Detailed Assessment of Air Quality 2012

Borough Green, Tonbridge and Malling, Kent

Report for Tonbridge and Malling Borough Council

Restricted Commercial
AEA/ENV/R/3262
ED57384001
Issue Number 7
Date 24/08/2012

Customer:

Tonbridge and Malling Borough Council

Customer reference:

Confidentiality, copyright & reproduction:

AEA reference:

ID: AEA/ENV

Ref: ED57384001- Issue Number 7

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Executive summary

AEA were commissioned to undertake a Detailed Assessment of Air Quality for Borough Green by Tonbridge and Malling 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 the Council to decide whether or not an Air Quality Management Area is required at the location.

This atmospheric dispersion modelling study, which has used recent traffic, monitoring and meteorological data for the area indicates that there are exceedances of the NO_2 annual mean objective at locations with relevant exposure.

The exceedance area encompasses:

- The houses by the pedestrian crossing traffic lights before the junction of Western Road and Sevenoaks Road.
- The houses that are close to the roadside on the Sevenoaks Road hill approaching the junction with the High Street.
- The houses close to the road where the 44 Sevenoaks Road diffusion tube is located, although this is a borderline location.

In light of this Detailed Assessment of Air quality, Tonbridge and Malling Borough Council should consider declaring an Air Quality Management Area encompassing all areas of exceedance of the NO_2 annual mean objective predicted in this study.

There are other locations within the study area where annual mean NO_2 concentrations close to the objective are predicted. Due to the uncertainties in the modelling process the Council could adopt a precautionary approach and declare a larger area.

We would also recommend that the Council expand their NO_2 diffusion tube network and install an automatic nitrogen dioxide monitor at Borough Green to improve the quality of the data needed for the Further Assessment that should be completed following declaration of an AQMA.

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Appendices

1 Introduction

AEA have been commissioned by Tonbridge and Malling Borough Council to undertake a Detailed Assessment of Air Quality for various streets within Borough Green town centre. The assessment has been undertaken to investigate the scale and extent of potential exceedances of the Air Quality Objectives for nitrogen dioxide in the study area. The Detailed Assessment will allow Tonbridge and Malling Borough Council to decide whether or not an Air Quality Management Area is required at this location.

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 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 µg.m^{-3} not to be exceeded more than 18 times a year	1 hour mean
	40 µg.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 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 selected locations in Borough Green.

1.4 Overview of the Detailed Assessment

The general approach taken to this Detailed Assessment was:

- 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 Tonbridge and Malling Borough Council should declare an AQMA at any location within Borough Green and suggest its spatial extent.
- The modelling methodologies provided for Detailed Assessments outlined in Defra Technical Guidance LAQM.TG(09)[1] were used throughout the study.

1.5 Previous Review and Assessments

Tonbridge and Malling Borough Council first started monitoring air quality in Borough Green in 1994 with a diffusion tube (TN 11) located on the junction of Quarry Hill, High Street and the A25 (near to 2 Sevenoaks Road).

[1] Local Air Quality Management Technical Guidance LAQM.TG(09), Defra, 2009
[2] Google (2012) www.maps.google.co.uk

1.5.1 2003 Updating and Screening assessment

The 2003 Updating and Screening assessment deemed that no exceedences of the NO_2 objectives were likely on the A25 Maidstone Rd and A227 Wrotham Road, Borough Green. Assessment of road traffic emissions using the DMRB screening model predicted an annual mean NO_2 concentration of 30.4 $\mu g.m^{-3}$ in 2005 at the junction of Sevenoaks Road and Quarry Hill Road, Borough Green meeting the air quality objective.

1.5.2 2005 Progress Report

The 2005 Progress Report predicted that concentrations would not exceed standards based on 1994-2004 data.

1.5.3 Updating and Screening Assessment (2009)

The 2009 Updating Screening and Assessment concluded that additional monitoring be undertaken for NO_2 at Borough Green at the junction of the A25 Sevenoaks Road/High Street as predicted annual mean NO_2 concentrations were 36 $\mu g.m^{-3}$ which was within 10% of the 40 $\mu g.m^{-3}$ air quality objective.

1.5.4 Progress Report (2010)

The 2010 Annual Progress report concluded that an annual mean NO_2 concentration in excess of the 40 $\mu g.m^{-3}$ objective was measured at diffusion tube site TN70, 55 Sevenoaks Road, Borough Green. This measurement was however based on only 4 months of available monitoring data, therefore further monitoring was recommended. In accordance with Defra's feedback; further monitoring was undertaken and the results presented in the 2011 Progress Report.

1.5.5 Progress Report (2011)

An annual mean NO_2 concentration in excess of the objective was recorded at the TN70,72,73 (triplicate) diffusion tube site at 55 Sevenoaks Road, Borough Green in 2010. The NO_2 annual mean measured at this site was in excess of 50$\mu g.m^{-3}$ both in 2009 (TN70) and 2010 (TN70,72,73 triplicate), although the 2009 result was based on only four months of available monitoring data.

The progress report recommended that the Council should progress to a Detailed Assessment for the area around Sevenoaks Road, Borough Green; as the monitoring results at TN70 continued to demonstrate a risk of exceeding the annual mean NO_2 objective at locations where relevant exposure may occur. The report also recommended that the additional monitoring at the site (now triplicate) that commenced in 2010 should be continued to aid the robustness of any assessment.

The results of diffusion tube measurements conducted during 2009 and 2010 at Borough Green are presented in Table 3.

