Ricardo
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Detailed Assessment of Air Quality – Montgomery Road, Paisley

Report for Renfrewshire Council

ED 59712 | Issue Number 1 | Date 04/12/2015

Customer:

Renfrewshire Council

Customer reference:

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04 December 2015

Ricardo Energy & Environment reference:

Ref: ED59712- Issue Number 1

Executive summary

Ricardo have been commissioned by Renfrewshire Council to undertake a Detailed Assessment of air quality for the area around Montgomery Road in Paisley due to an identified exceedance of the annual mean nitrogen dioxide (NO_2) objective at a residential receptor on Montgomery Road identified within the 2014 Progress Report. Air pollutant levels at Montgomery Road are heavily influenced by emissions from the surrounding road network which includes the M8 motorway, the Junction 27 slip roads and Renfrew Rd (A741). The assessment has been undertaken to investigate the potential scale and extent of exceedances of the Scottish Air Quality Objectives for nitrogen dioxide (NO_2) and particulate matter less than 10 microns in diameter (PM_{10}) within this study area.

This report describes a dispersion modelling study of road traffic emissions within the study area. This includes a source apportionment analysis to determine the contribution of different source types to local NO_2 and PM_{10} concentrations which will help inform appropriate air quality action plan measures. A combination of the available diffusion tube monitoring data and atmospheric dispersion modelling using ADMS-Roads has been used to conduct the study. The study utilises the latest available traffic and meteorological data for 2014.

The modelling study has indicated that there were no exceedances of the NO_2 and PM_{10} annual mean objectives occurring at any residential receptors on Montgomery Road during 2014, even at worst-case receptors.

Based on the available traffic data, the source apportionment study indicates that:

- Background NOx concentrations account for a significant proportion, up to 58.2% of total NOx concentrations within the study area; whereas background PM_{10} accounts for up to a more significant 95.4% of the total concentration at each receptor.
- At all receptor locations the highest proportion of road NOx and PM_{10}, following the background contribution, is attributable to cars movements.
- The proportion of NOx and PM_{10} emissions from HGV and LGV movements is much higher than buses at all receptor locations included in the source apportionment study.

In light of this Detailed Assessment of air quality in Montgomery Road, Paisley based on 2014 monitoring data, **Renfrewshire Council is not required to declare an Air Quality Management Area for this area.**

Table of contents

Table of Figures:

Table of Tables:

Appendices

1 Introduction

Ricardo has been commissioned by Renfrewshire Council to undertake a Detailed Assessment of air quality at Montgomery Road Paisley. The DA was undertaken due to an identified likely exceedance (42.1 µg.m^{-3}) of the annual mean NO_2 objective identified at Montgomery Road within the 2014 Progress Report based on 2013 diffusion tube data. Montgomery Road is located to the north of Paisley out with the existing Paisley Town Centre Air Quality Management Area. Air pollutant levels at Montgomery Road are heavily influenced by emissions from the surrounding road network which includes the M8 motorway, the Junction 27 slip roads and Renfrew Rd (A741) which have all been included within the study area. The assessment has been undertaken to investigate the scale and extent of potential exceedances of the Scottish Air Quality NO_2 and PM_{10} annual mean objectives within the study area. This report also includes a source apportionment analysis of road traffic emissions.

1.1 Policy Background

The Environment Act 1995 placed a responsibility on the 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) 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 the 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 & PM_{10} Annual Mean 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	40 µg.m^{-3}	Annual mean
Particles (PM_{10}) (gravimetric) Authorities in Scotland	18 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 to be exposed over the averaging period of the objective. Table 2 summarises examples of where the annual mean air quality objectives for NO_2 and PM_{10} should and should not apply.

Table 2 Examples of where the NO_2 & PM_{10} Annual Mean Air Quality Objectives should and should not apply

Averaging Period	Pollutant	Objectives should apply at….	Objectives should not generally apply at…
Annual mean	NO_2, PM_{10}	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.

1.3 Purpose of the Detailed Assessment

This study is a Detailed Assessment, which aims to assess the magnitude and spatial extent of any exceedances of the NO_2 and PM_{10} annual mean objectives at locations where relevant human exposure may occur within the study area in Paisley.

In addition to this, the assessment also includes a source apportionment analysis, whereby the contributions of different sources of pollutants to overall concentrations are quantified so that action planning measures may be appropriately targeted.

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 and PM_{10} concentrations at points of relevant exposure.
- Use dispersion modelling to produce contour plots showing the expected spatial variation in annual mean NO_2 concentrations.
- Recommend if Renfrewshire Council should declare an AQMA at any location within the study area and suggest its spatial extent.
- Apportion the main sources of NO_2 and PM_{10} at the locations where annual mean concentrations in excess of the objective are occurring.
- The modelling methodologies provided for Detailed Assessments outlined in the Scottish Government and Defra Technical Guidance LAQM.TG(09) were used throughout this study.

