roadside sites.

Table 3.1 presents the details of the NO_2 diffusion tube monitoring sites which are relevant to this Further Assessment. Table 3.2 displays the results of the diffusion tube monitoring for 2011 to 2013. Figure 3.1 shows the locations of the diffusion tubes.

Table 3.1 Diffusion Tube Monitoring Site Details

Site ID	Site Name	X (m)	Y (m)	In AQMA?
AH	Anchor Hill 1	496618	158699	Yes
AH2	Anchor Hill 2	496615	158696	Yes
AH3	Anchor Hill 3	496646	158750	Yes
AH4	Anchor Hill 4	496679	158767	No
AH5	Anchor Hill 5	496594	158698	Yes
AH6	Anchor Hill 6	496587	158689	Yes
LGR	Lower Guildford Road	496601	158668	Yes

Table 3.2 Bias Adjusted Diffusion Tube Monitoring Results for 2011-2013

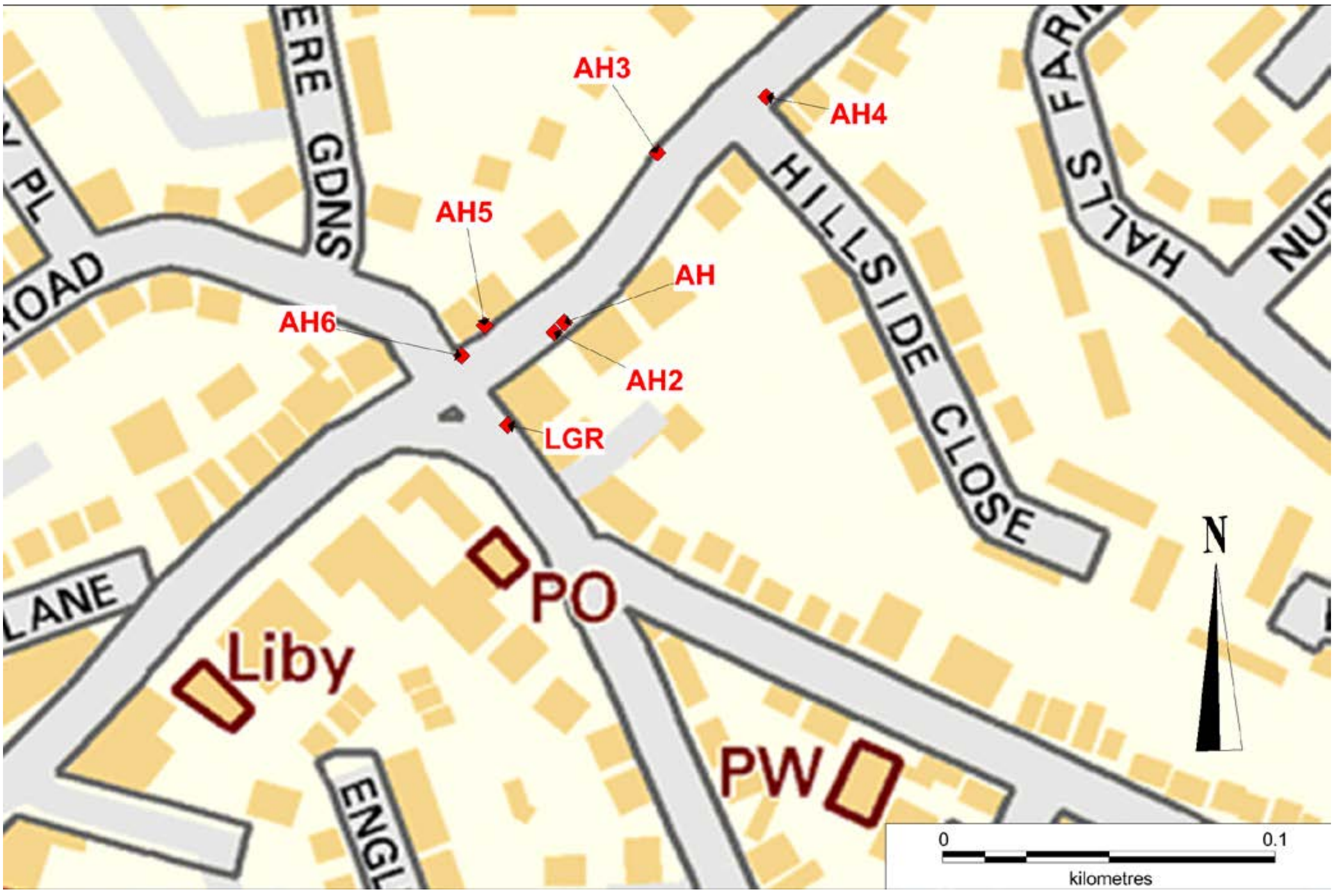
Site ID	Site Name	Annual Mean Concentrations (μg m^{-3})		
		2011	2012	2013
AH	Anchor Hill 1	**47.7**	35.1	**41.5**
AH2	Anchor Hill 2	37.6	**42.8**	36.5
AH3	Anchor Hill 3	28	30.4	30.7
AH4	Anchor Hill 4	-	33.3	32.0*
AH5	Anchor Hill 5	-	15.5[a]	32.0**
AH6	Anchor Hill 6	-	-	38.0**
LGR	Lower Guildford Road	-	-	32.3**

