Detailed Assessment of Air Quality 2011/12

Nantgarw Road, Caerphilly

Report for Caerphilly Borough Council

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Executive summary

AEA were commissioned to undertake this Detailed Assessment of Air Quality for Nantgarw Road, Caerphilly by Caerphilly County Borough Council. The assessment has been undertaken to investigate the potential scale and extent of exceedances of Air Quality Objectives in the study area. This Detailed Assessment will allow Caerphilly County Borough Council to decide whether or not an Air Quality Management Area is required at the location.

The study was based on measurements and dispersion modelling of traffic emissions covering the period 1st May 2011 to 30th April 2012. The study was not based on the time period of a calendar year as is typically used for a Detailed Assessment due to the availability of automatic monitoring data for the study.

The modelling study, which has used the most recent traffic, monitoring and meteorological data for the area indicates that there are exceedances of the NO_2 annual mean objective occurring at locations where relevant exposure is present along various sections of Nantgarw Road.

In light of the findings of this Detailed Assessment of Air quality, it is concluded that Caerphilly County Borough Council should extend the existing Caerphilly town centre Air Quality Management Area to include the affected sections of Nantgarw Road.

Table of contents

Table of figures

Appendices

1 Introduction

AEA have been commissioned by Caerphilly County Borough Council to undertake a Detailed Assessment of Air Quality for Nantgarw Road in Caerphilly. The assessment has been undertaken to investigate the scale and spatial extent of nitrogen dioxide (NO_2) concentrations that may potentially be in excess of the UK Air Quality Objectives within the study area. The Detailed Assessment will allow Caerphilly County Borough Council to establish if an Air Quality Management Area is required at the study location. The assessment also includes a breakdown of the various source contributions to NO_2 concentrations in the study area.

1.1 Policy background

The Environment Act 1995 placed a responsibility on UK Government to prepare an Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland. The most recent version of the strategy (2007) sets out the current UK framework for air quality management and includes a number of air quality objectives for specific pollutants.

The 1995 Act also requires that Local Authorities "Review and Assess" air quality in their areas following a prescribed timetable. The Review and Assessment process is intended to locate and spatially define areas where the AQS objectives are not being met. In such instances the Local Authority is required to declare an Air Quality Management Area (AQMA), carry out a Further Assessment of Air Quality, and develop an Air Quality Action Plan (AQAP) which should include measures to improve air quality so that the objectives may be achieved in the future. The timetables and methodologies for carrying out Review and Assessment studies are prescribed in Defra's Technical Guidance - LAQM.TG(09).

Table 1 lists the air quality objectives relevant to this assessment that are included in the Air Quality Regulations 2000 and (Amendment) Regulations 2002 for the purposes of Local Air Quality Management (LAQM).

Table 1: NO_2 Objectives included in the Air Quality Regulations and subsequent Amendments for the purpose of Local Air Quality Management

Pollutant	Air Quality Objective	
	Concentration	Measured as
Nitrogen dioxide	200 $\mu g.m^{-3}$ not to be exceeded more than 18 times a year	1 hour mean
	40 $\mu g.m^{-3}$	annual mean

1.2 Locations where the objectives apply

When carrying out the review and assessment of air quality it is only necessary to focus on areas where the public are likely to be regularly present and are likely to be exposed over the averaging period of the objective. Table 2 summarises examples of where air quality objectives for NO_2 should and should not apply.

Table 2: Examples of where the NO_2 Air Quality Objectives should and should not apply

Averaging Period	Pollutants	Objectives *should* apply at …	Objectives should *not* generally apply at …
Annual mean	NO_2	All locations where members of the public might be regularly exposed. Building façades 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
1-hour mean	NO_2	All locations where the annual mean and 24 and 8-hour mean objectives apply. Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks and railway stations etc. which are not fully enclosed. Any outdoor locations to which the public might reasonably be expected to have access.	Kerbside sites where the public would not be expected to have regular access.

1.3 Purpose of this Detailed Assessment

This study is a Detailed Assessment, which aims to assess the magnitude and spatial extent of any exceedances of the NO_2 objectives at locations where relevant human exposure may occur within the Nantgarw Road area of Caerphilly.

1.4 Overview of the Detailed Assessment

The general approach taken in this Detailed Assessment was to:

- Collect and interpret data from previous Review and Assessment reports.
- Collect and analyse recent traffic, monitoring, meteorological and background concentration data for use in a dispersion modelling study.
- Use dispersion modelling to produce numerical predictions of NO_2 concentrations at points of relevant exposure.
- Produce contour plots showing the spatial variation of predicted NO_2 concentrations;
- Recommend if Caerphilly Borough Council should extend their current AQMA within Caerphilly and suggest its spatial extent.

The modelling methodologies provided for Detailed Assessments outlined in Defra Technical Guidance LAQM.TG(09)[1] have been used throughout the study.

[1] Local Air Quality Management Technical Guidance LAQM.TG(09), Defra, 2009

1.5 Review and Assessment work completed to date

The following is summary of the information extracted from recent review and assessment reports relevant to air quality within the town of Caerphilly. This summary aims to provide the background history relevant to the Detailed Assessment currently being conducted for Nantgarw Road, Caerphilly.

2003 Updating and Screening assessment: The report concluded that all air quality objectives would be met by the relevant deadlines, but that further monitoring was required at a number of locations where road traffic emissions were highest.

2004 Progress Report: No measured pollutant concentrations in excess of the objectives were reported. The report recommended continued diffusion tube monitoring and the installation of an automatic monitoring site in Caerphilly town centre.

2005 Progress Report: Concentrations in excess of the annual mean NO_2 objective were measured at White Street in Caerphilly town centre during 2004.

2006 Detailed Assessment: The modelling assessment of NO_2 in Caerphilly predicted that the UK annual mean objective of 40µg.m^{-3} for NO_2 in 2005 was being exceeded at relevant receptors in White Street between Van Road and Bartlett Street. At this location it was "probable" (50% to 80% probability), that the annual mean objective was being exceeded. At all other locations it was at most "possible" (20% to 50% probability), that the annual mean objective was being exceeded.

Modelled projections of NO_2 concentrations in 2010 indicated that that the annual mean and hourly EU Limit Values for NO_2 in 2010 would not exceeded at any relevant receptor in the areas studied. At most it was "possible" that the annual limit value could be exceeded at any location.

The Detailed Assessment recommended that CCBC should declare an AQMA in Caerphilly Town Centre.

2006 Updating and Screening assessment; The report confirmed the finding of the Detailed Assessment with measured annual mean NO_2 concentrations in excess of the objective occurring in central Caerphilly.

2007 and 2008 Progress Reports: The subsequent Progress Reports in 2007 and 2008 also reported measured annual mean NO_2 concentrations in excess of the objective in central Caerphilly.

CCBC declared an AQMA on September 1st 2008, for the area encompassing a number of properties along Clifton Street, White Street and Bartlett Street in Caerphilly. The AQMA boundary is shown in Figure 1 below.

2009 Updating and Screening Assessment: The assessment concluded that annual mean NO_2 concentrations in excess of the 40 µg.m^{-3} objective were occurring within several areas in Caerphilly Town Centre. The majority of locations were however already within the existing AQMA for which a Further Assessment was planned.

The report also recommended that two additional areas outside of the Caerphilly Town centre AQMA should be included in the further assessment, namely Ton-Y Felin Road and Nantgarw Road

2010 Further Assessment: A Further Assessment of air quality in the Caerphilly Town Centre AQMA and surrounding road network was conducted using atmospheric dispersion modelling in 2010. The modelling study confirmed that the existing AQMA boundary was appropriate. The study also suggested that CCBC consider declaring a further AQMA (or extend the current AQMA) to encompass another area to the north of the gyratory system, namely Ton-Y-Felin Road.

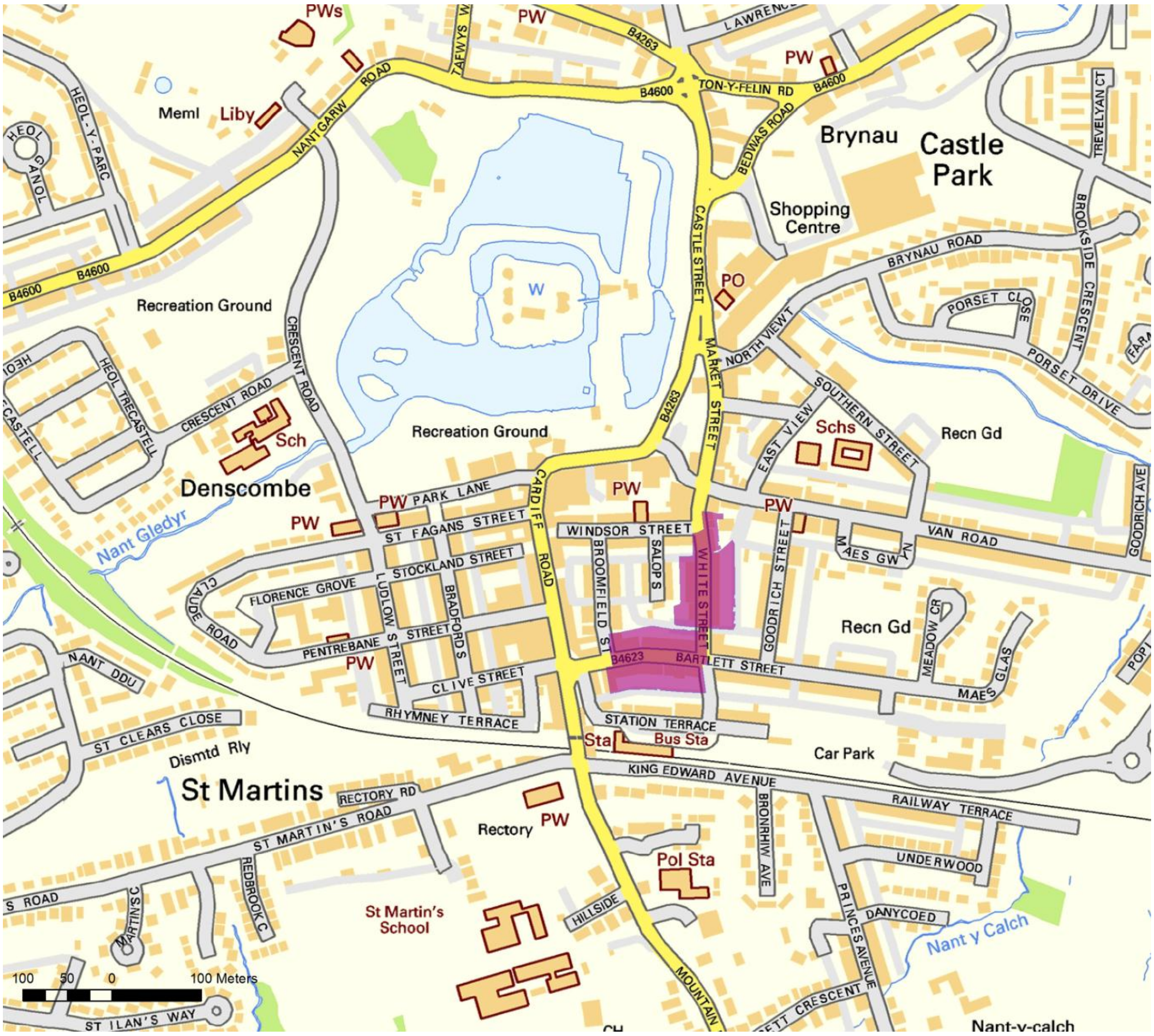
The modelling study for the Further Assessment used 2009 monitoring data. At the time, the measured concentrations in the Ton-y-Felin Road area of Caerphilly were not in excess of the NO_2 annual mean objective. The Authority sought permission from Welsh Government to monitor in this area for a further year to confirm whether there was general improvement occurring at this location or if it was a ‘one off’ result.