2 Detailed Assessment study area

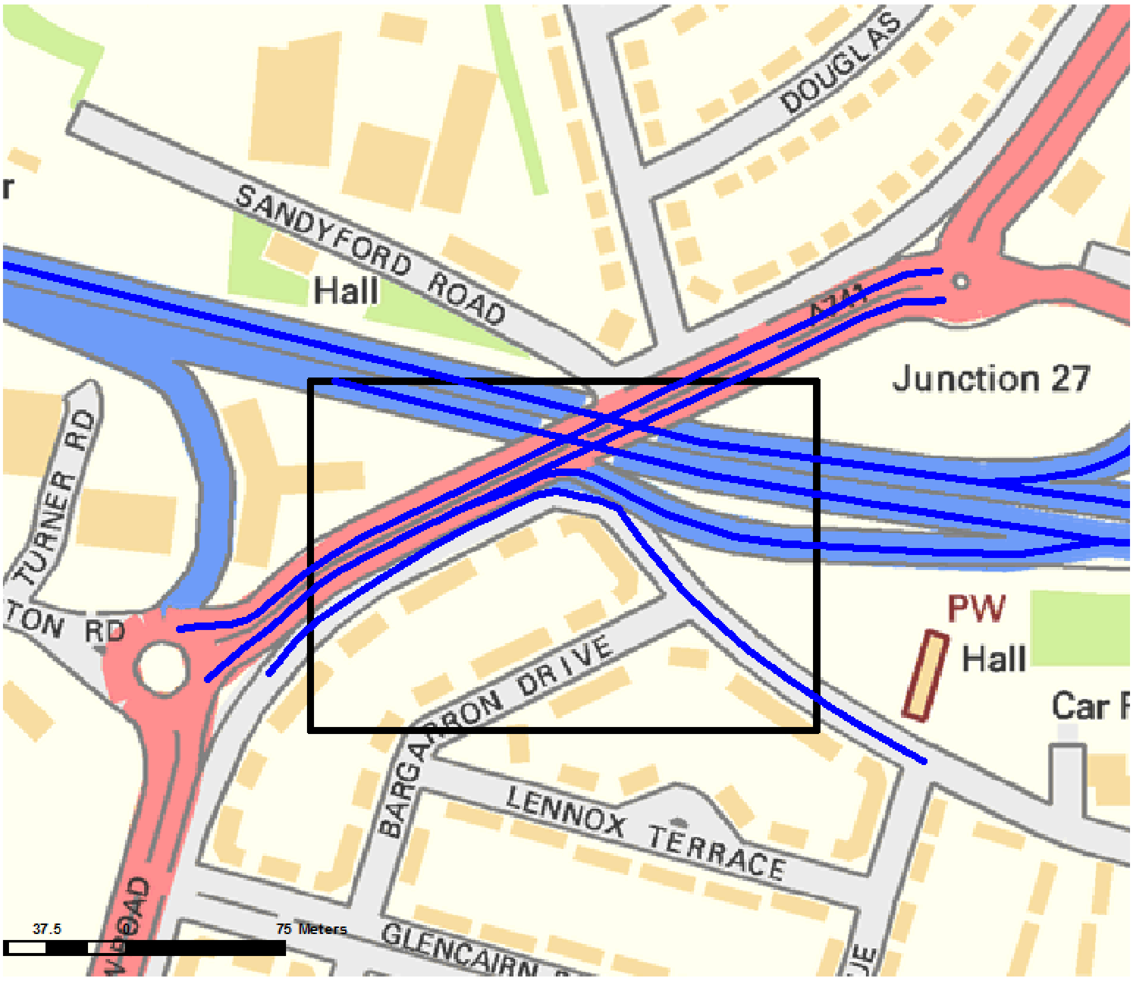
Paisley is a town within Renfrewshire located in the west central Lowlands of Scotland. The town is approximately 6 miles west of Glasgow.

Montgomery Road is located to the north of Paisley out-with the existing Paisley Town Centre Air Quality Management Area. Whilst Montgomery Road itself is not a particularly busy or congested road, air pollutant levels in this area are affected by emissions from the adjacent road network of the M8 motorway, M8 Junction 27 slip roads and Renfrew Rd (A741). This Detailed Assessment is concerned with road traffic emissions from this road network, impacting on residential receptors on Montgomery Road.

2.1 Model domain

The study area comprises of residential properties along Montgomery Road. 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 1500m by 600m.