Table 3: NO_2 diffusion tube results for Borough Green 2009 - 2010

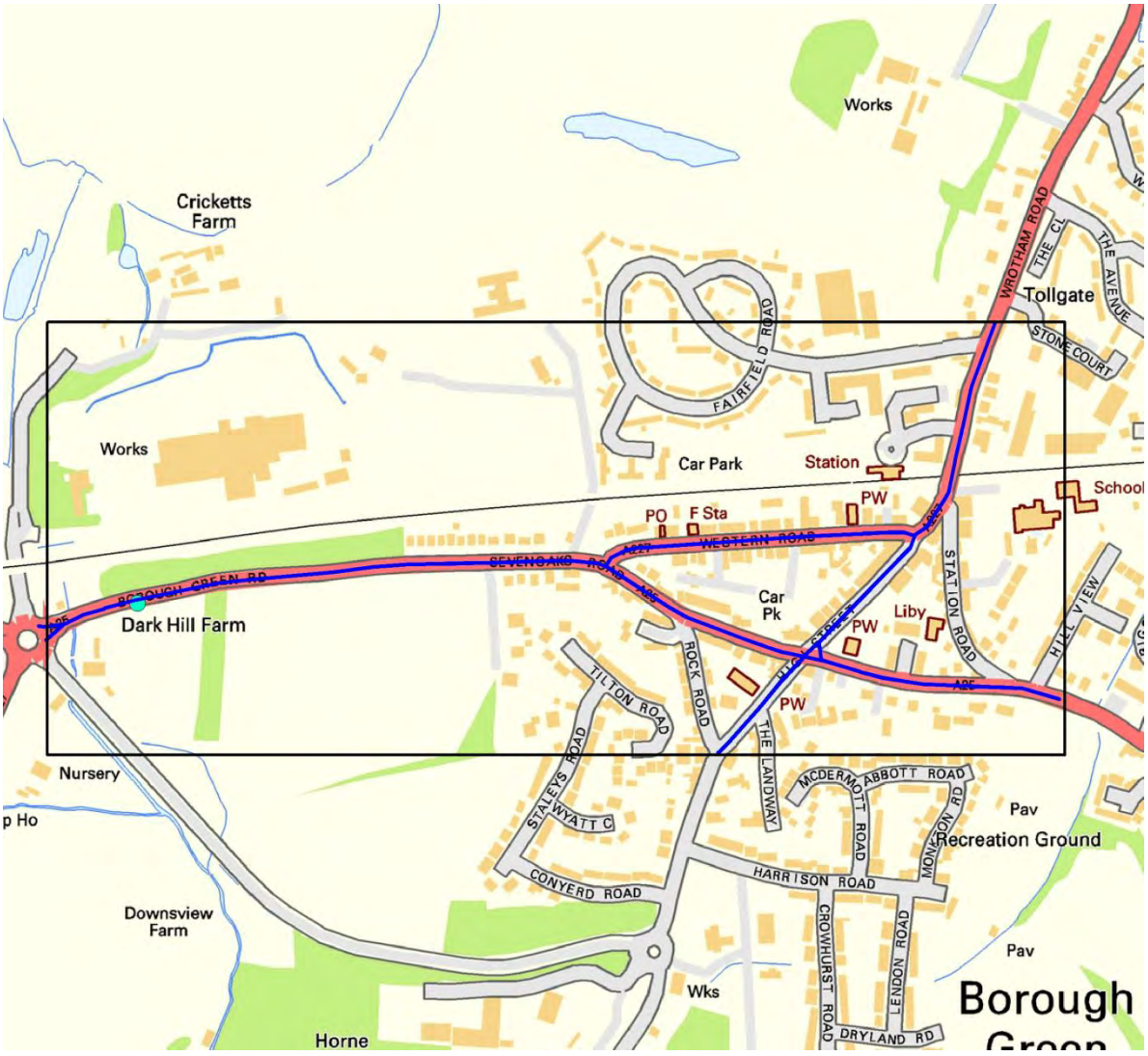
Location and site ID	Annual mean concentrations ($\mu g.m^{-3}$)	
	2009	2010
TN69; 3 High Street, Borough Green	24*	32.3*
TN70,72,73 (triplicate since 2010); 55 Sevenoaks Road, Borough Green	**51***	**50.7***
TN71; 2 Maidstone Road, Borough Green	26*	34.8*
TN78; 44 Sevenoaks Road, Borough Green	-	38.2*
TN79; Corner Rock/Sevenoaks, Road Borough Green	-	36.0*
In bold, exceedence of the NO_2 annual mean AQS objective of 40$\mu g.m^{-3}$ * Data has been annualised		

2 Detailed Assessment study area

Borough Green is a small town located in the borough of Tonbridge and Malling which lies in the heart of Kent. The Detailed Assessment is concerned with an area encompassing Borough Green and three of the main roads that connect the town to the north, east and west. The assessment will consider road traffic emissions from the main roads in the study area.

The study area, including the roads modelled and the extent of the detailed assessment is presented in Figure 1 below. The size of the study area is approximately 1 km by 450m

Figure 1: Detailed Assessment study area



N

Key:

Study area boundary

Road to be modelled

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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 the main roads entering Borough Green and from traffic count data provided by Tonbridge and Malling 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 Borough Green. 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 various locations regularly in Borough Green. Western Road is routinely congested due to the designated parking bays along one side restricting the traffic flow. Regular observations of traffic flow speeds using the Traffic layer on Google maps[2] has revealed that traffic is also regularly congested throughout the morning, lunchtime/afternoon and evening busy periods along the A25 on Sevenoaks Road and Maidstone Road in Borough Green. The A25 is the main road connecting the villages in this part of the Borough with the intersection joining the M26 to the north east. Traffic also uses Western Road (A227) and the High Street to gain access to the M20 via Wrotham Road (A227).

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 4m, 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.

3.2.3 Emissions factors

The most recent version of the Emissions Factors Toolkit[4] (EfT V4.2.2) was used in this assessment to calculate pollutant emissions factors for each road link modelled. The calculated emission factors were then imported in to the ADMS-Roads model.

Parameters such as traffic volume, speed and fleet composition are entered into the EfT, and an emissions factor in grams of NOx/kilometre/second is generated for input into the dispersion model. The version of the EfT used incorporates the latest emission factors published in 2009 by Department for Transport.