2010 Progress Report: NO_2 annual mean concentrations measured during 2009 in the Ton-y-Felin Road area were below the objective again.

An NO_2 annual mean concentration in excess of the 40 $\mu g.m^{-3}$ objective was measured at Nantgarw Road during 2009. The report concluded that the Authority would undertake further monitoring in this area.

2011 Progress Report and subsequent findings: The annual mean NO_2 concentrations measured during 2010 at locations on Ton-y-Felin Road and Nantgarw Road were in excess of the 40 $\mu g.m^{-3}$ objective; the report concluded that a Detailed Assessment of NO_2 be undertaken along Nantgarw Road to include Ton-y-Felin Road.

Figure 1: Caerphilly town centre AQMA.



Legend:

AQMA Boundary

AEA

2 Detailed Assessment study area

Nantgarw Road passes from the south western edge of Caerphilly to the central interchange junction at the Piccadilly. This Detailed Assessment studies the area encompassing the eastern section of Nantgarw Road from the junction with St Cenydd Road (B4263) to the junction at the Piccadilly where it joins with Ton-Y-Felin Road.

A small section of Ton-Y-Felin Road and Bedwas Road has also been included in the modelling study at the request of the Council; this was requested as measured annual mean NO_2 concentrations exceeded the objective limit at this location in 2010.

Traffic flows at the Piccadilly junction have not been included in this modelling assessment. The junction which has fairly complex traffic flows was modelled in the 2010 Further Assessment[2]

The land use in the study area is mainly residential with some commercial properties and recreational use close by. The terrain in the area is fairly flat with a slight gradient descending from west to east across the study area. A map showing the extent of the study area is presented in Figure 2 below.

[2] AEA (2010) Further Assessment of Air Quality Caerphilly Report to Caerphilly County Borough Council; AEAT/ENV/R/2813; Issue 4; February 2010

Figure 2: Detailed Assessment study area

Key:

Study area boundary

Road to be modelled

AEA

3 Information used to support this assessment

3.1 Maps

Ordnance Survey based GIS data of the model domain and a road centreline GIS dataset were used in the assessment. This enabled accurate road widths and the distance of the housing to the kerb to be determined in ArcMap.

3.2 Road traffic data

3.2.1 Average flow, speed and fleet split

Annual average daily traffic (AADT) flow data were collated from the Department for Transport (DfT) national traffic counts for 2010 for Nantgarw Road and from traffic count data provided by Caerphilly County Borough Council for some of the smaller local roads. Detailed vehicle split data was available from the DfT counts. Some assumptions have been made when calculating traffic flows on the roads within the study area. Appendix 1 summarises all of the traffic flow data used, the road links modelled, the data sources and any assumptions made.

It should be noted that traffic patterns in urban locations are complex and it is not possible to fully represent these in atmospheric dispersion models. By attempting to describe these complex traffic patterns using quite simple metrics (AADT, average speed and vehicle split composition) a degree of uncertainty is introduced into the modelling.

3.2.2 Congestion

Traffic is known to become congested at certain locations along Nantgarw Road during peak commuting hours in the morning and early evening. Caerphilly County Borough Council provided local knowledge of where and at what times the congestion typically occurs.

A method of modelling queuing traffic using ADMS-Roads proposed by model developers CERC has been used to represent the periodic congestion[3]. The method assumes that the vehicles are travelling at the lowest speed that can be modelled using ADMS-Roads (5 km/hr), with an average vehicle length of 4 m, and are positioned close to each other during congested periods. The annual average hourly traffic (AAHT) flow is calculated by dividing the speed of the vehicles by the average vehicle length, which gives a representative AAHT of 1250 vehicles per hour during congested periods.

A time–varying file is used in the model to turn the congested road sections on during the congested periods in the morning and afternoon/evening.

[3] CERC(2004) Modelling queuing traffic – Helpdesk note; Avaialble at http://www.cerc.co.uk/user-area/helpdesk-notes.html

3.2.3 Emissions factors

The most recent vehicle emissions factors from the NAEI (as derived from COPERT 4) released in June 2012 were used in this assessment. The emission factors derived for each of the modelled road links were input to the ADMS-Roads model.

Parameters such as traffic volume, speed and fleet composition are used to calculate the emission rates, and an emissions factor in grams of NOx/second/kilometre is generated for input into the dispersion model.

3.3 Ambient monitoring

Caerphilly County Borough Council currently undertakes monitoring of NO_2 in the Nantgarw Road area with one automatic monitoring site and a network of diffusion tubes. Further details of these monitoring locations and recent measured concentrations are provided in Section 4.

3.4 Meteorological data

Hourly sequential meteorological data (wind speed, direction etc.) covering the study period May 2011 to April 2012) from St Athans was obtained from a third party supplier and used in this assessment. The chosen site is located approximately 22 km south west of the study area and has good data quality for the period of interest. A wind rose for the meteorological dataset is presented in Appendix 2.

Meteorological measurements are subject to their own uncertainty which will unavoidably carry forward into this assessment.

3.5 Background concentrations

Background NOx concentrations for a dispersion modelling study can be derived from either local monitoring data conducted at a background site or from the Defra LAQM background maps[4] . There are no suitable background monitoring sites close to Nantgarw Road therefore the Defra background maps were used.

A CSV file containing concentrations across the Caerphilly County Borough Council area was obtained and the background NOx concentrations for the appropriate grid square extracted. A mapped NOx background concentration of 34.9 $\mu g.m^{-3}$ was used for the assessment.

It should be noted that the Defra background maps are the outputs of a national scale dispersion model provided at a 1km x 1km resolution and are therefore subject to a degree of uncertainty.

[4] Defra (2012) http://laqm1.defra.gov.uk/review/tools/background.php (accessed July 2012)

4 Monitoring Data

Caerphilly County Borough Council currently measure NO_2 concentrations in Nantgarw Road using one automatic monitoring site and a network of nine diffusion tubes. Maps showing the location of the monitoring sites are presented in Figure 3, Figure 4 and Figure 5.

It should be noted that this Detailed Assessment is not based on the time period of a calendar year as is typically used for a Detailed Assessment. Automatic monitoring of NO_2 commenced at Nantgarw Road in October 2011; at least six months' worth of valid data was required to estimate an NO_2 annual mean. The average NO_2 concentration from 11th October to 30th April 2012 was adjusted to an annual mean using the annual profile from 1st May 2011 to 30th April 2012 from three nearby background automatic monitoring site. Details of the monitoring QA/QC information and short to long-term period adjustment calculations are presented in Appendix 3.

The study period for the Detailed Assessment is therefore 1st May 2011 to 30th April 2012.

A bias adjustment factor of 0.86 was applied to the annual average of the diffusion tube measurements from May 2011 to April 2012. The adjustment factor was accessed from the 2011 national database of diffusion tube co-location studies[5] as published in June 2012.

A summary of the automatic and diffusion tube measurements for the study period are presented in Table 3 and Table 4 respectively.

Table 3: Nantgarw Road – Automatic monitor NO_2 annual mean 1st May 2011 to 30th April 2012

Site	Type	OS Grid Ref.		Data Capture (annual) (%)	Data Capture (period) (%)	NO_2 annual mean ($\mu g.m^{-3}$)
		Easting	Northing			
Nantgarw Road Automatic Analyser	R	314744	186997	53%	96.4%	32.4*
Exceedences of the annual mean objective are shown in bold ***** Short term to long term adjustment applied to derive annual mean due to data capture <75%						
R - Roadside, 1 - 5m from the kerb						

Table 4: Nantgarw Road NO_2 annual mean measurements 1st May 2011 to 30th April 2012

Site	Type	OS Grid Ref.		Data Capture (%)	Bias corrected (0.86) annual mean ($\mu g.m^{-3}$)
		Easting	Northing		
CCBC44 Downpipe 244 Nantgarw Road, Caerphilly	R	314718	187001	75%	39.9
CCB45 O/S 38 Bedwas Road, Caerphilly	R	315958	187370	100%	31.2
CCBC55 6 Ton y Felin Road, Caerphilly	R	315741	187312	100%	36.6
CCBC56 3 Nantgarw Road, Caerphilly	R	315579	187305	100%	33.1
CCBC59 30 Ton y Felin Road, Caerphilly	R	315793	187305	92%	36.8
CCBC61 258 Nantgarw Road	R	314684	186989	83%	37.9
CCBC64 3 St Cenydd Road	R	314478	186911	75%	21.3
CCBC65 60 Lon-y-llyn Caerphilly downpipe	R	314554	186865	75%	23.5
CCBC67 84 Nantgarw Road, Caerphilly downpipe	R	315244	187223	75%	39.7
Exceedences of the annual mean objective are shown in bold					
R - Roadside, 1 - 5m from the kerb					

[5] (National Physical Laboratory, 2012) Summary spreadsheet of co-location studies v06_12 available at http://laqm.defra.gov.uk/bias-adjustment-factors/national-bias.html