Figure 1 Detailed Assessment Study Area



Legend:

Study area boundary

Road to be modelled

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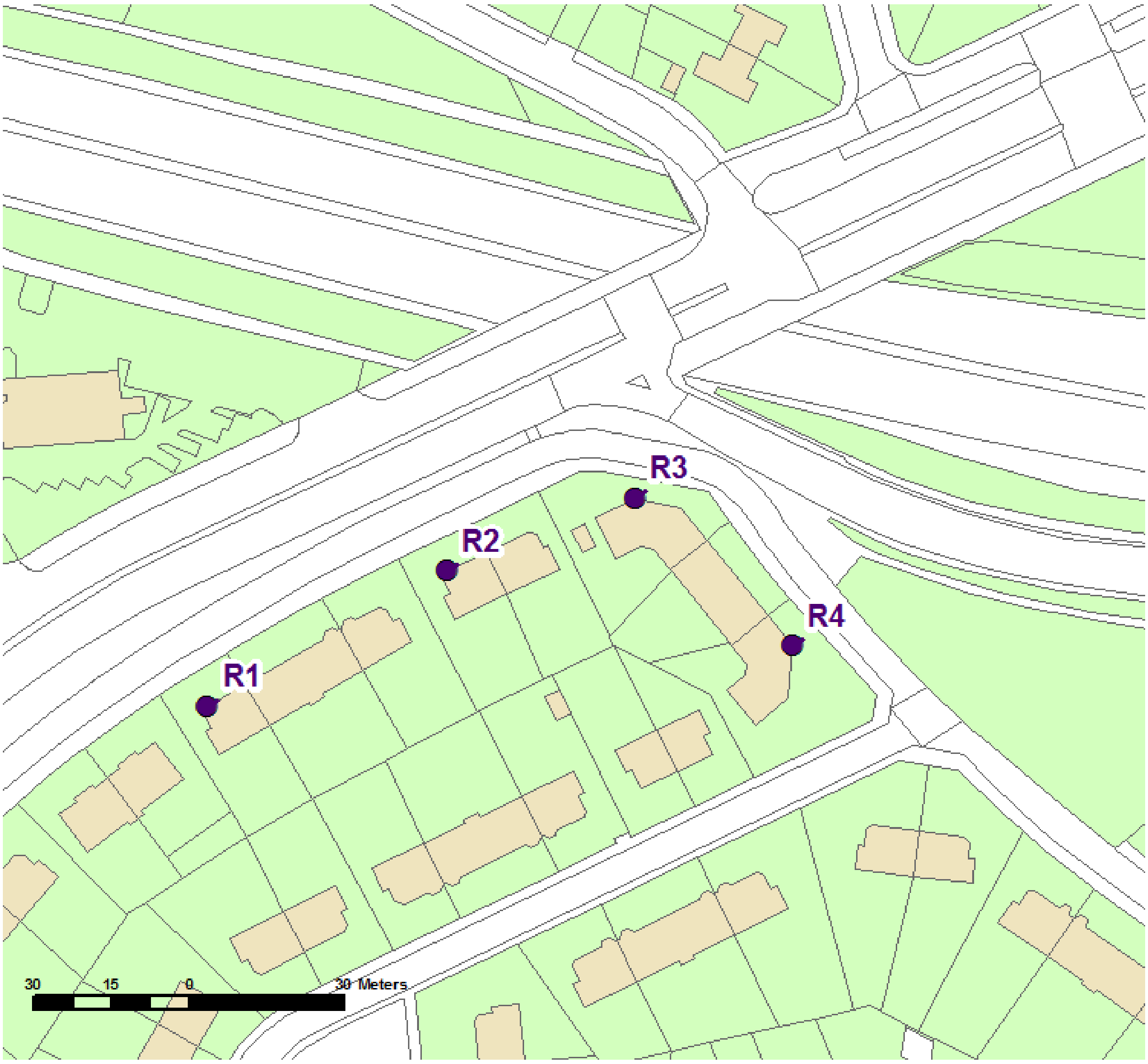
2.2 Receptor Locations

The model has been used to predict NO_2 and PM_{10} annual mean concentrations at a selection of discrete receptors within the study area. The receptors are located at the façade of buildings in the model domain where relevant exposure exists. The receptors have been modelled at 1.5m to represent human exposure at ground floor level. The locations of the selected receptors are presented in Table 3 and Figure 2.

Table 3 Residential Receptor Locations

Receptor	Address	Easting	Northing
R1	176 – 178 Montgomery Road	249099	665670
R2	186 – 188 Montgomery Road	249145	665696
R3	194 Montgomery Road	249181	665710
R4	4 Montgomery Road	249212	665681

Figure 2 Model receptor locations – Montgomery Road, Paisley



N

Legend:

ADMS Receptor

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 and fleet split

Traffic count data collected by a third party contractor[1] on behalf of Renfrewshire Council were used for the assessment, this included weekly automatic count and vehicle classification split data. Appendix 1 summarises all of the traffic flow data used for the road links modelled.

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.

Average vehicle speeds captured during the third party traffic counts were used in the modelling study.