Notes: *9 months of data available
** 11 months of data available
[a] Limited amount of data available
Figures in bold indicate a value above the annual mean AQO of 40 μg m^{-3}

The NO_2 diffusion tubes were supplied and analysed in 2013 by Lambeth Scientific Services and prepared using 50% TEA/Acetone. The most up to date diffusion tube bias adjustment value for 2012/13 of 0.87 was obtained from the LAQM spreadsheet published September 2013 produced by Defra.

Six of the seven diffusion tubes are in the AQMA that is subject of this Further Assessment. There have been exceedences of the NO_2 annual mean of 40 μg m^{-3}AQO in 2011 and 2013 at AH and in 2012 at AH2. AH was the only site to measure an exceedence of the annual mean in 2013, at 41.5 μg m^{-3}. There were no exceedences of this objective at AH3, AH4, AH5, AH6 or LGR in the data available.

Figure 3.1 Diffusion Tube Monitoring Locations



3.3 Background Concentrations

Defra maintains a nationwide model of existing future background air quality concentrations at 1 km grid square resolution. The 2013 background maps[2] for NO_X, derived from a 2011 base year, have been used to provide background concentrations for the Further Assessment of the AQMA at Anchor Hill in Woking.

The background NO_X and NO_2 concentrations used in the Further Assessment are given in Table 3.3.

Table 3.3 Annual Mean Background Concentrations used in the Further Assessment

Grid Reference 496500, 158500	2013 Concentration (µg m^{-3})
NO_2	15.4
NO_x	21.5

[2] Defra (2014) *Background Maps* [online] Available at: http://uk-air.defra.gov.uk/data/laqm-background-home

4. Results

4.1 Modelled Receptor Results

Annual average concentrations for NO_2 were predicted at relevant receptors for 2013. The results are given in Table 4.1. The predicted annual mean concentrations of NO_2 at Receptor 6, on the corner of Highclere Road and Anchor Hill was 43.4 µg m^{-3}. All other modelled receptors and monitoring locations in the vicinity of the junction between Anchor Hill, Lower Guildford Road and Highclere Road meet the AQO of 40 µg m^{-3}. As all modelled annual mean concentrations are less than 60 µg m^{-3}, exceedences of the hourly mean at relevant receptors in this area are unlikely.

Table 4.1 Results of Detailed Dispersion Modelling at Anchor Hill

Receptor	X (m)	Y (m)	Z (m)	Road NO_x Contribution (µg m^{-3})	Total Modelled NO_2 (µg m^{-3})
Receptor 1	496644	158713	1.5	18.4	24.4
Receptor 2	496623	158721	1.5	23.8	26.9
Receptor 3	496628	158700	1.5	24.6	27.3
Receptor 4	496606	158701	1.5	48.1	37.2
Receptor 5	496609	158685	1.5	34.1	31.4
Receptor 6	496593	158693	1.5	64.6	43.4
Receptor 7	496607	158668	1.5	29.2	29.3
Receptor 8	496527	158648	1.5	40.0	33.9
Receptor 9	496594	158642	1.5	21.5	25.9
Receptor 10	496567	158681	1.5	33.3	31.1
Receptor 11	496580	158658	1.5	39.4	33.7
Receptor 12	496550	158668	1.5	43.3	35.3

4.2 Source Apportionment

In order to develop an appropriate Action Plan it is necessary to identify the sources contributing to the objective exceedences at locations within the AQMAs. This has been broken down in to the regional and local background contribution as well as the local traffic contribution. Local traffic contributions have been derived by apportioning the road NOx contribution at the free-flowing sections of High Street, Anchor Hill and Lower Guildford Road in accordance with the contributions from each vehicle class in the Emissions Factor Toolkit.

Table 4.2 sets out the source contributions to the total ambient concentration, at representative receptors for each road (High Street – Receptor 8, Anchor Hill - Receptor 2, and Lower Guildford Road – Receptor 9) as actual NO_2

concentrations and as percentages. The regional and local background concentrations use the data for 2013 supplied by Defra. The percentages are shown in Figure 4.1, Figure 4.2 and Figure 4.3.

The results clearly show that local traffic sources are generally the predominant source of NO_2 concentrations within the AQMA, contributing between 50% and 65%. Diesel cars and Light Goods Vehicles (LGVs) are a key source of emissions, as combined they contribute 46% to NO_2 concentrations on the High Street and 37% on Anchor Hill and on Lower Guildford Road.