Figure 3: Monitoring locations western section of study area

Figure 4: Monitoring locations central section of study area

N

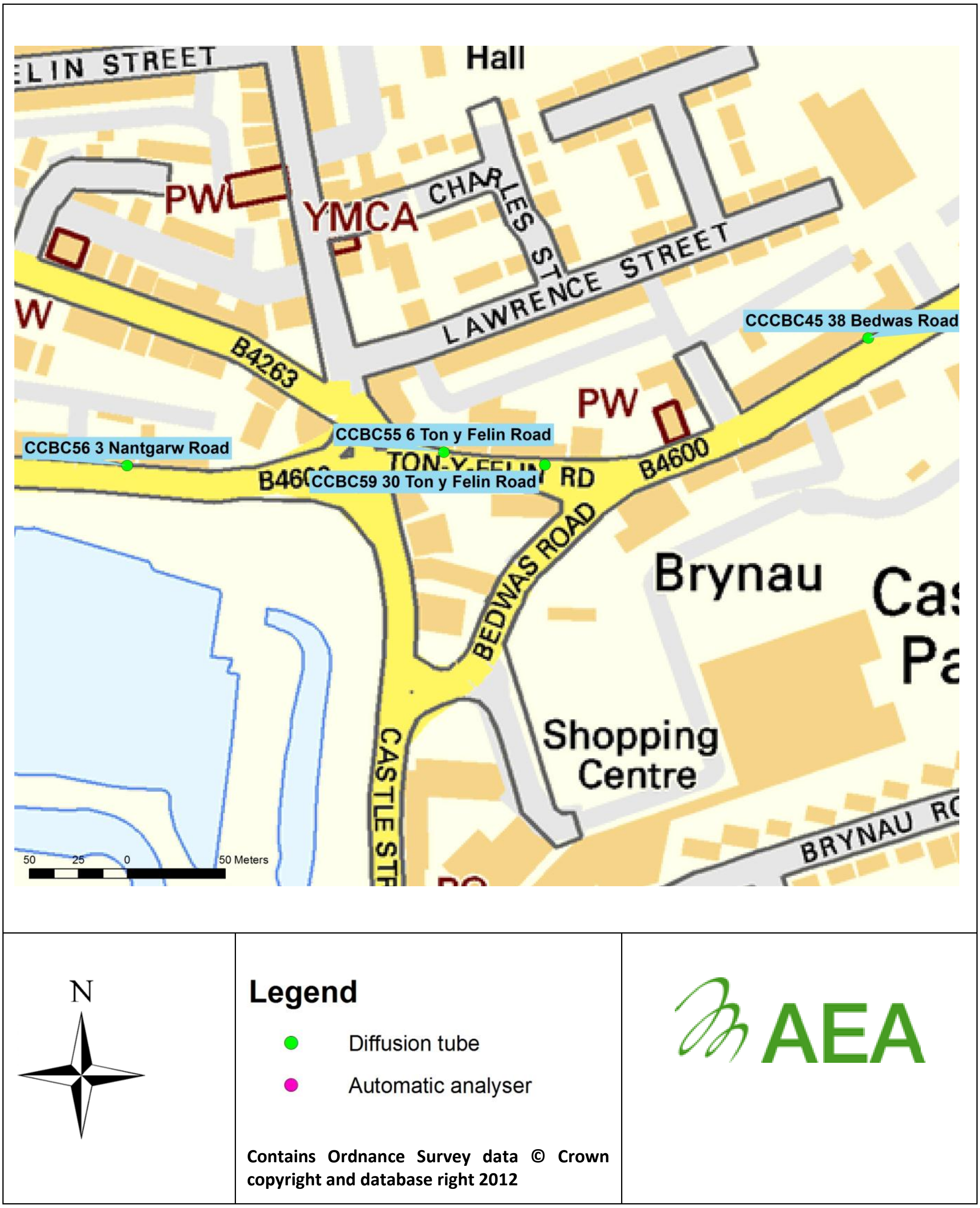
Legend

- Diffusion tube
- Automatic analyser

Contains Ordnance Survey data © Crown copyright and database right 2012

AEA

Figure 5: Monitoring location eastern section of study area



5 Modelling

5.1 Modelling methodology

Annual mean NO_2 concentrations for the study period have been modelled using the atmospheric dispersion model ADMS Roads (version 3.1).

The model was verified by comparing the modelled predictions of road NOx with local monitoring results. The available roadside diffusion tube and automatic analyser measurements (described in Section 4) were used to verify the annual mean road NOx model predictions. Following initial comparison of the modelled concentrations with the available monitoring data, refinements were made to the model input to achieve the best possible agreement with the monitoring results. Further information on model verification is provided in Section 5.1.3 and Appendix 4.

A surface roughness of 0.5 m was used in the modelling to represent the open suburbia land-use present across the modelled domain. A limit for the Monin-Obukhov length of 10 m was applied to represent a small town.

The source-oriented grid option was used in ADMS-Roads; this option provides finer resolution of predicted pollutant concentrations along the roadside, with a wider grid spaced at approximately 15 m being used to represent concentrations further away from the road. The grid height was set at 1.5 m to represent human exposure at head height. The predicted concentrations were interpolated to derive values between the grid points using the Spatial Analyst tool in the GIS software ArcMap 10. This allows contours showing the predicted spatial variation of pollutant concentrations to be produced and added to the digital base mapping.

It should be noted that any dispersion modelling study has a degree of uncertainty associated with it; all reasonable steps have been taken to reduce this where possible.

Queuing traffic was treated in the model using the methodology described in Section 3.2.2 above as provided by the model developers. Queuing was assigned to specific road sections based on local knowledge following consultation with Caerphilly County Borough Council. A time varying emissions file was used in the model to account for daily variations in queuing traffic. Further information on the queues modelled is presented in Appendix 1.

5.1.1 Treatment of modelled NOx road contribution

It is necessary to convert the modelled NOx concentrations to NO_2 for comparison with the relevant objectives.

The Defra NOx/NO_2 model[6] was used to calculate NO_2 concentrations from the NOx concentrations predicted by ADMS-Roads. The model requires input of the background NOx, the modelled road contribution and the proportion of NOx released as primary NO_2. For the purposes of this assessment we have assumed that 18.6% of NOx is released as primary NO_2- the value associated with the "All other UK urban traffic" option in the model.

5.1.2 Validation of ADMS-Roads

In simple terms, validation of the model is the process by which the model outputs are tested against monitoring results at a range of locations and the model is judged to be suitable for use in specific applications. CERC have carried out extensive validation of ADMS applications by comparing modelled results with standard field, laboratory and numerical data sets, participating in EU workshops on short range dispersion models, comparing data between UK M4 and M25 motorway

[6] http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php

field monitoring data, carrying out inter-comparison studies alongside other modelling solutions such as DMRB and CALINE4, and carrying out comparison studies with monitoring data collected in cities throughout the UK using the extensive number of studies carried out on behalf of local authorities and DEFRA.

5.1.3 Verification of the model

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. Dispersion models of this nature carry a degree of uncertainty for the reasons explained in previous sections so it is important to check their performance against measurements and adjust their outputs accordingly.

LAQM.TG(09) recommends making the adjustment to the road contribution only and not the background concentration these are combined with.

The approach outlined in Example 2 of LAQM.TG(09) has been used in this case.

The modelled concentrations in this study were verified using the seven available monitoring sites, all of which were at roadside locations. The comparison of monitored against modelled NO_x revealed that the model was under-predicting the Road NOx component when compared with the measurements.

Following various refinements to the model input; the modelled Road NOx contribution required adjustment by a factor of 2.12 (derived from a linear regression analysis of measured Vs modelled Road NOx) to bring the predicted NO_2 concentrations within good agreement of those results obtained from the monitoring data. This factor was applied to all Road NOx concentrations predicted by the model; the adjusted total NO_2 concentrations were then calculated using the Defra NOx/NO_2 calculator.

After the NOx/NO_2 model was run no further adjustments were made to the data. Table 5 and Figure 6 show model agreement with the NO_2 monitoring data after adjustment. Full model verification data is provided in Appendix 4.

Verifying modelling data with diffusion tube monitoring data will always be subject to uncertainty due to the inherent limitations in such monitoring data (even data from continuous analysers has notable uncertainty). Following adjustment, the modelled concentrations agreed reasonably well with the available local monitoring.

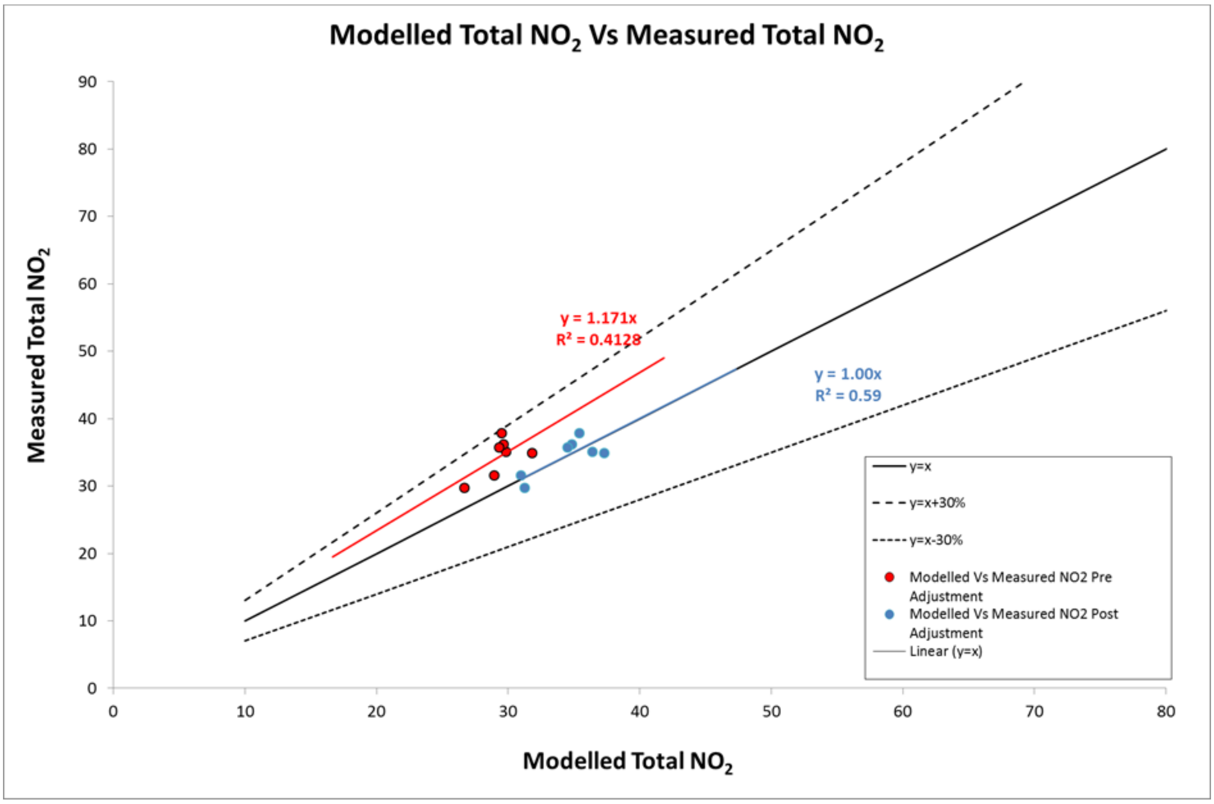
The root mean square error (RMSE) provides an estimate of model uncertainty. Ideally, more than five monitoring data points for inclusion in the calculation would provide a better indication of uncertainty. In this case the RMSE was 2.2 µg m^{-3} after adjustment which is within the suggested value (10% of the objective being assessed) in LAQM.TG(09). The model has therefore been assessed to perform sufficiently well for use within this assessment.