3.2.2 Congestion

During congested periods average vehicle speeds reduce when compared to the daily average; the combination of slower average vehicle speeds and more vehicles lead to higher pollutant emissions during peak hours; it's therefore important to account for this when modelling vehicle emissions to estimate pollutant concentrations.

No queue observation data from traffic surveys were available for the assessment. The TG(09) guidance states that the preferred approach to representing the resulting increase in vehicle emissions during these peak periods is to calculate the emission rate for the affected roads for each hour of the day or week, on the basis of the average speeds and traffic flows for each hour of the day. The hourly specific emission rates can then be used to calculate a 24-hr diurnal emission profile which can be applied to that section of road.

In this case locally specific average weekday, Saturday and Sunday diurnal profiles of traffic flow across the study area were calculated using the local automatic traffic count data, but no hourly speed measurement data were available. Peak periods in traffic flow were therefore accounted for in the model by applying the typical diurnal traffic flow profile to the average hourly emission rate assuming an average daily vehicle speed provided by the third party contractor.

3.2.3 Vehicle emission factors

The latest version of the Emissions Factors Toolkit[2] (EFT V6.0.2 November 2014 release) was used in this assessment to calculate pollutant emission factors for each road link modelled. The calculated emission factors were then imported into 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 pollutant/kilometre/second is generated for input into the dispersion model. In the latest version of the EFT, NOx emissions factors previously based on DFT/TRL functions have been replaced by factors from COPERT 4 v10. These emissions factors are widely used for the purpose

[1] Sky High Count On Us –SC2095 Renfrewshire ATC Report; January 2015

[2] http://laqm.defra.gov.uk/review-and-assessment/tools/emissions.html#eft

of calculating emissions from road traffic in Europe. Defra recognise these as the current official emission factors for road traffic sources when conducting local, regional and national scale dispersion modelling assessments.

The latest version of the EFT also includes addition of road abrasion emission factors for particulate matter; and changes to composition of the vehicle fleet in terms of the proportion of vehicle km travelled by each Euro standard, technology mix, vehicle size and vehicle category. Much of the supporting data in the EfT is provided by the Department for Transport (DfT), Highways Agency and Transport Scotland.

Vehicle emission projections are based largely on the assumption that emissions from the fleet will fall as newer vehicles are introduced at a renewal rate forecast by the DfT. Any inaccuracy in the projections or the COPERT IV emissions factors contained in the EFT will be unavoidably carried forward into this modelling assessment.

3.3 Ambient monitoring

During 2014 Renfrewshire Council measured NO_2 concentrations at three diffusion tube sites within the study area. Further details of these monitoring locations and measured concentrations are provided in Section 4.

3.4 Meteorological data

Hourly sequential meteorological data (wind speed, direction etc.) for 2014 measured at the Glasgow Bishopton site was used for the modelling assessment. The meteorological measurement site is located approximately 10 km west 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 accessed from either local monitoring data conducted at a background site or from the Scottish Government background maps. The Scottish Government 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.

In this case there are no urban background monitoring sites in Paisley therefore the Scottish Government mapped background NOx and PM_{10} concentrations for the relevant 1 km x 1km grid square were used. The mapped annual mean background NOx and PM_{10} concentrations used in this assessment are presented in Table 4. The contribution of the M8 motorway and A-roads within each grid square have been removed from the background concentrations to avoid double counting.

Table 4 Paisley North Study Area Background NO_2 and PM_{10} Values 2014 ($\mu g.m^{-3}$)

X	Y	Total background	A Roads contribution	Motorway contribution	Total minus both contributions
			NOx		
249500	665500	28.4	1.28	7.5	19.6
			PM_{10}		
249500	665500	14.6	0.03	0.2	14.3

4 Monitoring data 2014

Renfrewshire Council currently measures NO_2 concentrations within the study area in Paisley at three diffusion tube sites. A map showing the location of each monitoring location is presented in Figure 3. Details of the monitoring sites and the annual mean NO_2 concentrations measured during 2014 are presented in Table 5.

Annual mean NO_2 concentrations in excess of the 40 $\mu g.m^{-3}$ objective were measured during 2014 at two of the diffusion tube sites. After distance correction, the estimated annual mean NO_2 concentrations at the closest residential properties were below the annual mean objective. The requirement to conduct a Detailed Assessment was identified in the 2014 Progress report where the distance corrected NO_2 annual mean from diffusion site 15 was 41.2 $\mu g.m^{-3}$, The distance corrected measurement in 2014 was however lower than the previous year at 36.2 $\mu g.m^{-3}$.

Full details of bias adjustment factors applied to the diffusion tube results and QA/QC procedures are presented in the Renfrewshire Council 2015 LAQM Updating and Screening Assessment[3].