Table 4.2 Source Apportionment Results

	High Street		Anchor Hill		Lower Guildford Road	
	Concentration (µg m^{-3})	%	Concentration (µg m^{-3})	%	Concentration (µg m^{-3})	%
Regional Background	9.5	15.5	9.5	21.0	9.5	22.2
Local Background	12.0	19.5	12.0	26.4	12.0	27.8
Local	40.0	65.1	23.8	52.6	21.5	50.0
- Petrol Cars	2.2	3.6	2.2	4.9	1.3	3.0
- Diesel Cars	8.3	13.5	8.1	17.8	4.7	10.9
- Petrol LGV	0.3	0.6	0.2	0.4	0.2	0.5
- Diesel LGV	20.2	32.8	8.9	19.6	11.1	25.8
- Rigid HGV	6.9	11.3	3.6	7.9	3.7	8.7
- Artic HGV	0.8	1.3	0.7	1.6	0.3	0.7
- Buses/Coaches	1.1	1.8	0.1	0.3	0.2	0.4
- Motorcycles	0.1	0.1	0.0	0.1	0.0	0.1

Figure 4.1 Source Apportionment – High Street

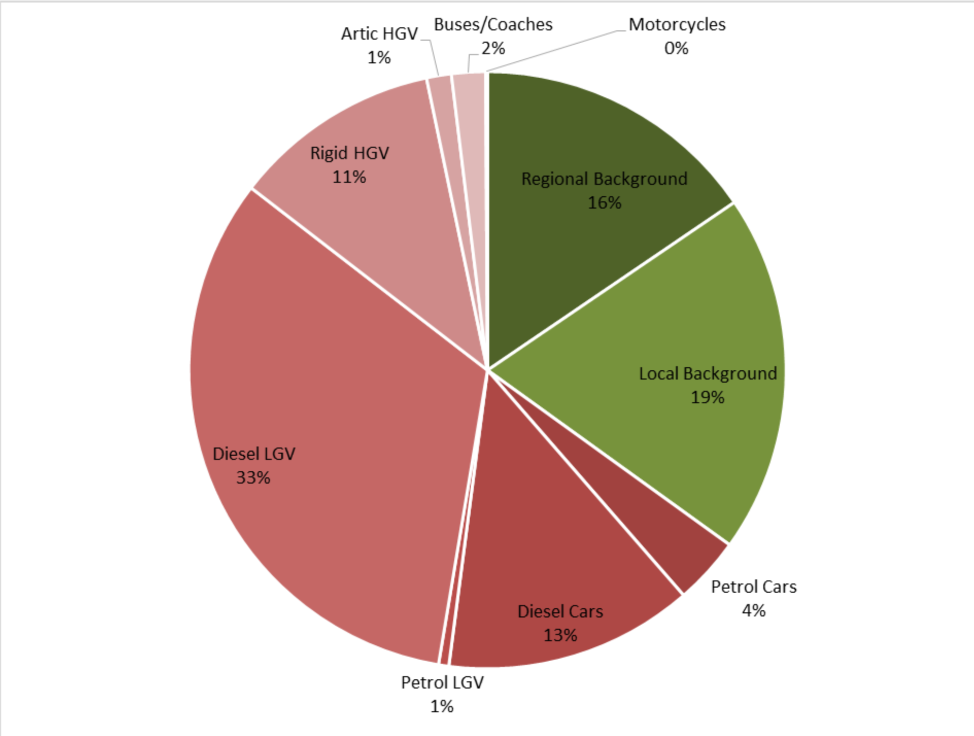


Figure 4.2 Source Apportionment – Anchor Hill

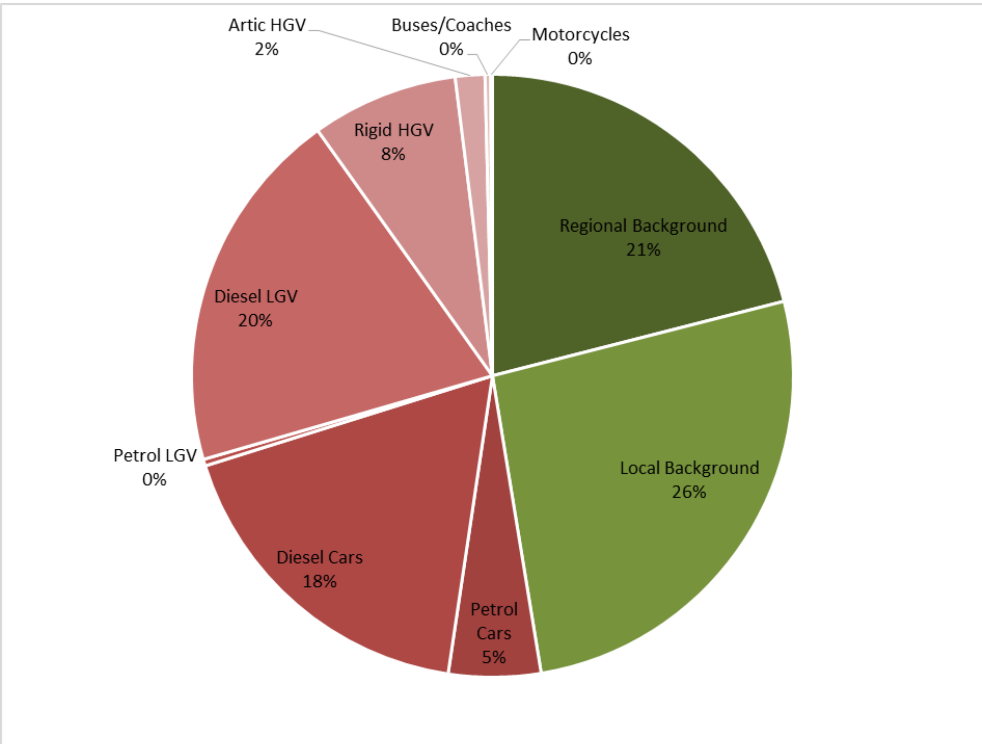
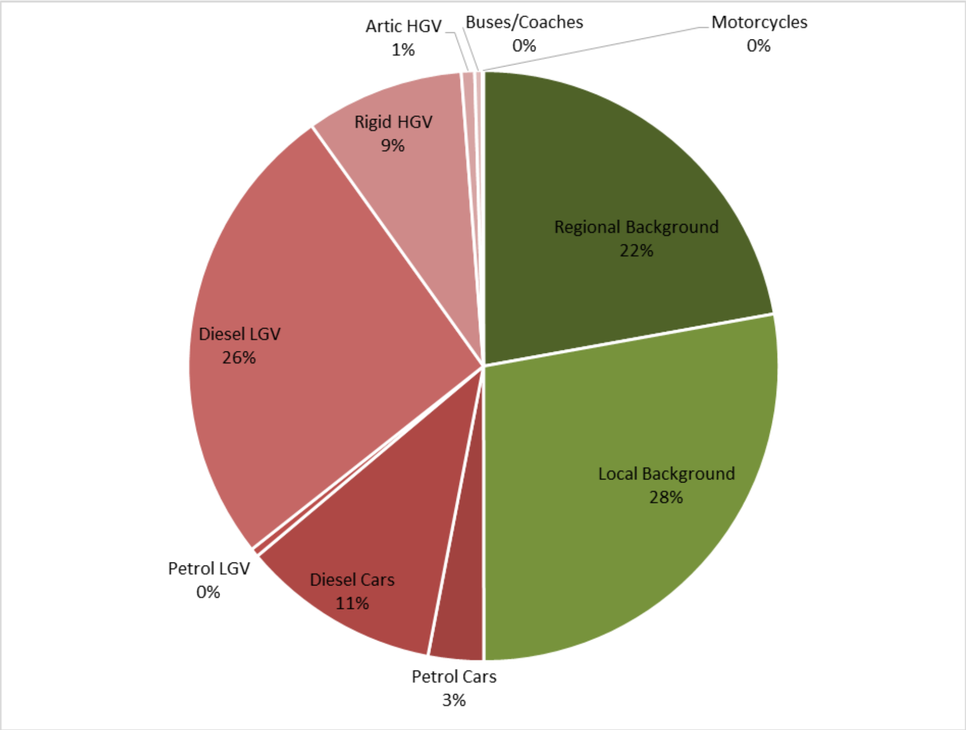


Figure 4.3 Source Apportionment – Lower Guildford Road



5. Air Quality Improvements Required

It should be noted that the issue of NO_2 reduction is complex in that a certain reduction in NO_X emissions does not necessarily deliver an equivalent improvement in air quality (reduction in NO_2 concentration) since non-linear chemical transformations take place between the emitted NO_X and the background NO_X. The non-linear chemistry is taken into account when estimating the amount of emission reduction necessary to achieve the AQOs.

The emissions reduction required at the modelled receptor with the highest NO_2 concentration (Receptor 6) is given in Table 5.1. This shows the reductions required to achieve the annual mean NO_2 AQO as both road NO_X concentrations and the percentage reductions required in NO_X emissions. The reductions have been calculated using the methodology in LAQM.TG (09).

Table 5.1 Estimates of Emissions Reductions required to achieve the Annual NO_2 AQO.

Receptor	Modelled NO_2 concentration (µg m^{-3})	Road NOx concentration (µg m^{-3})	Road NOx concentration required for NO_2 concentration of 40µg m^{-3} (µg m^{-3})	% NO_X emissions reduction required
Receptor 6	43.9	66.4	55.4	16.6%

The results show that a reduction in NO_X emissions and, therefore, road NOx concentrations of around 17% is required to achieve compliance within the AQMA.

Using the guidance in LAQM TG (09) located in paragraphs 2.10 to 2.14, a prediction of when the annual mean AQO for NO_2 will be met at the receptor locations can be undertaken. This method uses the ratio of adjustment factors for the future year and the year in which data is available, to predict the NO_2 concentrations in future years. The adjustment factors have been taken from the Defra website which provides the most up to date factors.