Further information on the verification process including the linear regression analysis is provided in Appendix 4.

Table 5: Modelled vs. measured annual mean NO_2 concentrations 2010

Site	NO_2 annual mean concentration ($\mu g.m^{-3}$)	
	Modelled NO_2	Measured
CCBC44 Diffusion Tube	36.7	39.9
CCBC45 Diffusion Tube	32.6	31.2
CCBC55 Diffusion Tube	39.2	36.6
CCBC56 Diffusion Tube	32.2	33.1
CCBC59 Diffusion Tube	38.2	36.8
CCBC61 Diffusion Tube	36.5	37.9
CCBC67 Diffusion Tube	37.1	39.7
Auto-monitor	35.2	32.4
	RMSE =	**2.2**

Figure 6: Linear regression analysis of modelled vs. monitored NO_2 annual mean 2010



5.2 Modelling results

Contour plots showing the spatial variation in predicted annual mean NO_2 annual concentrations during the study period are presented in Figure 7 to Figure 10 for both Nantgarw Road and Ton-Y-Felin Road/Bedwas Road.

It can be observed from the NO_2 annual mean contour plots that the 40 $\mu g.m^{-3}$ NO_2 annual mean objective is predicted to be exceeded at various locations where relevant human exposure may occur on Nantgarw Road. During model verification the diffusion tube locations were modelled using the heights at which the measurements were taken. Reducing the height to that which is representative of relevant exposure has increased the concentrations and marginal exceedances are predicted.

The highest concentrations are predicted at locations where canyon effects were included in the model; these are the locations at the western end of Nantgarw Road where there are rows of houses present on either side of the road, and the building facades are very close to the road side.

The results indicate that, based on measurements and subsequent dispersion modelling of traffic emissions covering the period 1st May 2011 to 30th April 2012, an AQMA for NO_2 is required at these locations on Nantgarw Road- though given the model carries a RMSE of 2.2 $\mu g.m^{-3}$ the exceedances are marginal and within the error of the model.

5.2.1 People exposed to exceedences of the annual mean NO_2 and PM_{10} objectives

The number of properties that were exposed to NO_2 annual mean concentrations in excess of the objective during the study period was estimated using GIS mapping data.

Within the study area 87 residential properties were estimated to lie within the 40 $\mu g.m^{-3}$ contour, equating to an exposed population of approximately 200 people (based on census data which suggests an average occupancy per household of 2.3 in the UK[7]).

[7] http://www.ons.gov.uk/ons/rel/census/2011-census/population-estimates-by-five-year-age-bands--and-household-estimates--for-local-authorities-in-the-united-kingdom/stb-population-and-household-estimates-for-the-united-kingdom-march-2011.html

Figure 7: Predicted annual mean NO_2 concentrations in Nantgarw Road (Western section)

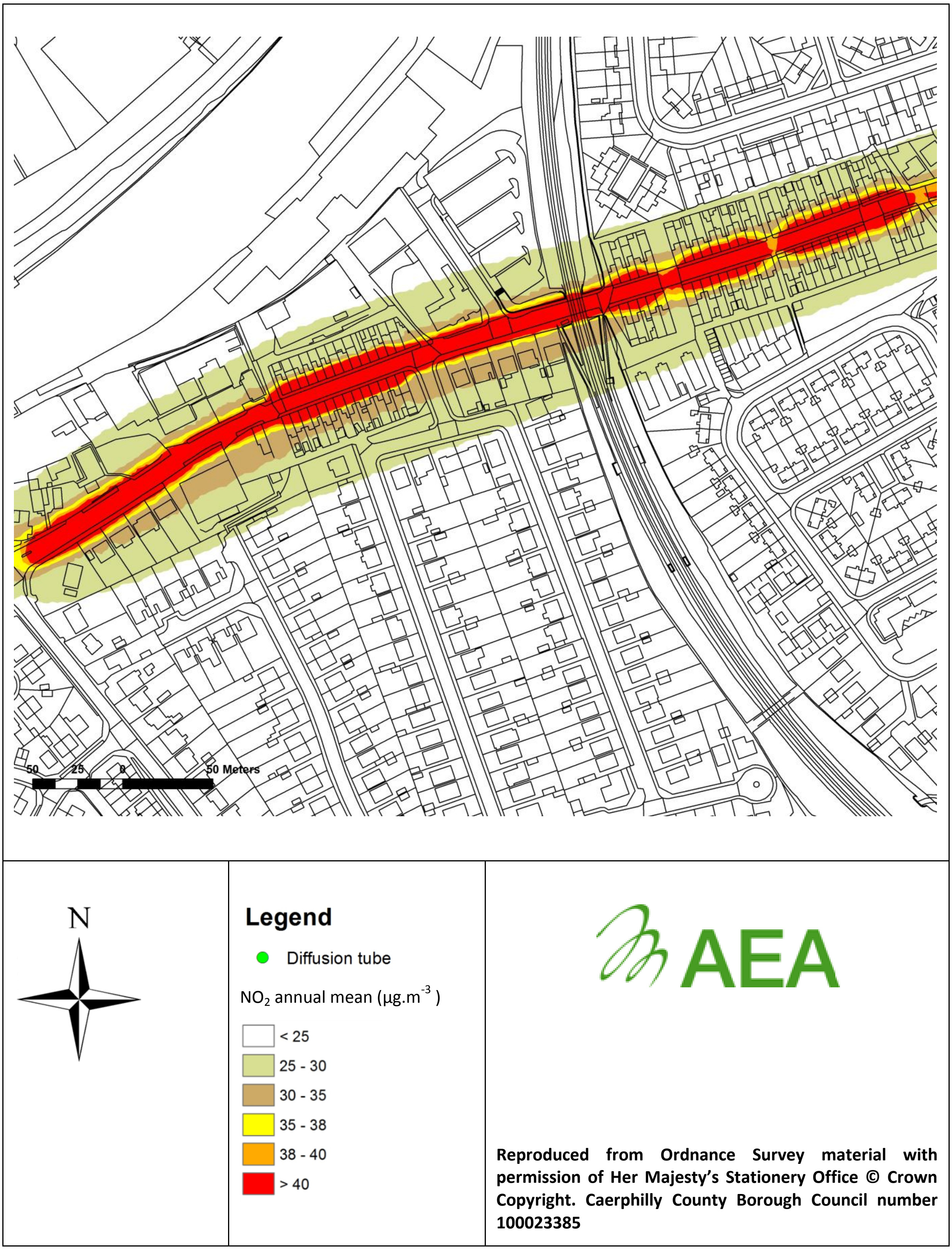


Figure 8: Predicted annual mean NO_2 concentrations in Nantgarw Road (middle section)