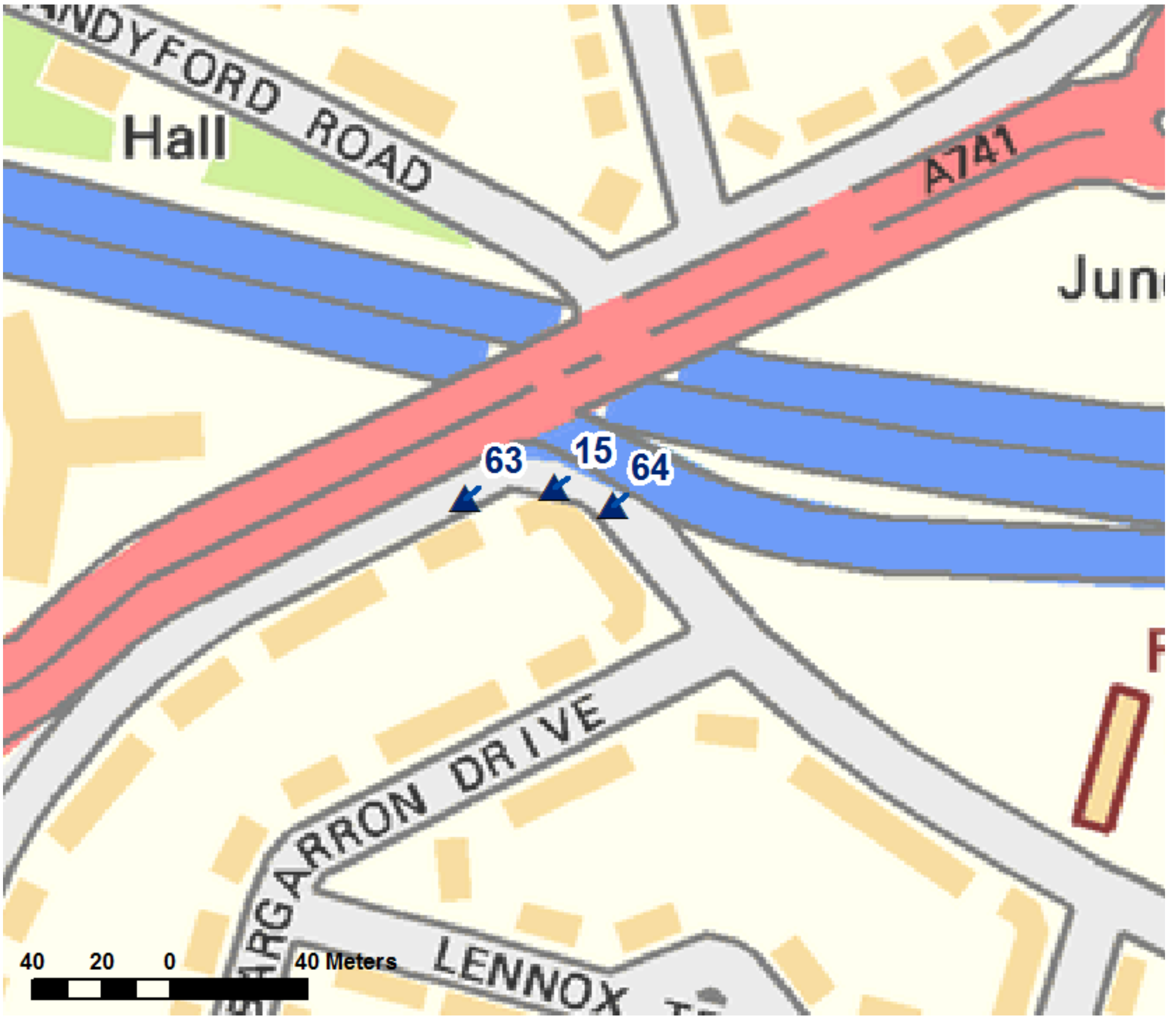
Table 5 NO_2 measurements 2014

Site	Type	Easting	Northing	Data Capture 2014 (%)	Bias corrected (1.06) annual mean 2014 ($\mu g.m^{-3}$)
		Diffusion Tubes			
Renfrew 15 – Montgomery Road	R	249185	665713	92	**41.2** (36.2)
Renfrew 63 – Montgomery Road	R	249159	665710	25	**40.1** (35.5)
Renfrew 64 – Montgomery Road	R	249202	665708	33	32.3

Exceedances of the annual mean objective in bold
Concentration in brackets has been distance corrected to estimate annual mean at nearest location of relevant exposure.
R – Roadside monitoring location, 1-5m from the kerb of a busy road
UB – Urban Background monitoring location, urban location

[3] Ricardo-AEA (2015) Renfrewshire Council LAQM Updating and Screening assessment 2015.

Figure 3 Montgomery Road Monitoring Site Locations



Legend:

▲ **Monitoring site location**

5 Modelling methodology

Annual mean concentrations of NO_2 and PM_{10} during 2014 have been modelled within the study area using the atmospheric dispersion model ADMS Roads (version 3.4).