The guidance has therefore been used to predict when the annual mean AQO for NO_2 will be met at modelled location with the highest concentration (43.4 µg m^{-3} at Receptor 6). The calculations show that the annual mean NO_2 AQO is likely to be achieved by 2017. Actual monitored concentrations (maximum of 41.5 µg m^{-3}) are lower than the maximum modelled concentration, so the AQO may be achieved earlier (2016).

These predictions assume only that the emissions factors associated with the vehicle fleet mix in Woking would change as a result of changes to the national fleet, as newer cars are brought onto the market that have lower emissions. In the past few years it has become apparent that this decrease in emissions associated with the national fleet has not been realised. Monitoring data has shown that NO_2 concentrations at roadside locations are remaining the same or in some cases increasing. The reason for this disparity is thought to be related to the poorer actual on-road performance of diesel road vehicles when compared to their performance under test conditions for the Euro standards. The forecast reductions in background NO_X and the associated NO_2 concentrations associated with the road traffic component (which have been used in these calculations) are, therefore, likely to be optimistic. These results do not take into account any growth in traffic data or congestion as a result of new developments or changes in road layouts. Therefore, if the traffic levels should increase significantly and/or changes to emissions from the vehicles fleet do not occur as currently predicted then, in the absence of other action, the AQO may not be achieved by 2017.

6. Conclusions and Recommendations

This Further Assessment, using monitoring data and modelling for 2013, has been undertaken in order to assess whether the conclusions of the Detailed Assessment undertaken in 2012 were valid and remain valid and to determine the sources of pollutants within the declared AQMAs and what reduction in emissions is required within the AQMAs in order for the AQOs to be achieved. The assessment used monitoring data in addition to detailed dispersion modelling of emissions in the AQMA. ATC data supplied collected in 2014 has been used in the detailed dispersion modelling. This data has been processed to provide an hourly emissions profile for use in the detailed dispersion model.

The Detailed Assessment undertaken in 2012 resulted in the declaration of an AQMA at the Anchor Hill junction as a result of exceedence of the annual average NO_2 AQO. This Further Assessment has shown that both the monitoring results for 2013 and the modelling undertaken confirm the conclusions of the Detailed Assessment and for the extent of the AQMA. In 2013, exceedence of the annual mean NO_2 AQO was recorded at diffusion tube AH on the south side of Anchor Hill. Modelling predicted that, at the junction between Anchor Hill, Lower Guildford Road and Highclere Road annual mean NO_2 AQO is likely to be exceeded. These results, with recorded and predicted exceedences of the AQO on both sides of Anchor Hill suggest that the existing extent of the AQMA should be maintained as it includes the relevant receptors immediately to the east of the junction.

The calculation of the likely sources of NO_2 concentrations within the AQMAs has also been undertaken as part of this Further Assessment. This has found that a largest proportion of NO_2 concentrations within the AQMAs are from local traffic in the area. Breaking down this local traffic proportion into the source of annual mean NO_2 concentrations, the contribution of diesel cars and LGVs was found to have a significant influence on total concentrations as a result of their number (41% of cars, 97% of LGVs) and significantly higher NO_X emissions relative to petrol equivalents.

As part of this Further Assessment, a calculation of the reduction in NO_X emissions required for the annual mean NO_2 AQO to be achieved within the AQMA has also been undertaken. This has been based on the maximum modelled NO_2 concentration within the AQMA. The estimate of the NO_X emission reduction required is up to 17% which corresponds to a reduction in road NOx concentrations of around 11 $\mu g\ m^{-3}$.

A prediction of when the annual mean NO_2 AQO will be achieved in the AQMA was also undertaken. This predicted that the annual mean NO_2 AQO will be achieved by 2017 assuming that predicted reductions in roadside NO_2 concentration as a result of fleet renewal actually occur. This prediction is based only on changes to the national fleet emissions and does not take into account any increase in traffic flows or congestion in the area. It has been found nationally that the prediction of the effect of national fleet emissions on actual NO_X and NO_2 concentrations, especially at roadside locations, is optimistic and NO_2 concentrations are not decreasing as predicted. This situation is expected to improve with the progressive introduction of Euro VI diesel cars into the fleet from 2015. However, NO_2 concentrations within the AQMA may not be below the AQOs by 2017 without action being taken by WBC.