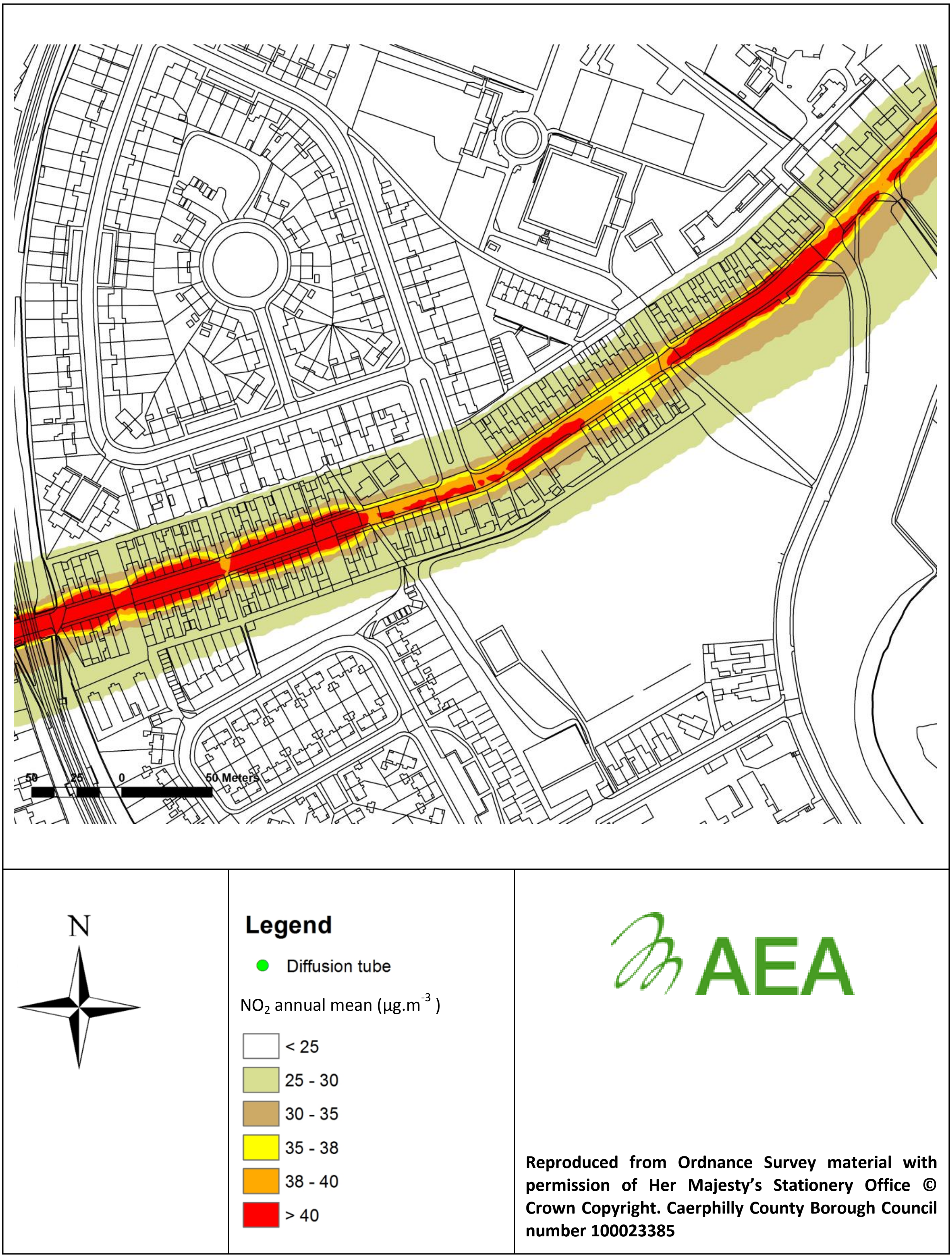
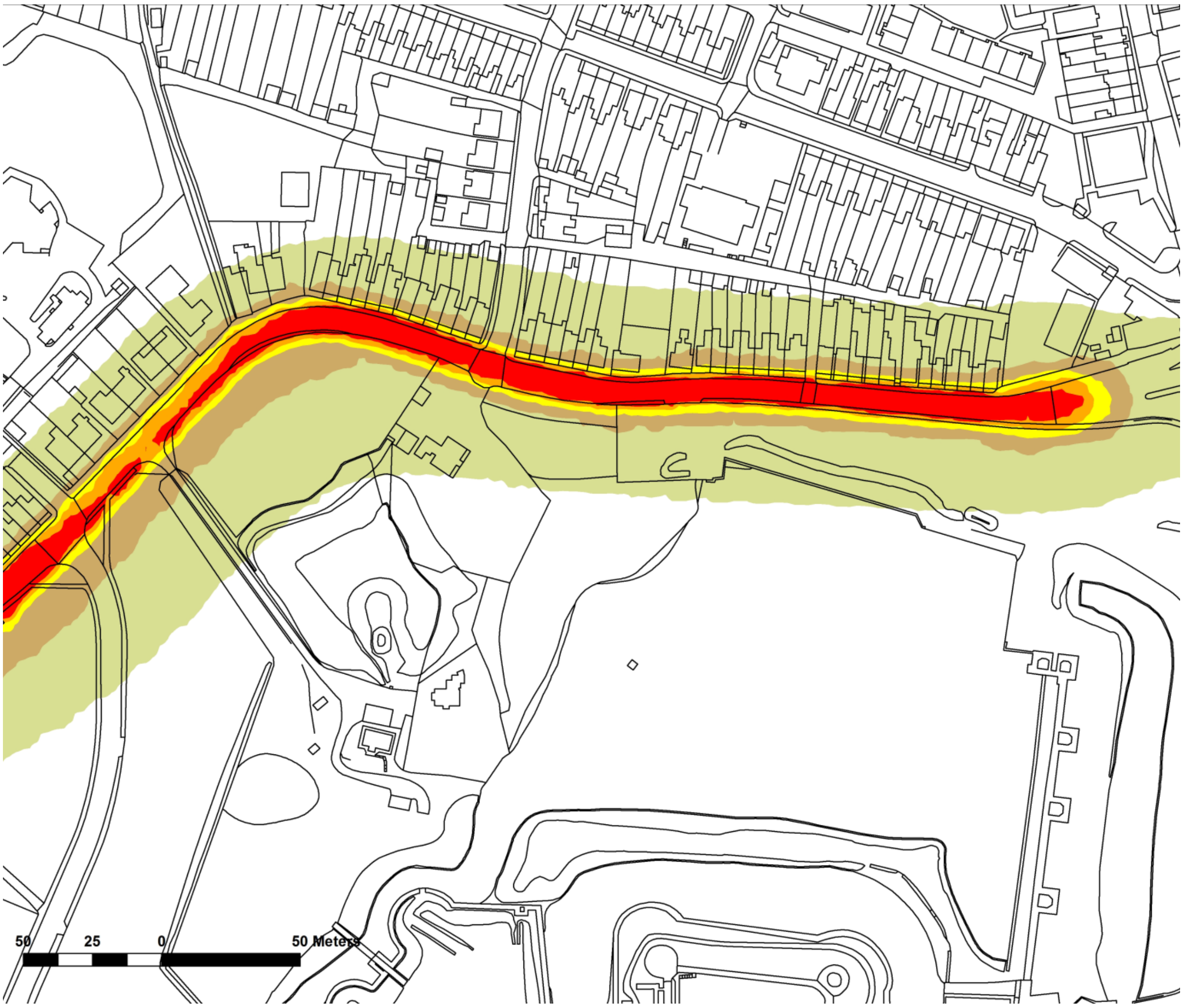


Figure 9: Predicted annual mean NO_2 concentrations in Nantgarw Road (eastern section)



N

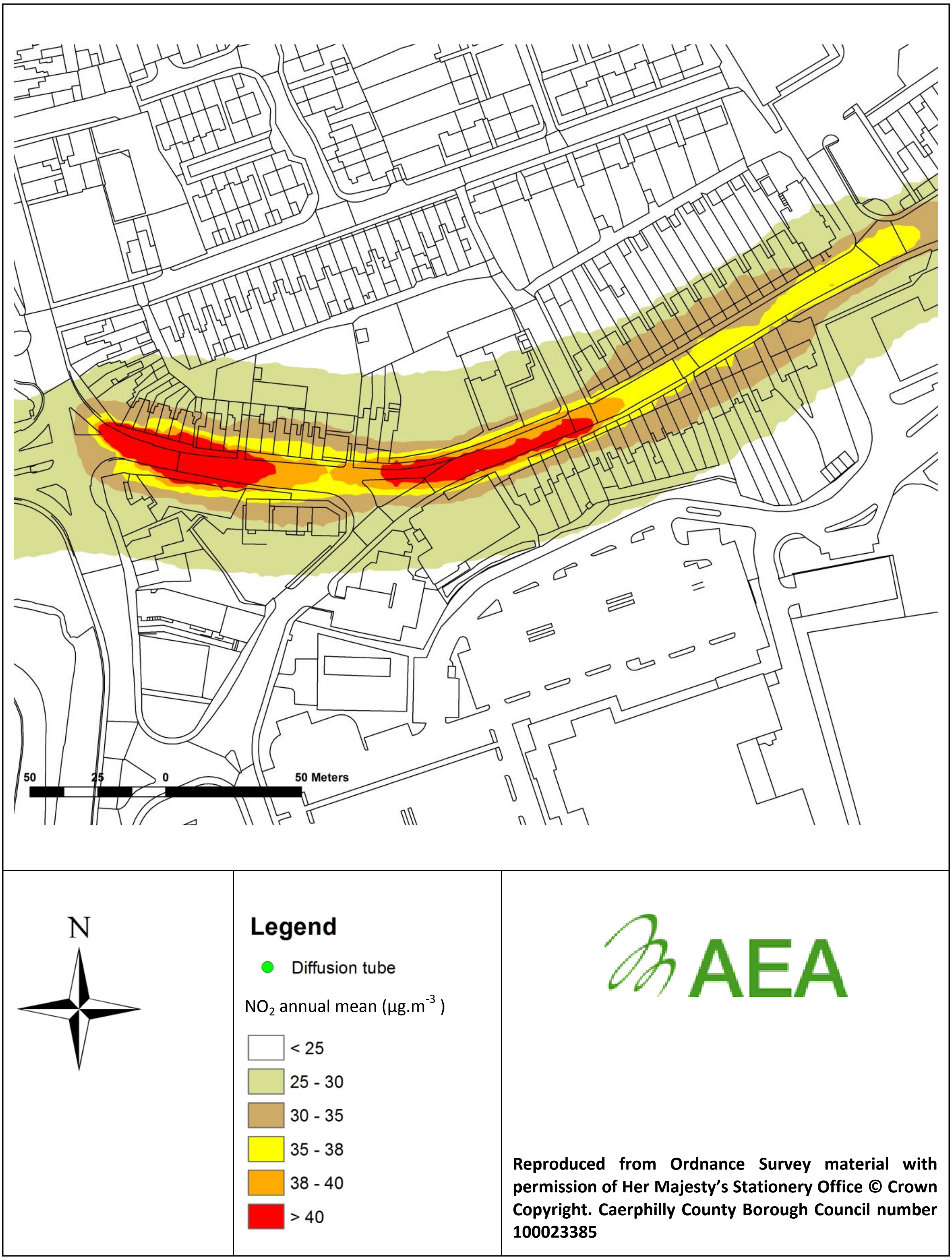
Legend

- Diffusion tube

NO_2 annual mean ($\mu g.m^{-3}$)

- < 25
- 25 - 30
- 30 - 35
- 35 - 38
- 38 - 40
- > 40

Figure 10: Predicted annual mean NO_2 concentrations in Ton-Y-Felin Road/Bedwas Road



6 Source apportionment

Source apportionment is the process whereby the contribution of different pollutant sources to ambient concentrations is quantified. It is usually included in a Further Assessment following the declaration of an AQMA.

Source apportionment has been included in this Detailed Assessment to provide Caerphilly County Borough Council with information that may assist with implementing their action plan for the Caerphilly town Centre AQMA.

The source apportionment aims to:

- Determine the extent to which different vehicle types are responsible for the emission contributions to NOx/NO_2
- Quantify what proportion of total NOx are due to background emissions, or local emissions from busy roads in the local area.

To calculate the proportion of total NOx concentrations attributable to various types of vehicles, emission factors for each individual vehicle type were calculated separately. This allowed derivation of new emission factors for the road segments which were then modelled in ADMS-Roads to obtain the contribution of each source to ambient NOx concentrations at the various monitoring locations.

The contributions from each of the following sources have been quantified:

- Background
- Moving vehicles
- Queuing vehicles
- Cars
- Light Goods Vehicles
- Heavy Goods Vehicles
- Buses

Table 6 to 9 summarise the relevant NOx contributions from the above sources at each of the monitoring locations. The breakdown of NOx attributable to the different vehicles types is presented in Figure 11.