The model has been verified by comparison of the modelled predictions of road NOx with local monitoring results. The available roadside diffusion tube measurements within the study area (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 diffusion tube measurements. Further information on model verification is provided in Section 6 and Appendix 3.

A surface roughness of 0.5 m was used in the modelling to represent the sub-urban conditions in the model 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 being used to represent concentrations further away from the road, the resolution of which is dependent upon the total size of the domain being modelled. 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.

Queuing traffic was considered using the methodology described in Section 3.2 above; whereby a time varying emissions file was used in the model to account for daily variations in traffic.

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.

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[4] 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 Renfrewshire Council area in 2014 with the "All other UK urban Traffic" option in the model, the NOx/NO_2 model estimates that 22.8% of NOx is released as primary NO_2.

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.

[4] Defra (2014) NOx NO_2 Calculator v4.1 released June 2014; Available at http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc

6 Model Results

6.1 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. LAQM.TG(09) recommends making the adjustment to the road contribution of the pollutant 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.

6.1.1 NO_2

The modelled NOx concentrations in this study were verified using the 2014 measurements from two of the diffusion tubes on Montgomery Road, tube numbers 15 and 63. Following various refinements to the model input, tube number 64 was excluded from model verification as it became apparent that it was a clear outlier; the model was overestimating the NO_2 annual mean at this location. Inclusion of this measurement point when deriving a NOx adjustment factor would skew the model agreement at the tube sites where the measured annual mean was in excess of the 40 µg.m^{-3} objective,

A reason why the model may not agree well at tube site 64 may be the site topography; the tube is located at a higher elevation than the adjacent motorway slip road which ascends from the motorway carriageway to meet ground level beside Montgomery Road.

This approach means the model has a much lower RMSE than if tube 64 was included in the adjustment factor calculation; there is therefore less uncertainty in the model results at the locations where concentrations are close to the objective. The measured annual mean at tube 64 was 32.3 µg.m^{-3}, this location is therefore of less concern that where higher concentrations were measured.

Following various checking and refinements to the model input; the modelled Road NOx contribution required adjustment by an average factor of 1.7556 to bring the predicted NO_2 concentrations within close agreement of those results obtained from the monitoring data. A plot showing modelled vs measured NOx concentrations is presented in Figure 4.

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. Model agreement for the NO_2 monitoring data after adjustment is presented in Table 6 and Figure 5. Full model verification data is provided in Appendix 3.

Model uncertainty can be estimated by calculating the root mean square error (RMSE). In this case the calculated RMSE was 0.47 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.

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). The model results should be considered in context with the uncertainties associated with both measurements and the modelling process. The predicted concentrations are not therefore absolute values. Further information on the verification process including the linear regression analysis is provided in Appendix 3.

Table 6 Modelled vs. measured annual mean NO_2 concentrations 2014

Site	Measured ($\mu g.m^{-3}$)	Modelled ($\mu g.m^{-3}$)
Renfrew 15 – Montgomery Road	41.2	40.7
Renfrew 63 – Montgomery Road	40.1	40.6
	RMSE	**0.47**