There is current concern in the air quality community that the emission factors in the EfT for diesel vehicles may be underestimating real world emissions. Recent national projections that predicted falling ambient NOx/NO_2 concentrations over time have proven to be optimistic. These projections are based largely on the assumption that emissions from the fleet would fall as newer vehicles are introduced so this points towards an issue with the accuracy of the emission factors. Any inaccuracy in the emissions factors contained in the EfT will be unavoidably carried forward into this modelling assessment.

3.2.4 Gradients

Hills with gradients may slow traffic significantly. As vehicles start to climb the hill, the power demand from the engine will increase, and hence vehicle emissions will increase. However for vehicles going downhill, the opposite occurs and emissions decrease. A method described in TG(09), to derive the change in vehicles emissions attributable to a vehicle ascending or descending a hill with approximately equal vehicle flow in either direction; indicates that for gradients up to 2.5% there are no net changes in emissions. For gradients greater than this there will likely be an increase in net emissions from HDVs.

One road in Borough Green has a hill with a gradient greater than 2.5%. The section of Sevenoaks Road from the junction with Western Road up to High Street has a gradient of approximately 4.3%.

[2] Google (2012) www.maps.google.co.uk
[3] CERC(2004) Modelling queuing traffic – Helpdesk note; Avaialble at http://www.cerc.co.uk/user-area/helpdesk-notes.html
[4] http://laqm1.defra.gov.uk/documents/tools/EFT_Version_4_2.zip

This has been accounted for in the dispersion modelling study. Although there is no accepted method of increasing HDV emissions in relation to gradients, decreasing the vehicle speed entered into the EfT for that section of road (by an amount relative to the steepness of the gradient) will results in a higher emission factor being used. This approach has been adopted to represent the higher emissions that will occur on this particular section of road.

There is another hill in the study area, on Maidstone Road (between Station Road and the High Street junction) but this gradient was 2.4% which is below the threshold of influence.

3.3 Ambient monitoring

Tonbridge and Malling Borough Council currently undertake monitoring of NO_2 within Borough Green using a network of diffusion tubes. Further details of these monitoring locations and recent measured concentrations are provided in Section 4.

No monitoring of PM_{10} is currently conducted in Borough Green.

3.4 Meteorological data

Hourly sequential meteorological data (wind speed, direction etc.) for 2010 from the RAF Manston site was obtained from a third party supplier and used for the modelling assessment. The meteorological measurement site is located approximately 68 km to the east of the study area and has good data quality for the period of interest.

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[5]. There are no background monitoring sites close to Borough Green therefore the Defra background maps were used.

A CSV file containing concentrations across the Tonbridge and Malling Borough Council area was obtained and the background NOx concentrations for the appropriate grid square extracted. A mapped NOx background concentration of 16.5 $\mu g.m^{-3}$ 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.

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

4 Monitoring data 2010

Tonbridge and Malling Borough Council currently monitors NO_2 in Borough Green using a network of diffusion tubes. A map showing the location of the diffusion tube sites is presented on Figure 2.

Table 4 lists the 2010 NO_2 diffusion tube monitoring sites in Borough Green, all of which are relevant to this assessment. A bias adjustment factor of 0.85 was applied to all of the reported 2010 diffusion tube results as specified on the most recent summary spreadsheet of co-location studies[6]

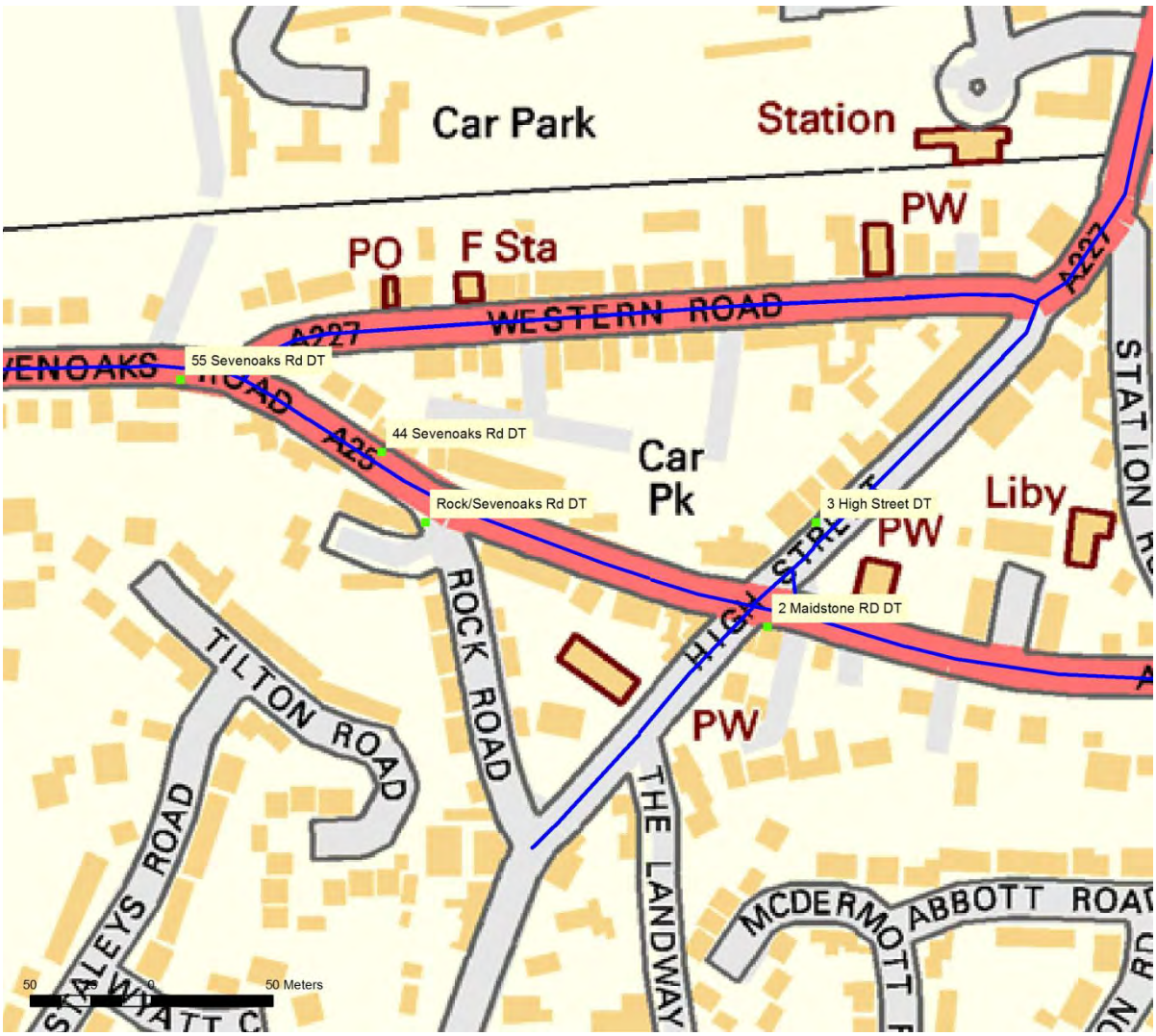
A summary of the diffusion tube measurements at the Borough Green sites in 2010 is presented in Table 4. Annual mean NO_2 concentrations in excess of the 40 $\mu g.m^{-3}$ objective were measured at one of the sites during 2010 - TN70,72,73 (triplicate site).