Table 6: NOx Source Apportionment - Moving and Queuing Vehicles (µg.m^{-3})

Site	Contribution to annual mean NOx (µg.m^{-3})				
	Total NOx	Background	Road NOx	Moving traffic	Queuing Traffic
CCBC44 Diffusion Tube	71.8	34.9	36.9	28.1	8.8
CCBC45 Diffusion Tube	61.4	34.9	26.5	26.4	0.1
CCBC55 Diffusion Tube	78.8	34.9	43.9	39.7	4.1
CCBC56 Diffusion Tube	60.5	34.9	25.6	25.2	0.4
CCBC59 Diffusion Tube	76.0	34.9	41.1	40.6	0.5
CCBC61 Diffusion Tube	71.4	34.9	36.5	27.6	8.9
CCBC67 Diffusion Tube	73.0	34.9	38.1	38.1	0.1
Auto-monitor	68.0	34.9	33.1	26.4	6.7

Table 7: NOx Source Apportionment - Moving and Queuing Vehicles (% of total NOx)

Site	Contribution to annual mean NOx (% contribution)				
	Total NOx	Background	Road NOx	Moving traffic	Queuing Traffic
CCBC44 Diffusion Tube	100%	48.6%	51.4%	39.1%	12.3%
CCBC45 Diffusion Tube	100%	56.8%	43.2%	43.0%	0.2%
CCBC55 Diffusion Tube	100%	44.3%	55.7%	50.4%	5.2%
CCBC56 Diffusion Tube	100%	57.7%	42.3%	41.7%	0.7%
CCBC59 Diffusion Tube	100%	45.9%	54.1%	53.4%	0.7%
CCBC61 Diffusion Tube	100%	48.9%	51.1%	38.7%	12.5%
CCBC67 Diffusion Tube	100%	47.8%	52.2%	52.2%	0.1%
Auto-monitor	100%	51.3%	48.7%	38.8%	9.9%

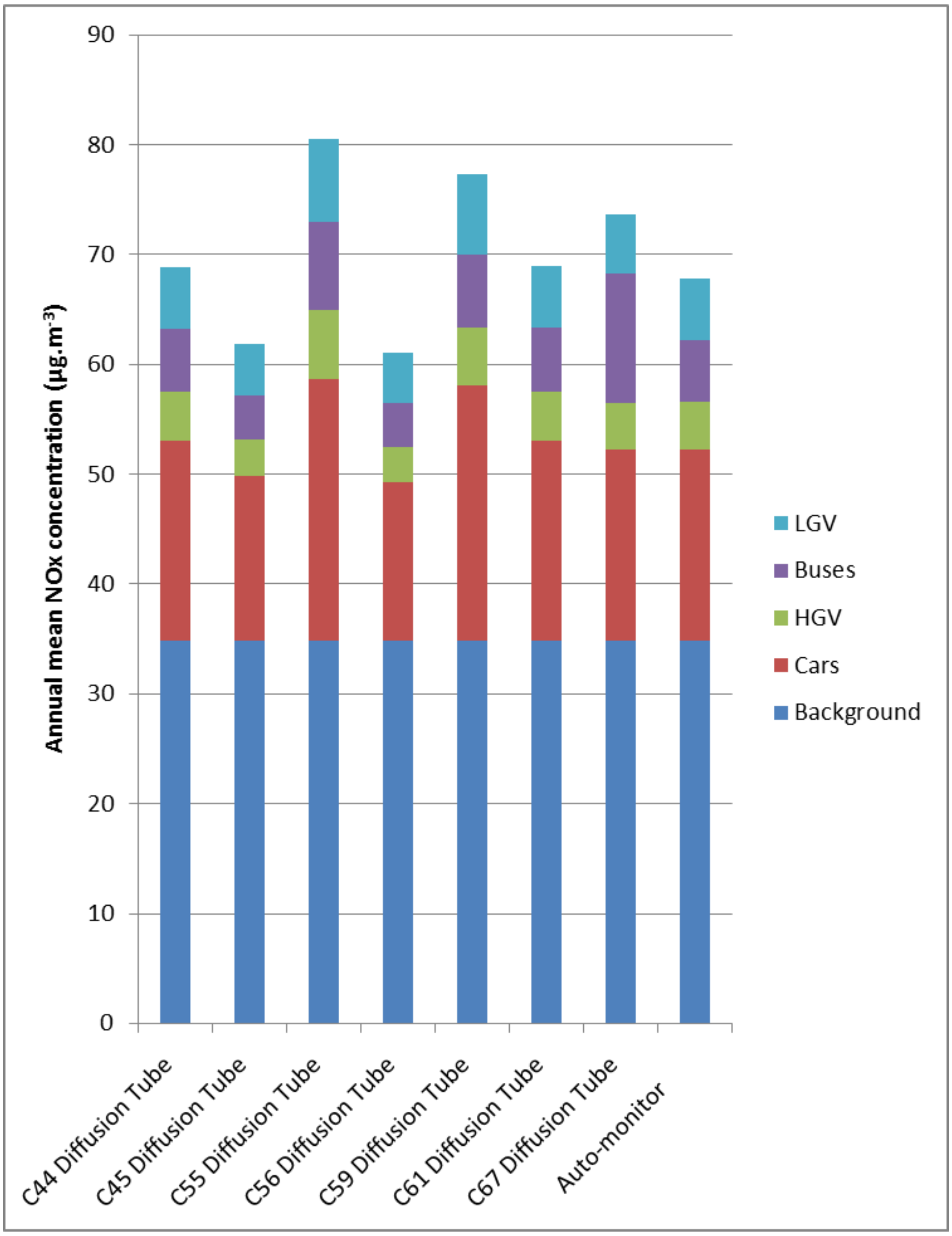
Table 8: NOx source apportionment – Contribution by vehicle type (µg.m^{-3})

Site	Contribution to annual mean NOx (µg.m^{-3})						
	Total NOx	Background	Road NOx	Cars	HGV	Buses	LGV
CCBC44 Diffusion Tube	71.8	34.9	36.9	19.7	4.9	6.2	6.2
CCBC45 Diffusion Tube	61.4	34.9	26.5	14.7	3.2	4.0	4.6
CCBC55 Diffusion Tube	78.8	34.9	43.9	22.8	6.1	7.8	7.2
CCBC56 Diffusion Tube	60.5	34.9	25.6	14.1	3.2	4.0	4.4
CCBC59 Diffusion Tube	76.0	34.9	41.1	22.5	5.1	6.4	7.1
CCBC61 Diffusion Tube	71.4	34.9	36.5	19.4	4.8	6.2	6.1
CCBC67 Diffusion Tube	73.0	34.9	38.1	17.0	4.1	11.6	5.3
Auto-monitor	68.0	34.9	33.1	17.4	4.5	5.6	5.6

Table 9: NOx source apportionment – Contribution by vehicle type (% of total NOx)

Site	Contribution to annual mean NOx (µg.m^{-3})						
	Total NOx	Background	Road NOx	Cars	HGV	Buses	LGV
CCBC44 Diffusion Tube	100%	48.6%	51.4%	27.4%	6.8%	8.6%	8.6%
CCBC45 Diffusion Tube	100%	56.8%	43.2%	23.9%	5.2%	6.5%	7.5%
CCBC55 Diffusion Tube	100%	44.3%	55.7%	29.0%	7.7%	9.9%	9.2%
CCBC56 Diffusion Tube	100%	57.7%	42.3%	23.3%	5.2%	6.6%	7.3%
CCBC59 Diffusion Tube	100%	45.9%	54.1%	29.6%	6.7%	8.4%	9.4%
CCBC61 Diffusion Tube	100%	48.9%	51.1%	27.2%	6.8%	8.7%	8.5%
CCBC67 Diffusion Tube	100%	47.8%	52.2%	23.3%	5.6%	16.0%	7.3%
Auto-monitor	100%	51.3%	48.7%	25.6%	6.6%	8.3%	8.3%

Figure 11: Chart showing contribution by vehicle type (µg.m^{-3})



7 Conclusion

A dispersion modelling study of road traffic emissions at Nantgarw Road in Caerphilly has been conducted to allow a Detailed Assessment of nitrogen dioxide concentrations at this location. The study was based on measurements and dispersion modelling of traffic emissions covering the period 1st May 2011 to 30th April 2012.

The modelling study, which has used the most recent traffic, monitoring and meteorological data for Nantgarw Road, Caerphilly, indicates that there are exceedances of the NO_2 annual mean objective occurring at locations where relevant exposure is present along various sections of Nantgarw Road.

The results of the modelling assessments should be considered in context with the calculated error/uncertainty calculated when verifying the model output against local measurements. The calculated error is ± 2.2 $\mu g.m^{-3}$ which means that the predicted exceedances are very marginal.

In light of the findings of this Detailed Assessment of Air quality, it is concluded that Caerphilly County Borough Council should extend the existing Caerphilly town centre Air Quality Management Area to include the affected sections of Nantgarw Road.

8 Acknowledgements

AEA gratefully acknowledge the support received from Maria Godfrey of Caerphilly County Borough Council when completing this assessment.

Appendices

Appendix 1: Traffic data

Appendix 2: Wind Rose

Appendix 3: Diffusion Tube QA/QC and bias adjustment factors

Appendix 4: Model verification

Appendix 1: Traffic data

Table A1.1 summarises the Annual Average Daily Flows (AADF) of traffic and fleet compositions used within the model.

Table A1.1: Nantgarw Road Annual Average Daily Traffic Flows - 2011

Street	Data source	%Cars	%LGV	%HGV	%Bus	%2WM	AADF
Nantgarw Road	Dft automatic count 2010	86.6%	10.5%	1.2%	1.3%	0.4%	14984
Bedwas Road	Caerphilly council count (1 week)	No split data available					
Tonyfelin Road	AEA Caerphilly Further Assessment	No split data available					

LGV – Light Goods Vehicles
HGV – Heavy Goods Vehicles (Articulate and Rigid)
2WM – Motorcycles

Queuing Traffic

CERC note 60 was used for estimating emissions from queuing traffic, which defines a representative AADF for queuing traffic to be 30,000 at 5 km h^{-1}, assuming an average vehicle length of 4m. The emissions from this AADF figure with the traffic composition of the corresponding road were then input into the Emission Factor Toolkit to calculate and emission rate. The emission rates were then used within the dispersion model as a separate line emissions of pre-defined length representing each queue. A time–varying file was used within the model to turn the congested road sections on during the congested periods in the morning and afternoon/evening, and off at all other times. Information on congestion periods was provided by Caerphilly County Borough Council based on local knowledge.