Figure 4: Comparison of modelled Road NOx Vs Measured Road NOx

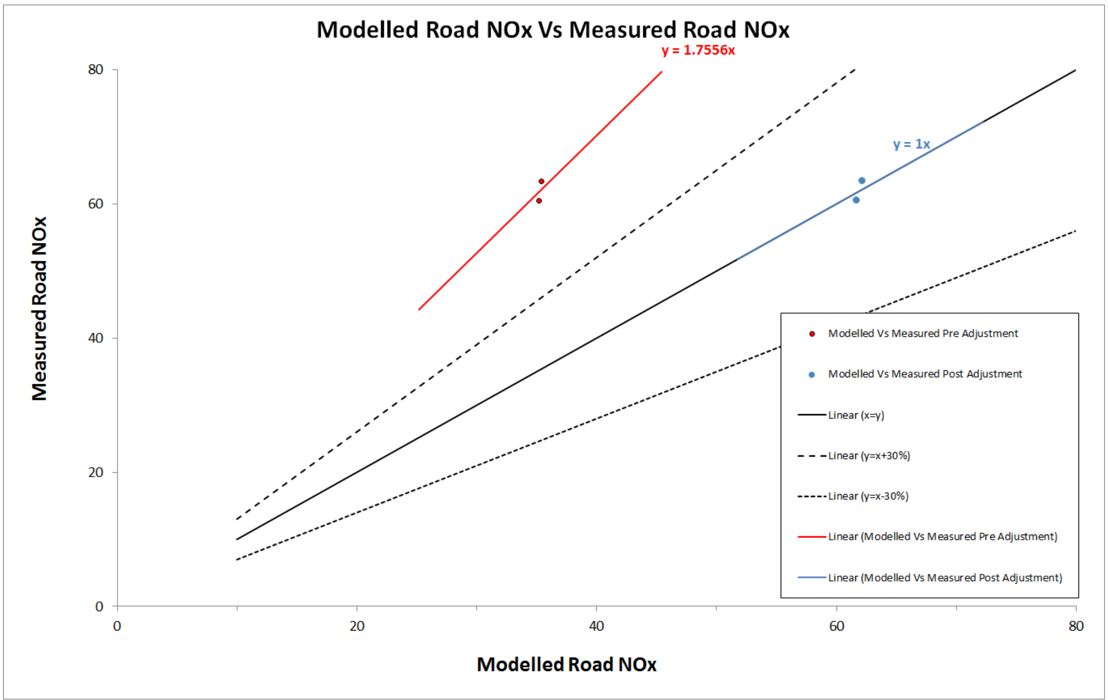
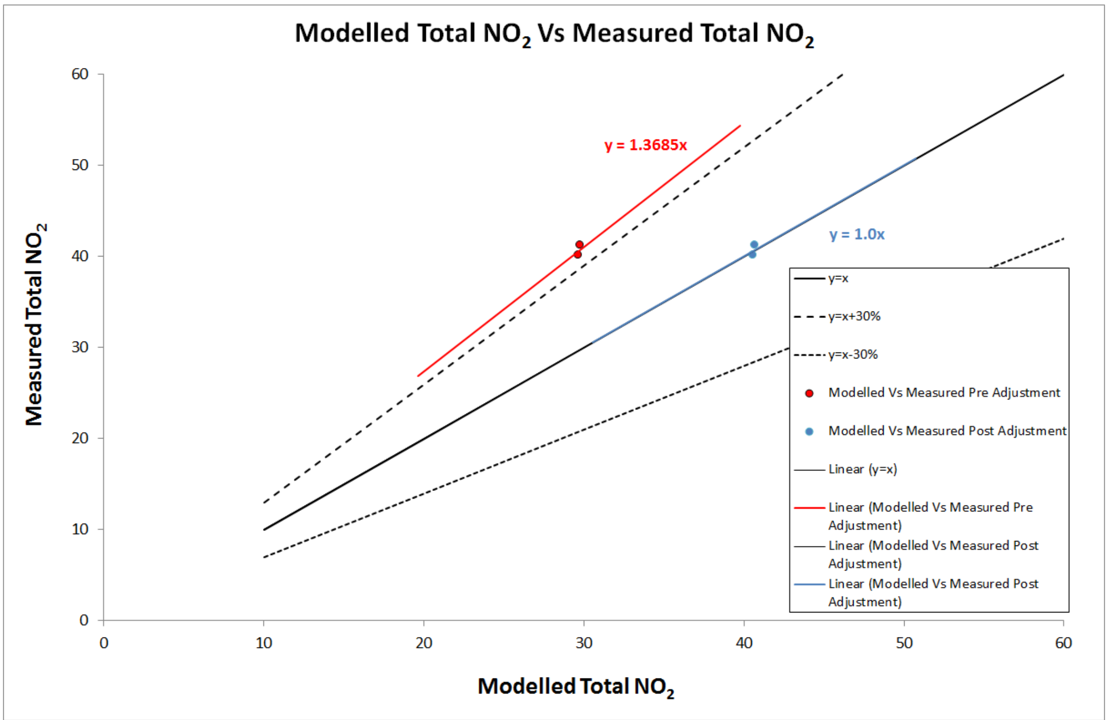


Figure 5 Linear regression plot of modelled vs. monitored NO_2 annual mean 2014



6.1.2 PM_{10}

There is no PM_{10} measurement site within the study area. Therefore the automatic monitoring site located at Cockels Loan in Renfrew approximately 1km east, along the M8, has been used to verify the model. The same adjustment factor of 1.096 as used in the Renfrew M8 study[5] has been applied to all modelled PM_{10} concentrations before adding the background concentrations.

6.2 Adjusted Modelling Results

The adjusted predicted annual mean NO_2 and PM_{10} concentrations at each specified receptor are presented in Table 7 and Table 8 respectively, with exceedances of the respective objectives highlighted in pink cells.

6.2.1 NO_2

There are no predicted exceedances of the NO_2 annual mean objective of 40 $\mu g.m^{-3}$ at any of the specified receptors.

[5] Detailed Assessment of Air Quality – Renfrew M8, 2015

Table 7 Predicted annual mean NO_2 concentrations at specified receptors 2014

Receptor	Location	Easting	Northing	Height (m)	NO_2 annual mean (µg.m^{-3})
R1	176 – 178 Montgomery Road	249099	665670	1.5	27.3
R2	186 – 188 Montgomery Road	249145	665696	1.5	32.9
R3	196 Montgomery Road	249181	665710	1.5	38.8
R4	4 Montgomery Road	249212	665681	1.5	28.7

6.2.2 PM_{10}

There are no predicted exceedances of the 18 µg.m^{-3} annual mean objective in 2014 at any of the specified receptors.