Table 4: Diffusion tube locations in Borough Green with bias corrected data for 2010

Site	Type	OS Grid Ref.		Data Capture 2010 (%)	Bias corrected annual mean ($\mu g.m^{-3}$)
		Easting	Northing		
TN69; 3 High Street	R	560831	157269	42%	32.3*
TN70,72,73 (triplicate); 55 Sevenoaks Road	R	560569	157328	72%	**50.7***
TN71; 2 Maidstone Road	R	560811	157226	42%	34.8*
TN78; 44 Sevenoaks Road	R	560652	157298	58%	38.2*
TN79; Corner Rock/Sevenoaks Road	R	560670	157269	58%	36.0*
Exceedences of the annual mean objective are shown in bold * Annualised annual mean due to data capture <75%					
K - Kerbside, 0 - 1m from the kerb of a busy road R - Roadside, 1 - 5m from the kerb					

[6] (National Physical Laboratory, 2011) Summary spreadsheet of co-location studies v0611 available at http://laqm.defra.gov.uk/bias-adjustment-factors/bias-adjustment.html

Figure 2: Borough Green diffusion tube locations



N

Key:

Diffusion tube site

Contains Ordnance Survey data © Crown copyright and database right 2011

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5 Modelling

5.1 Modelling methodology

Annual mean concentrations of NO_2 for 2010 have been modelled within the study area using the atmospheric dispersion model ADMS Roads (version 3.1).

The model was verified by comparing the modelled predictions of road NO_x with local monitoring results. The available roadside diffusion tube measurements (described in Section 4 above) 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 1.

A surface roughness of 0.5m 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 10m being used to represent concentrations further away from the road. The grid height was set at 1.5m 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 discussion with Tonbridge and Malling 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[7] 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 accounts for the proportion of NOx released as primary NO_2. For the Tonbridge and Malling Borough area in 2010 with the "All other UK urban Traffic" option in the model, the NOx/NO_2 model estimates that 17.3% of NOx is released as primary NO_2.

[7] Defra (2010) NOx to NO_2 conversion spreadsheet; Available at http://laqm1.defra.gov.uk/review/tools/monitoring/calculator.php

5.1.2 Validation of ADMS-Roads

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; this is usually conducted by the model developer.

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 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. This helps to identify how the model is performing at the various monitoring locations. The verification process involves checking and refining the model input data to try and reduce uncertainties and produce model outputs that are in better agreement with the monitoring results. This can be followed by adjustment of the modelled results if required.

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 five 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 an average factor of 1.9 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 3 show model agreement with the NO_2 monitoring data after adjustment. Full model verification data is provided in Appendix 3.

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 agree reasonably well with the available local monitoring.

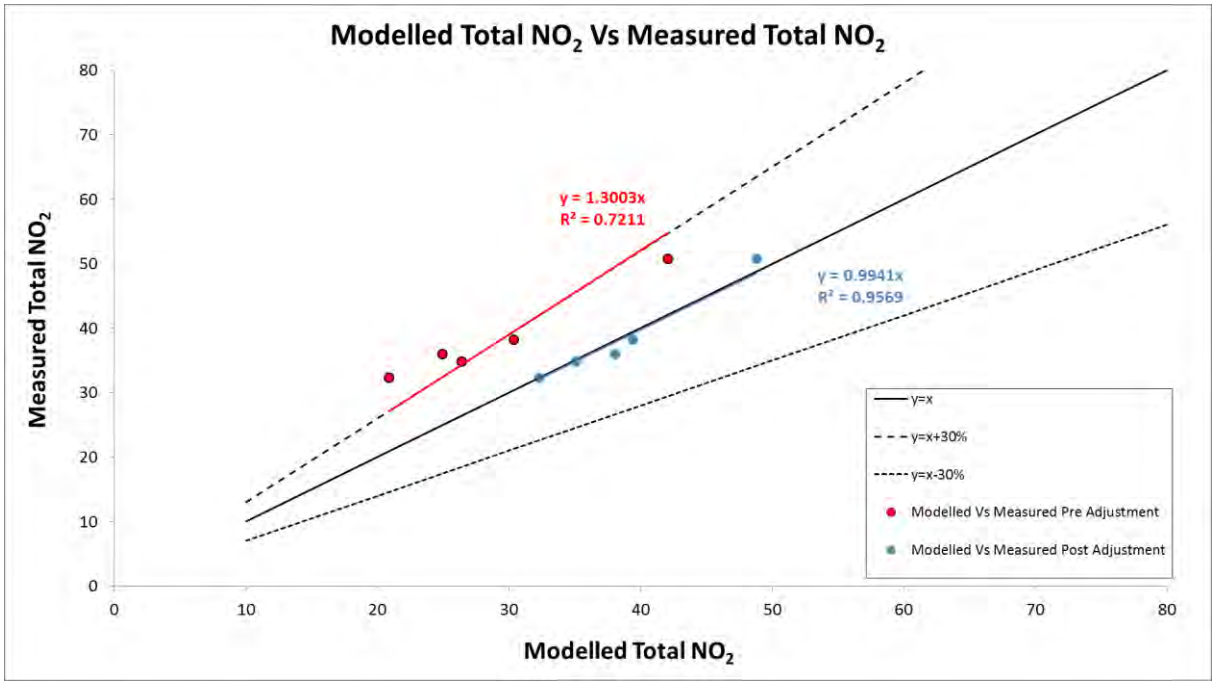
The root mean square error (RMSE) provides an estimate of model uncertainty. Ideally, more than five monitoring data points for inclusion in the calculation would provide a better indication of uncertainty. In this case the RMSE was 1.36 µg m^{-3} after adjustment which is within the suggested value (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 3.