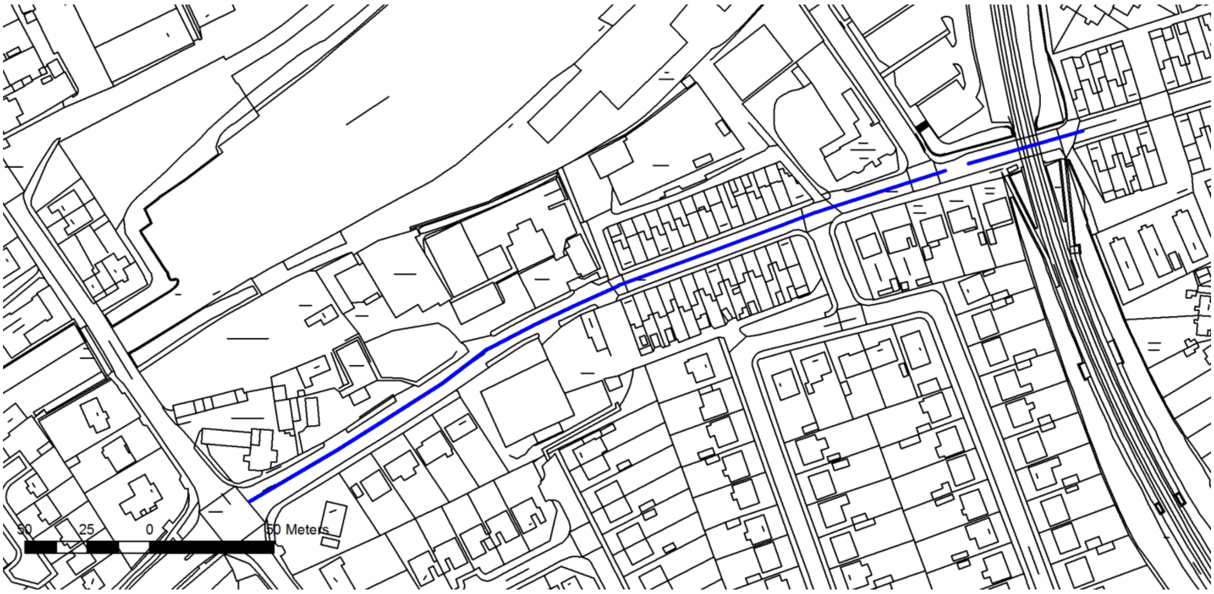
Figure A1.1 shows the locations where queuing traffic was modelled.

Traffic Speeds

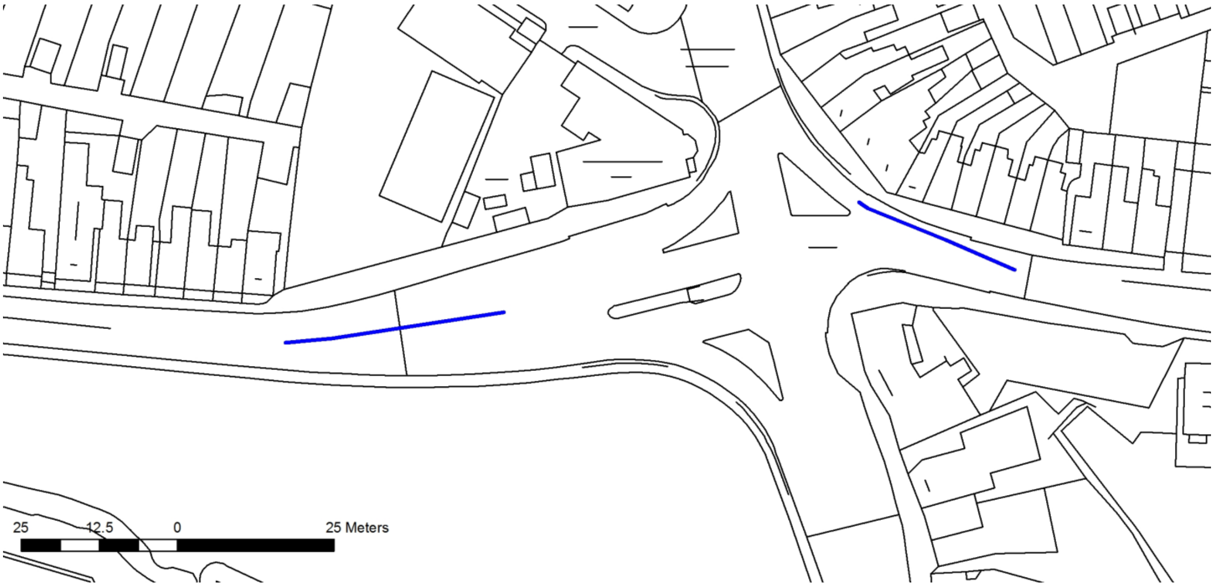
As stated in Technical Guidance LAQM.TG(09), the speed of traffic on a road will change approximately 50m from a junction. As such the speed of traffic was changed linearly between the maximum “open road” speed to the “close to a junction” speed approximately 50m from the junctions. As no traffic speed data were available, local speed limits were used for average “open road” speeds; with speeds close to junctions; through known congested/slow moving areas; and on gradients; varying from 5 km h^{-1} to 30 km h^{-1}.

Figure A1.1 Modelled queue locations

Queue locations at western end of study area



Queue locations at eastern end of study area



Key

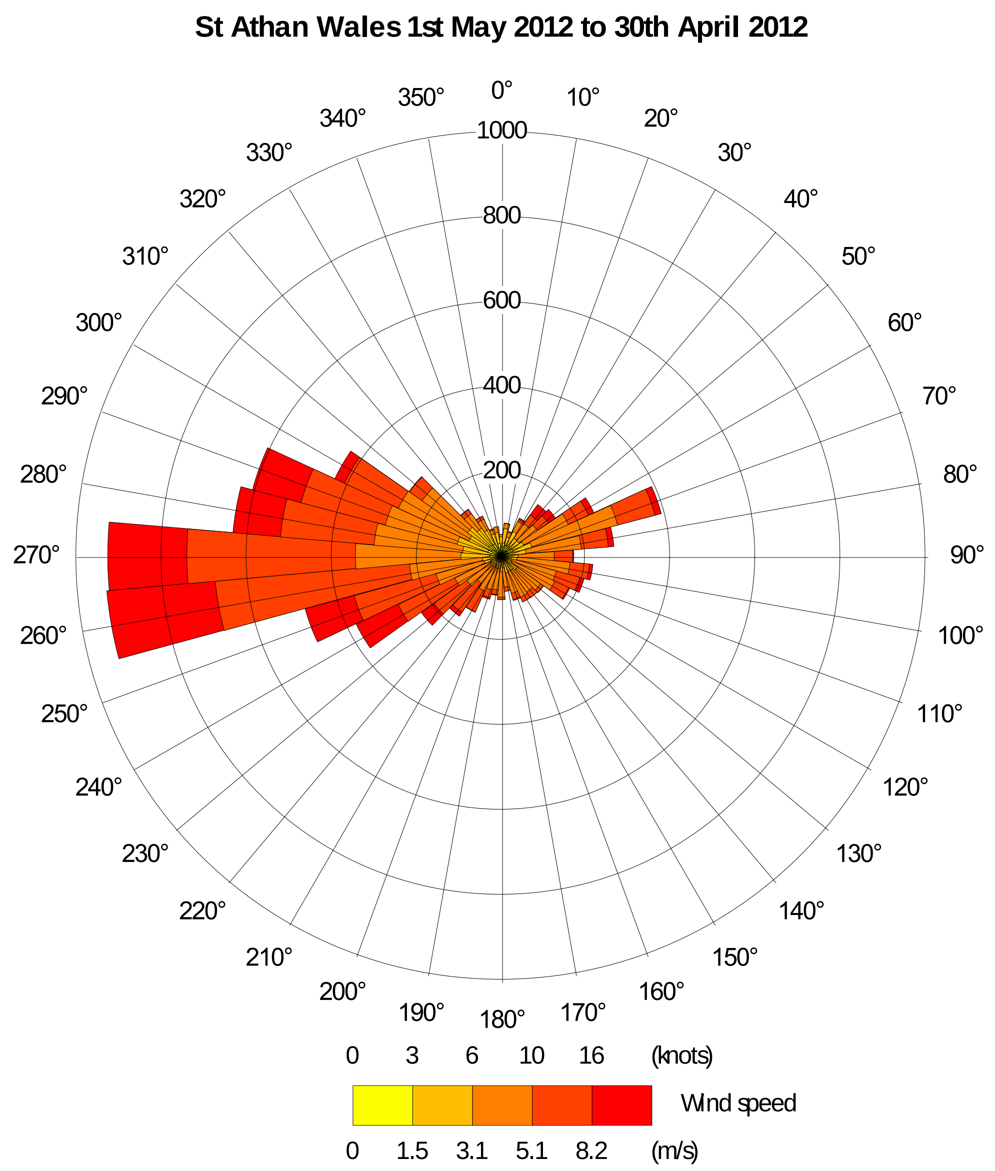
Modelled queue section

AEA

Appendix 2: Wind Rose

The wind rose for the meteorological dataset covering the period 1st May 2011 to 30th April 2012 for St Athans is presented in Figure A2.1

Figure A2.1: Meteorological dataset wind rose



Appendix 3: Monitoring QA/QC

QA/QC of automatic monitoring

The Caerphilly County Borough Council automatic analysers at Nantgarw Road and White Street are part of the National Automatic Monitoring Calibration Club, whereby monitoring data are managed to the same procedures and standards as AURN sites by AEA Technology.

Short-term to Long-term Data adjustment

As stated in Section 4 above, this Detailed Assessment is not based on the time period of a calendar year as is typically used for a Detailed Assessment. Automatic monitoring of NO_2 commenced at Nantgarw Road in October 2011; at least six months' worth of valid data was required to estimate an NO annual mean.

The average NO_2 concentration from 11th October to 30th April 2012 was adjusted to an annual mean using the measurements from 1st May 2011 to 30th April 2012 from three nearby continuous background monitoring sites. A short to long term data adjustment was applied to the 6 months and nineteen days of available NO_2 measurements at the Nantgarw Road automatic monitoring location to derive an annual mean NO_2 concentration. Details of the calculation are presented in Table A.4.