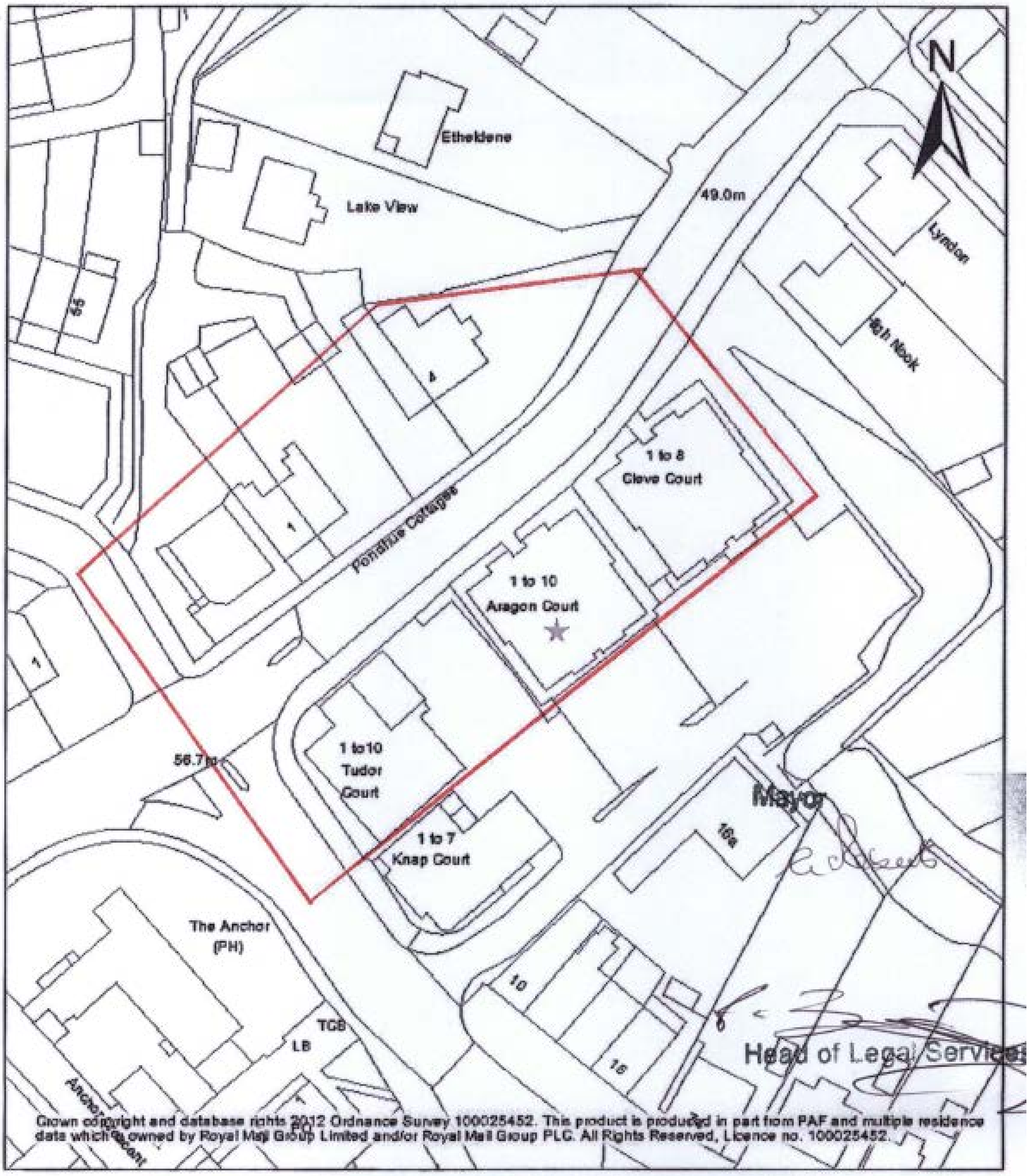
6.1 Recommendations

Based on the results of the assessment it is recommended that the AQMA should remain in place as both monitoring and modelling results show that although in some places the objective is being achieved, concentrations in some places are above the AQO.

WBC should also use the results of the source apportionment calculations and the reduction in NOx emissions calculations to inform development of an AQAP to achieve compliance with the AQO at an earlier date than would be the case if relying on fleet renewal alone. As WBC has no feasible mechanism for control over the proportion of diesel cars and LGVs in the fleet accessing the Anchor Hill junction, the most effective measures to tackle pollution in the AQMA would be those that reduce the total traffic volume, the amount of time that vehicles spend at the junction with their engines running and/ or those that reduce acceleration across the junction.

Appendix A
Map of Anchor Hill AQMA

A1



Woking Borough Council	Title	Scale 1:700
		Date 01/11/2012 / XY centrepoint 496623,158696
	Project / Details	Drawn by / Department
		Drawing / Reference Number

Appendix B
Atmospheric Dispersion Modelling

Introduction

The ADMS-Roads dispersion model, developed by CERC[3], is tool for investigating air pollution problems due to small networks of roads that may be in combination with industrial sites, for instance small towns or rural road networks. It calculates pollutant concentrations over specified domains at high spatial resolution (street scale) and in a format suitable for direct comparison with a wide variety of air quality standards for the UK and other countries. The latest version of the model, version 3.4.2, was used in this study.