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
TN70,72,73(triplicate); 55 Sevenoaks Road	48.8	50.7
TN78; 44 Sevenoaks Road	39.4	38.2
TN79; Corner Rock/Sevenoaks Road	38.1	36
TN71; 2 Maidstone Road	35.1	34.8
TN69; 3 High Street	32.3	32.3
RMSE =		**1.36**

Figure 3: Linear regression analysis of modelled vs. monitored NO_2 annual mean 2010



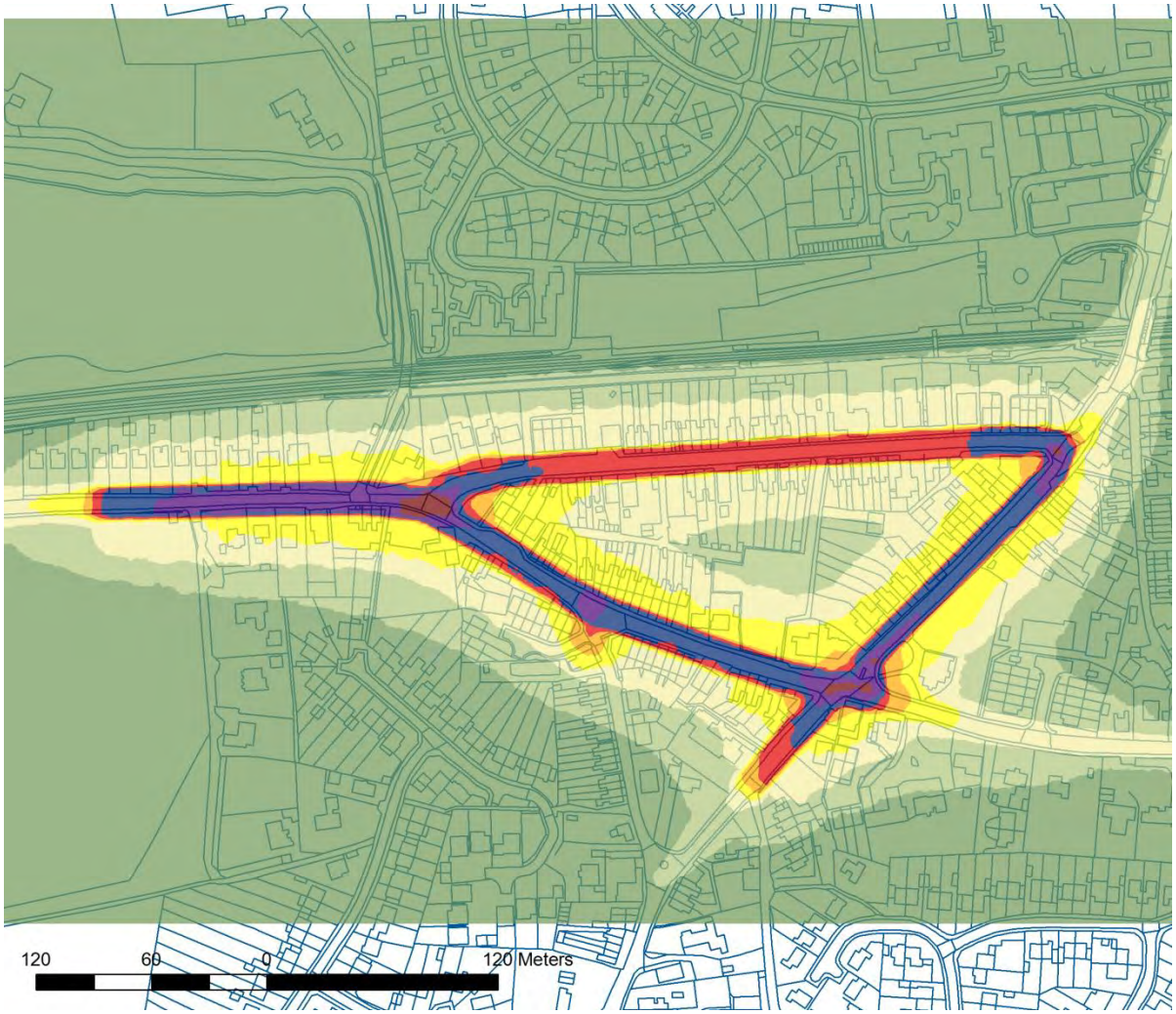
5.2 Modelling results

A contour plot showing the spatial variation of the predicted annual mean NO_2 annual concentrations across the study area during 2010 is presented in Figure 4a. It can be observed that the 40 $\mu g.m^{-3}$ NO_2 annual mean objective is predicted to be exceeded at a few locations where relevant human exposure may occur. A close up of the modelled NO_2 annual mean 40 $\mu g.m^{-3}$ contour at Borough Green is presented in Figure 4b. Examination of this plot indicates that exceedances of the NO_2 annual mean objective may be occurring at:

- The houses by the pedestrian crossing traffic lights before the junction of Western Road and Sevenoaks Road.
- The houses that are close to the roadside on the Sevenoaks Road hill approaching the junction with the High Street.
- The houses close to the road where the 44 Sevenoaks Road diffusion tube is located. The model is however slightly over-predicting at this location (modelled concentration of 39.4 $\mu g.m^{-3}$ vs. a measured concentration of 38.2 $\mu g.m^{-3}$)

Annual mean NO_2 concentrations in excess of the objective have also been predicted at other locations close to the roads included in the study. At all of these other locations the building facades are sufficiently far enough back from the roadside that relevant exposure is not expected to occur.