Table A3.1: Short to long term data adjustment derivation (1st May 2011 to 30th April 2012)

Site	Site Type	Annual Mean (Am) (01.05.11 to 30.04.12)	Period Mean (Pm) (11.10.11 to 30.04.12)	Ratio (Am/Pm)
V Glamorgan Fonmon	BG	10.6	12.3	0.86
Newport St Julians	BG	22.5	28.8	0.78
Cwmbran	BG	11.9	15.0	0.79
			Average ratio	**0.81**

Nantgarw Road period mean (11.10.11 to 30.04.12) = 40 $\mu g.m^{-3}$

Derived annual mean (01.05.11 to 30.04.12) = 0.8913 x 40 $\mu g.m^{-3}$ = 32.4 $\mu g.m^{-3}$

QA/QC of diffusion tubes

The Council uses diffusion tubes provided and analysed by Cardiff Scientific Services using 50% TEA (triethanolamine) in acetone, which are typically exposed for four week periods in accordance with the National NO2 Network exposure calendar. The laboratory is accredited to NAMAS and UKAS BS EN ISO 9001 and has implemented the methodology set out in the Harmonisation Practical Guidance.

Results from the WASP1 scheme show good performance and the laboratory precision is also good.

A bias adjustment factor of 0.86 was applied to the annual average of the diffusion tube measurements from May 2011 to April 2012. The adjustment factor was accessed from the 2011 national database of diffusion tube co-location studies.

Appendix 4: Model Verification

It is appropriate to verify the performance of the ADMS Roads model in terms of primary pollutant emissions of nitrogen oxides (NOx = NO + NO_2). To verify the model the predicted annual mean Road NOx concentrations were compared with concentrations measured at the monitoring sites at Nantgarw Road during the study period 1st May 2011 to 30th April 2012.

The model output of Road NOx (the total NOx originating from road traffic) has been compared with the measured Road NOx, where the measured Road NOx contribution is calculated as the difference between the total NOx and the background NOx value. Total measured NOx for each diffusion tube was calculated from the measured NO_2 concentration using the 2010 version of the Defra NOx/NO_2 calculator.

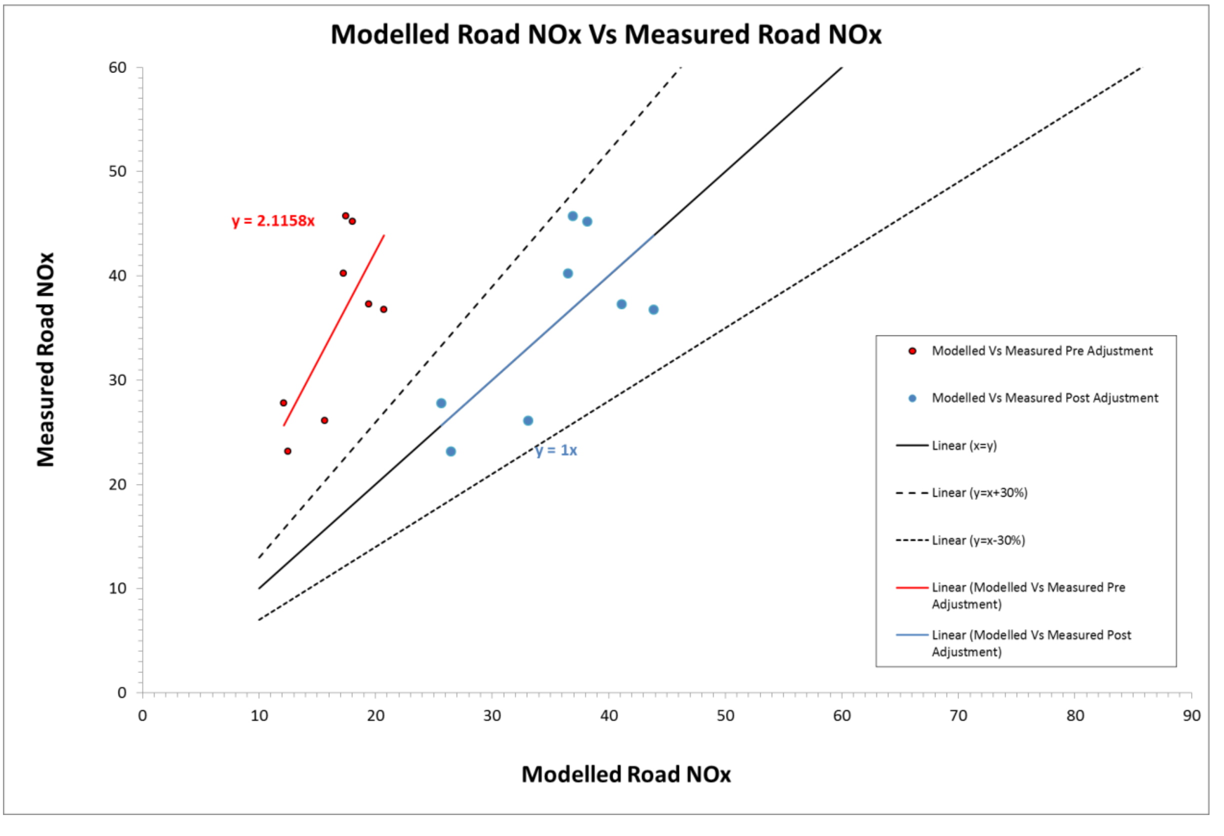
The initial comparison of the modelled vs measured Road NOx identified that the model was under-predicting the Road NOx contribution. Various refinements were subsequently made to the model input to improve the overall model performance.

The gradient of the best fit line for the modelled Road NOx contribution vs. measured Road NOx contribution was then determined using linear regression and used as the adjustment factor. This factor was then applied to the modelled Road NOx concentration for each modelled point to provide adjusted modelled Road NOx concentrations. A linear regression plot comparing modelled and monitored Road NOx concentrations before and after adjustment is presented in Figure A4.1.

The background NOx concentration was then added to determine the adjusted total modelled NOx concentrations. The total annual mean NO_2 concentrations were then determined using the NOx/NO_2 calculator.

A primary adjustment factor (PAdj) of **2.12** was applied to all modelled Road NOx data.

Figure A4.1 Comparison of modelled Road NO_x Vs Measured Road NO_x before and after adjustment



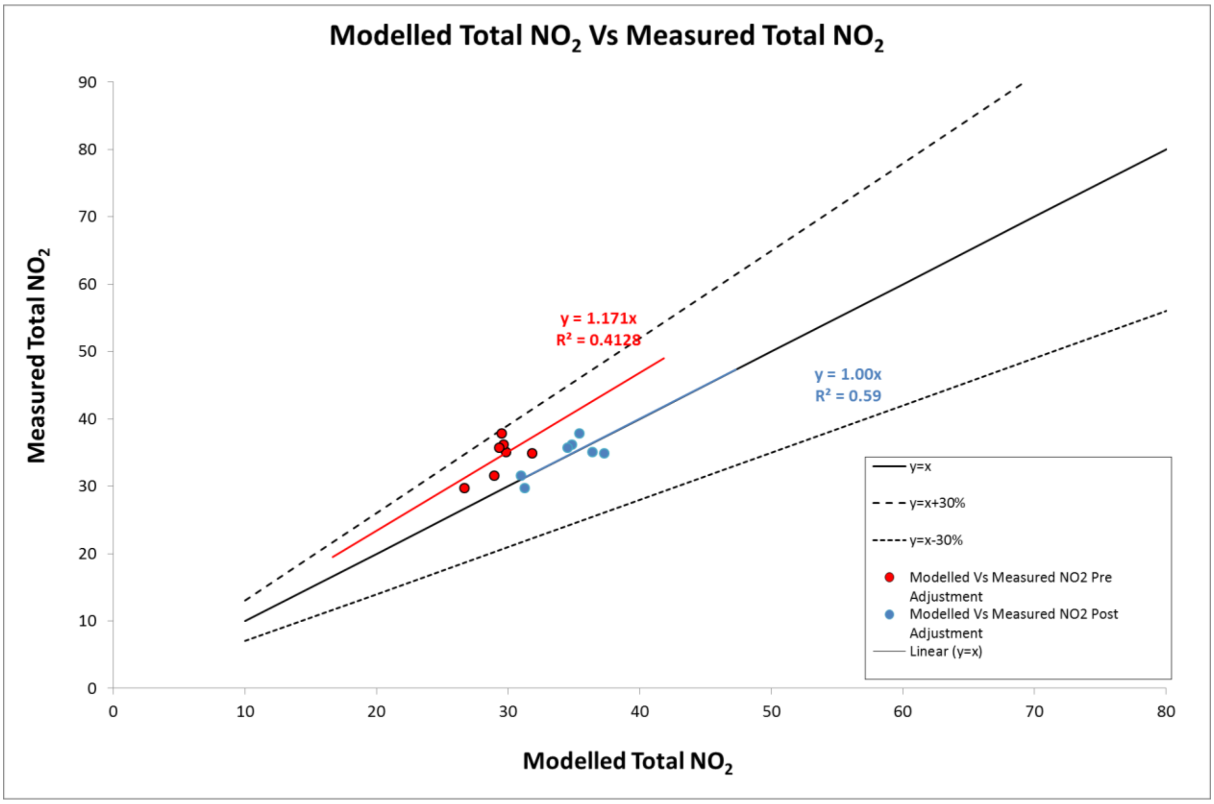
To evaluate the model performance and uncertainty, the Root Mean Square Error (RMSE) for the observed vs predicted NO_2 annual mean concentrations was calculated, as detailed in Technical Guidance LAQM.TG(09), Box A3.7, Appendix 3. The calculated RMSE is presented in Table A4.1.

It is recommended that the RMSE is below 25% of the objective that the model is being compared against, but ideally under 10% of the objective i.e. 4 $\mu g.m^{-3}$ (NO_2 annual mean objective of 40 $\mu g.m^{-3}$). In this case the RMSE is calculated at 2.2 $\mu g.m^{-3}$, the model uncertainty is therefore considered acceptable.

Table A4.1: Root mean square error

Site	NO_2 annual mean concentration ($\mu g.m^{-3}$)	
	Modelled NO_2	Measured
CCBC44 Diffusion Tube	36.7	39.9
CCBC45 Diffusion Tube	32.6	31.2
CCBC55 Diffusion Tube	39.2	36.6
CCBC56 Diffusion Tube	32.2	33.1
CCBC59 Diffusion Tube	38.2	36.8
CCBC61 Diffusion Tube	36.5	37.9
CCBC67 Diffusion Tube	37.1	39.7
Auto-monitor	35.2	32.4
	RMSE =	**2.2**

Figure A4.2: Linear regression analysis of modelled vs. monitored NO_2 annual mean 2010



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