ADMS-Roads is referred to as an advanced Gaussian or, new generation, dispersion model as it incorporates the latest understanding of the boundary layer structure. It differs from old generation models such as ISC, R91 and CALINE in two main respects:

- It characterises the boundary layer structure and stability using the boundary layer depth and Monin-Obukhov length to calculate height-dependent wind speed and turbulence, rather than using the simpler Pasquill-Gifford stability category approach; and
- It uses a skewed-Gaussian vertical concentration profile in convective meteorological conditions to represent the effect of thermally generated turbulence.

Model Features

A description of the science used in ADMS-Roads and the supporting technical references can be found in the model's User Guide[4]. The main features of ADMS-Roads are:

- It is an advanced Gaussian, "new generation" dispersion model;
- Includes a meteorological pre-processor which calculates boundary layer parameters from a variety of input data e.g. wind speed, day, time, cloud cover and air temperature;
- Models the full range of source types encountered in urban areas including industrial sources (up to 3 point sources, up to 3 lines sources, up to 4 area sources, up to 25 volume sources) and road sources (up to 150 roads, each with 50 vertices);
- Generates output in terms of average concentrations for averaging times from 15minutes to 1 year, percentile values and exceedences of threshold values. Averages can be specified as rolling (running) averages or maximum daily values;

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[3] CERC (2012) *ADMS-Roads* [online]. Available at: http://www.cerc.co.uk/environmental-software/ADMS-Roads-model.html [Accessed 19 October 2012]

[4] CERC (2011) *ADMS-Roads, an Air Quality Management System, Version 3.1 User Guide* [online]. Available at: http://www.cerc.co.uk/environmental-software/assets/data/doc_userguides/CERC_ADMS-Roads3.1_User_Guide.pdf [Accessed 19 October 2012]

- The option to calculate emissions from traffic count data, speed and fleet split (light duty/heavy duty vehicles) using UK emission factors. Alternatively, road emissions may be entered directly as user specified values;

- Models plume rise by solving the integral conservation equations for mass, momentum and heat;

- Models the effect of street canyons on concentrations within the canyon and vehicle–induced turbulence using a formulation based on the Danish OSPM model. It is usually only important to model street canyons when the aspect ratio (ratio of the height of buildings along the road to the width of the road) is greater than 0.5;

- Models the effects of noise barriers on concentrations outside the road;

- Models NO_X chemistry using the 8 reaction Generic Reaction Set plus transformation of SO_2 to sulphate particles, which are added to the PM_{10} concentration;

- Models the effect of a small number of buildings on dispersion from point sources;

- Models the effect of complex terrain (hills) and spatially varying surface roughness. Terrain effects only become noticeable for gradients greater than 1:10, but for ground level sources in a built up area, such as urban roads, low gradients will have a negligible effect;

- Models concentrations in units of $ou_E m^{-3}$ for odour studies;

- Link to MapInfo and ArcGIS for input of source geometry, display of sources, aggregation of emissions and plotting of contours; and

- Link to an emissions inventory in Microsoft Access for input and export of source and emissions data.

In this study, street canyons, buildings and complex terrain were not modelled. The link to MapInfo was used to enter source geometry. Emissions were calculated outside ADMS-Roads from traffic count, speed and fleet composition data using the very latest version of the UK's Emission Factor Toolkit (version 6.0.1), and then entered directly as user specified values.

Validation

ADMS-Roads has been validated using UK and US data and has been compared with the DMRB spreadsheet model and the US model, CALINE. Validation of the ADMS and ADMS-Urban models are also applicable to the performance of ADMS-Roads as they test common features: basic dispersion, modelling of roads and street canyons, the effect of buildings and the effect of complex terrain. These validation studies are all reported on the CERC web site[5]. In addition, ADMS-Urban has been validated during its use in modelling many urban areas in the

[5] CERC (2012) *Model Documentation* [online]. Available at: http://www.cerc.co.uk/environmental-software/model-documentation.html#validation [Accessed 19 October 2012]

UK for local authorities as part of LAQM, Heathrow Airport for the Department for Transport[6] and all of Greater London for a Defra model inter-comparison exercise[7].

[6] CERC (2007) *Air Quality Studies for Heathrow: Base Case, Segregated Mode, Mixed Mode and Third Runway Scenarios Modelled Using ADMS-Airport, prepared for the Department for Transport, HMSO* Product code 78APD02904CERC

[7] Carslaw, D. (2011) *Defra urban model evaluation analysis – Phase 1, a report to Defra and the Devloved Authorities*. [online] Available at: http://uk-air.defra.gov.uk/library/reports?report_id=654 [Accessed 19 October 2012]