Figure 4a: Predicted annual mean NO_2 concentrations in Borough Green, 2010



Legend

NO2 annual mean (ug/m3)

- 13.5 - 20
- 20 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 62.3

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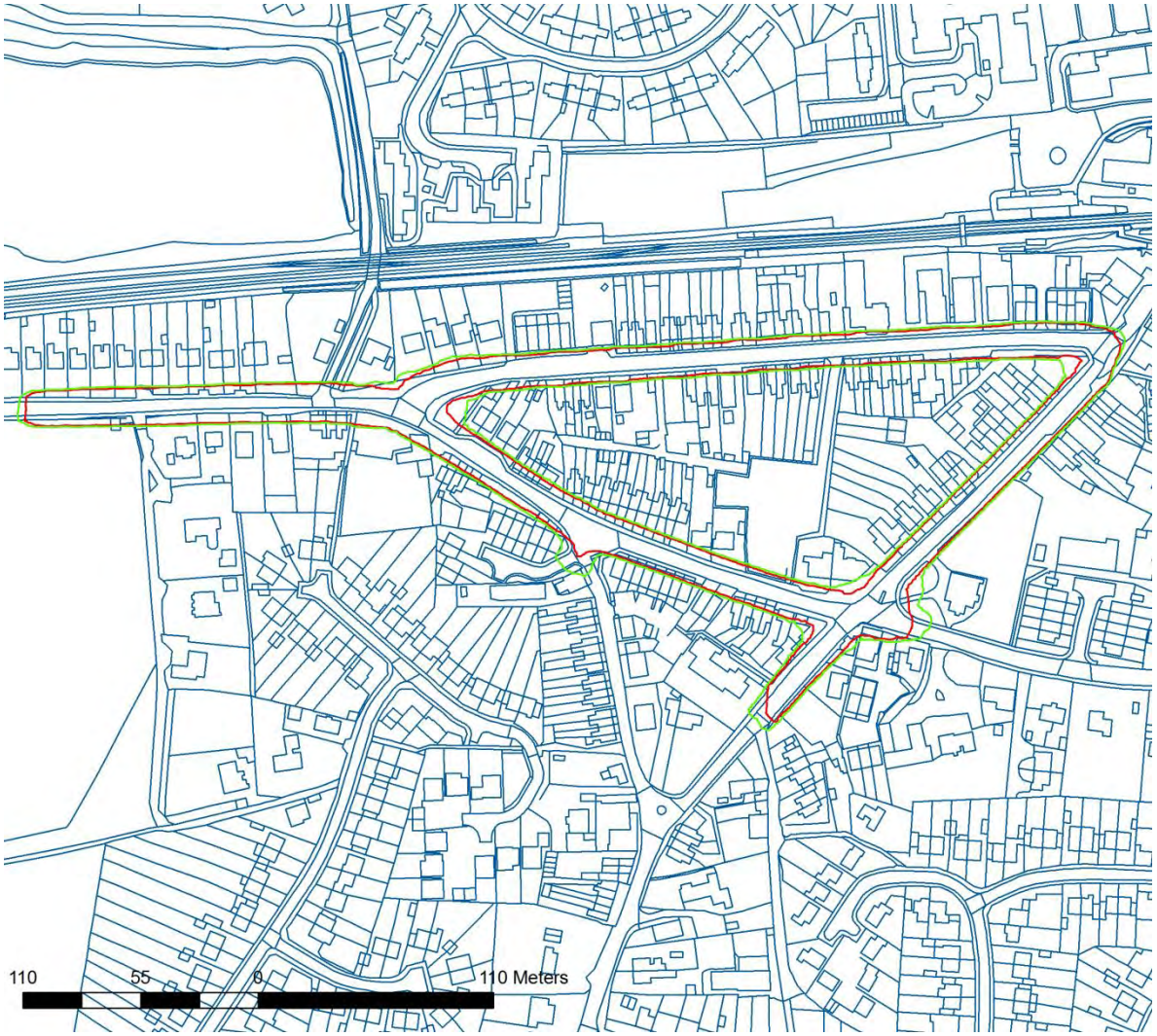
Figure 4b: Contours showing predicted annual mean NO_2 in Borough Green, 2010



Legend

NO2 annual mean 36 ug.m-3 contour

NO2 annual mean 40 ug.m-3 contour

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6 Conclusion

A dispersion modelling study of road traffic emission in Borough Green has been conducted to allow a detailed assessment of nitrogen dioxide concentrations at this location.

The modelling study, which has used the most recent traffic, monitoring and meteorological data for Borough Green indicates that there are exceedances of the NO_2 annual mean objective occurring at locations with relevant human exposure.

The exceedance area encompasses stretches of Sevenoaks Road and Maidstone Road.

In light of this Detailed Assessment of Air quality, Tonbridge and Malling Borough Council should declare an Air Quality Management Area encompassing all areas of exceedance of the NO_2 annual mean objective predicted in this study.

There are other locations within the study area where annual mean NO_2 concentrations close to the objective are predicted. Due to the uncertainties in the modelling process the Council could adopt a precautionary approach and declare a larger area.

We would also recommend that the Council expand their NO_2 diffusion tube network and install an automatic nitrogen dioxide monitor at Borough Green to improve the quality of the data needed for the Further Assessment that should be completed following declaration of an AQMA.

7 Acknowledgements

AEA gratefully acknowledge the support received from Jacqui Rands, Mary-Anne Norton and Carol Oakley of Tonbridge and Malling Borough Council when completing this assessment.

Appendices

Appendix 1: Traffic data

Appendix 2: Wind Rose

Appendix 3: Model verification

Appendix 4: Diffusion Tube QA/QC and bias adjustment factors

Appendix 1 – Traffic Data 2010

Table A1.1 summarises the Annual Average Daily Flows (AADF) of traffic and fleet compositions used within the model. As no distinct traffic count data was available for Western Road or Sevenoaks Roads, a value had to be calculated based on the available counts on the surrounding roads.

Table A1.1: Borough Green Annual Average Daily Flows - 2010

Street	Data source	%Cars	%LGV	%HGV	%Bus	%2WM	AADF
Borough Green Road	DfT Automatic count	81.65%	12.91%	3.92%	0.49%	1.02%	17086
Maidstone Road	DfT Automatic count	76.66%	16.83%	5.18%	0.57%	0.76%	11437
Wrotham Road	DfT Automatic count	80.13%	14.32%	4.26%	0.64%	0.66%	8340
Sevenoaks Road	Assumed from DFT count	81.65%	12.91%	3.92%	0.49%	1.02%	17086
Western Road	Assumed from DFT count	81.65%	12.91%	3.92%	0.49%	1.02%	5649
High Street	Tonbridge & Malling BC	95.78%	-	4.22%	-	-	4536

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

Queuing Traffic

CERC note[8] 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 an 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.

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}.

Gradients

One road in Borough Green has a hill with a gradient greater than 2.5%. The section of Sevenoaks Road from the junction with Western Road up to High Street has a gradient of approximately 4.3%. This has been accounted for in the dispersion modelling study. Although there is no accepted method of increasing HDV emissions in relation to gradients, decreasing the vehicle speed entered into the EfT for that section of road (by an amount relative to the steepness of the gradient) will results in a higher emission factor being used. This approach has been adopted to represent the higher emissions that will occur on this particular section of road. There is another hill in the study

[8] Cambridge Environmental Research Consultants Ltd, Modelling Queuing Traffic – note 60, 20th August 2004

area, on Maidstone Road (between Station Road and the High Street junction); this gradient is approximately 2.4% which is below the threshold of influence.

Figure A1.1 Modelled queue locations

N

Key

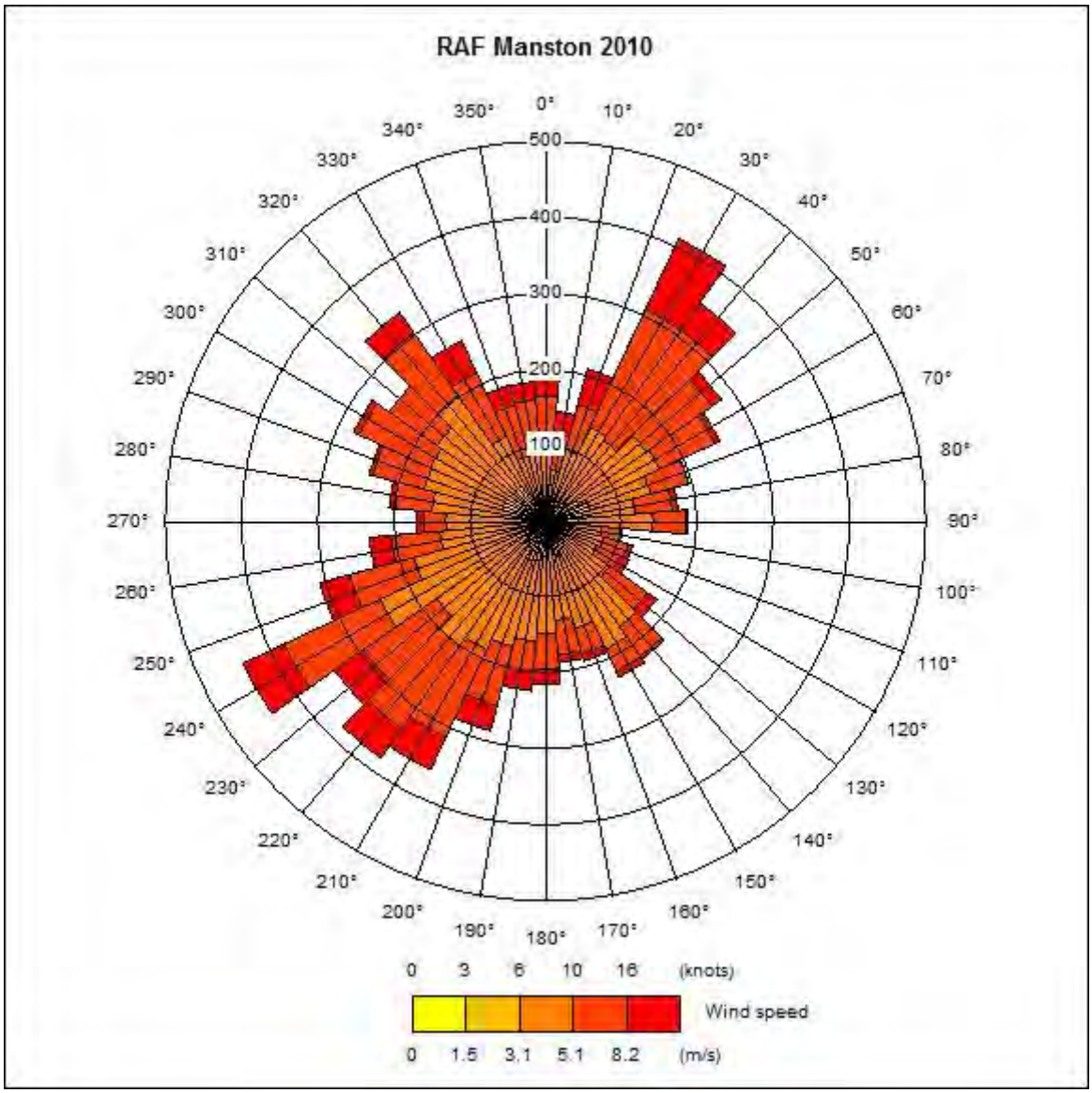
Modelled queue section

AEA

Appendix 2 – Wind Rose

The Wind Rose for the 2010 RAF Manston meteorological dataset is presented in Figure A2.1

Figure A2.1: Wind Rose



Appendix 3 - 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 diffusion tube sites in Borough Green during 2010.