Appendix C
Receptor Locations

Figure C1 Receptor Locations

Appendix D
Traffic Data

Table D1 Summary of Traffic Data used in the Assessment

Road Source	AADT	% HDV	Average Speed (kmh^{-1})	Road Width (m)**
Anchor Hill Top (AB)	7,299	2.66	43.2	5
Anchor Hill Top (BA)	6,313	3.07	36.6	5
LGR (AB)	4,242	3.59	35.3	4
LGR (BA)	3,574	3.72	44.8	4
High Street (AB)	6,353	3.26	34.4	4
High Street (BA)	6,389	3.94	34.2	4
Anchor Lights (AB)	7,299	2.66	15.00*	5
Anchor Lights (BA)	6,313	3.07	15.00*	5
LGR Lights (AB)	4,242	3.59	15.00*	8
LGR Lights (BA)	3,574	3.72	15.00*	5
High St Lights (AB)	6,353	3.26	15.00*	5
High St Lights (BA)	6,389	3.94	15.00*	6

Note: * An estimated average speed of 15 kmph has been provided for traffic on all roads approaching the traffic lights.
** Road widths were estimated using grid reference finder[8].

[8] http://www.gridreferencefinder.com

Appendix E
Model Verification

ADMS-Roads 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(09) guidance as an accepted dispersion model.

Model validation undertaken by the software developer (CERC) will not have included validation in the vicinity of the proposed development site. 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;
- Meteorological data;
- Source activity data such as traffic flows and emissions factors;
- Model input parameters such as surface roughness length, minimum Monin-Obukhov length;
- 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;
- Road widths;
- Distance between sources and monitoring as represented in the model;
- Speed estimates on roads;
- Source types, such as elevated roads and street canyons;
- Selection of representative meteorological data;
- Background monitoring and background estimates; and
- Monitoring data.

Traffic data was obtained from surveys undertaken in Autumn 2014. Road widths and receptor distances were checked using electronic OS mapping data.

Suitable local monitoring data for the purpose of verification is available for annual mean NO_x/NO_2 concentrations as shown in Table E1 below.

Table E1 Local Monitoring Data Suitable for ADMS-Roads Model Verification

Site	X (m)	Y (m)	2013 Annual Mean NO_2 (μgm^{-3})
AH	496618	158699	41.5
AH2	496615	158696	36.5
AH3	496646	158750	30.7
AH4	496549	158636	32.0
AH5	496594	158698	32.0
AH6	496587	158689	38.0
LGR	496601	158668	32.3

Verification Calculations

The verification of the modelling output was performed in accordance with the methodology provided in Annex 3 of LAQM.TG(09). Table E2 shows that the agreement between monitored and modelled concentrations was not within 25%, with modelled concentrations being below modelled at all sites. It was decided to determine an adjustment factor to be applied to the results.

Table E3 shows the comparison of modelled road NO_X, a direct output from the ADMS-Roads modelling, with the monitored road NO_X, determined from the AEA NO_X to NO_2 conversion tool. The comparison of modelled and monitored road NO_X gives a regression adjustment factor of 2.6. Table E4 shows the comparison of the modelled NO_2 concentrations calculated by multiplying the modelled road NO_X by the adjustment factor of 2.6 and using AEA's NO_X to NO_2 conversion tool to calculate the total adjusted modelled NO_2. Table E4 shows that the adjusted modelled annual mean concentrations show an agreement with the monitored concentrations that is within 25% at all sites.

Table E2 Verification, Modelled Versus Monitored

Site	2013 Modelled Annual Mean NO_2 (μg m^{-3})	2013 Monitored Annual Mean NO_2 (μg m^{-3})	% (Modelled-Monitored)/Monitored
AH	24.0	41.5	-42.27%
AH2	23.8	36.5	-34.79%
AH3	20.9	30.7	-32.08%
AH4	22.3	32.0	-30.41%
AH5	21.9	32.0	-31.63%
AH6	27.4	38.0	-27.79%
LGR	22.8	32.3	-29.35%

Table E3 Comparison of Modelled and Monitored Road NO_X to Determine Verification Factor

Site	2013 Monitored Annual Mean Road NO_X (μg m^{-3})	2013 Modelled Annual Mean Road NO_X (μg m^{-3})	Ratio
AH	59.4	17.4	3.4
AH2	46.4	17.0	2.7
AH3	32.3	10.9	3.0
AH4	35.4	13.8	2.6
AH5	35.4	13.0	2.7
AH6	50.2	24.9	2.0
LGR	36.1	15.0	2.4

Table E4 Comparison of Adjusted Modelled NO_2 and Modelled NO_2

Site	2013 Background NO_X Concentration	2013 Background NO_2 Concentration	2013 Adjusted Modelled Annual Mean NO_2 (μgm^{-3})	2013 Monitored Annual Mean NO_2 (μgm^{-3})	% (Modelled-Monitored) /Monitored
AH	21.5	15.4	35.8	41.5	-12.9%
AH2	21.5	15.4	35.4	36.5	-1.9%
AH3	21.5	15.4	28.8	30.7	-9.7%
AH4	21.5	15.4	32.0	32.0	-18.4%
AH5	21.5	15.4	31.1	32.0	-1.8%
AH6	21.5	15.4	43.2	38.0	15.4%
LGR	21.5	15.4	33.3	32.3	5.9%