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.

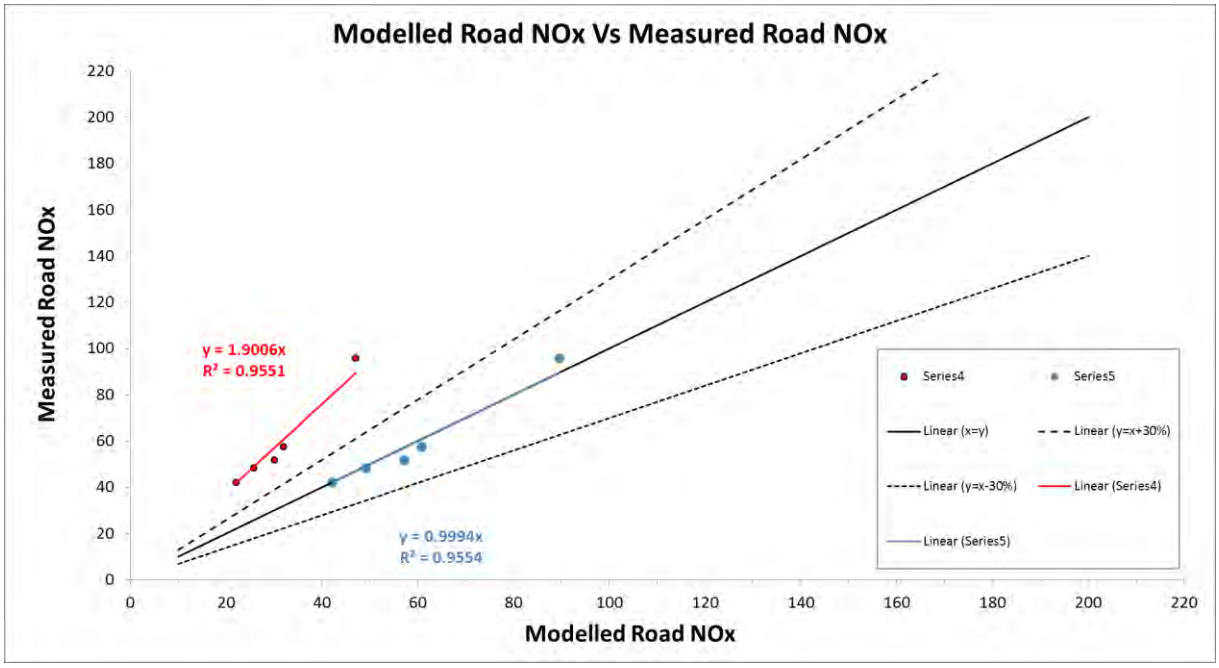
The initial comparison of the modelled vs measured Road NOx identified that the model was under-predicting the Road NOx contribution. Subsequently, various refinements were made to the model input to improve the overall model performance.

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 A3.1.

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 **1.9** was applied to all modelled Road NOx data.

Figure A3.1 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 A3.1.

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 1.36 $\mu g.m^{-3}$, the model uncertainty is therefore considered acceptable.

Table A3.1: Root mean square error

Site	NO_2 annual mean concentration ($\mu g.m^{-3}$)	
	Modelled NO_2	Measured
TN70, 72,73 (triplicate); 55 Sevenoaks Road	48.8	50.7
TN78; 44 Sevenoaks Road	39.4	38.2
TN79; Corner Rock/Sevenoaks Road	38.1	36
TN71; 2 Maidstone Road	35.1	34.8
TN69; 3 High Street	32.3	32.3
RMSE =		**1.36**

Appendix 4

Diffusion Tube Bias Adjustment Factors

Diffusion tubes are supplied and analysed by Scientifics (part of ESG formerly Harwell Scientifics) utilising the 50% Triethanolamine (TEA) in acetone preparation method. A bias adjustment of 0.85 for year 2010 has been derived from the national bias adjustment calculator (Version 04/11).

Tonbridge and Malling Borough Council did not operate any co-location monitoring sites in 2010. The national bias adjustment calculator has been used for bias adjustment of the 2010 diffusion tube data. A bias adjustment factor of 0.85 was applied to all of the reported 2010 diffusion tube results. This is consistent with previous LAQM reporting.

Short-term to Long-term Data adjustment

A number of the diffusion tubes monitoring locations were installed or discontinued part way through the year. As a consequence the data capture at these sites for 2010 was less than 75%. Average concentrations at these sites were annualised using the method outlined in Technical Guidance LAQM.TG (09), based on results from NOx urban background continuous monitoring analysers installed in Kent. A summary of these reference sites and associated annualisation factors is provided in Table A.1 of the 2011 Progress Report.

QA/QC of diffusion tube monitoring

Tube preparation and analysis follows operating procedure HS/WI/1015 (NO_2). Nitrogen dioxide analysis procedures are compliant with the Diffusion Tubes for Ambient NO_2 Monitoring: Practical Guidance for users and laboratories (February 2008). Scientifics participates in the Workplace Analysis Scheme for Proficiency (WASP) for NO_2 diffusion tube analysis and the Annual Field Inter-Comparison Exercise. These provide strict performance criteria for participating laboratories to meet, thereby ensuring NO_2 concentrations reported are of a high calibre. In 2010 the Inter-Comparison rating for Harwell Scientifics was “good”. The 2010 WASP rounds have not yet been made available. However, for the latest rounds (covering April 2009 to April 2010), Scientifics performance was ‘good’.

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