Table 8 Predicted annual mean PM_{10} concentrations at specified receptors 2014

Receptor	Location	Easting	Northing	Height (m)	PM_{10} annual mean (µg.m^{-3})
R1	176 – 178 Montgomery Road	249099	665670	1.5	15.2
R2	186 – 188 Montgomery Road	249145	665696	1.5	15.6
R3	196 Montgomery Road	249181	665710	1.5	16.1
R4	4 Montgomery Road	249212	665681	1.5	15.3

6.2.3 Modelling Results - Contour Plots

Annual mean NO_2 and PM_{10} concentrations have been predicted across a grid of points covering the entire study area. The gridded point values have been interpolated to produce contour plots showing the spatial variation of predicted concentrations across the study area. Each grid has been modelled at a height of 1.5 m to represent human exposure at ground level.

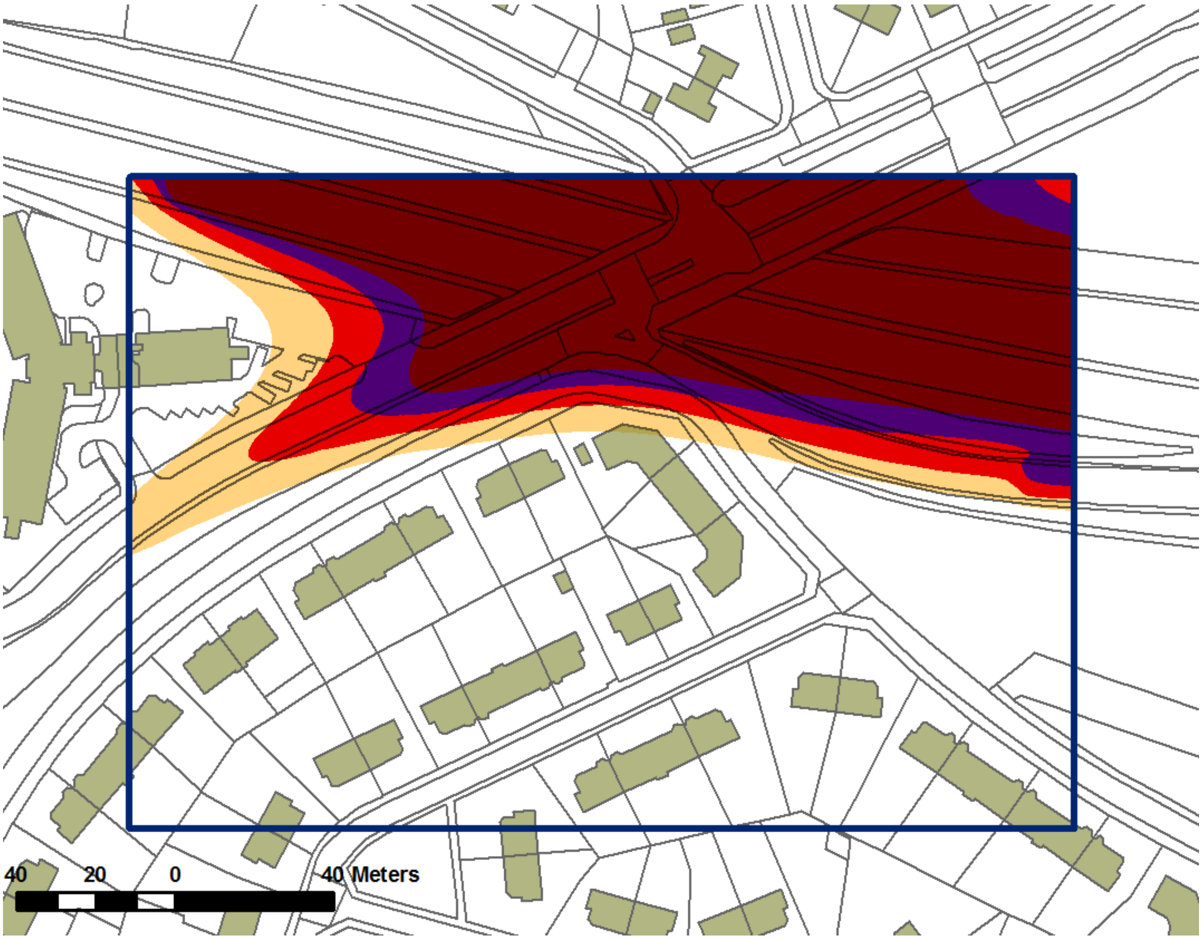
6.2.3.1 NO_2

Contour plots showing the spatial variation of the predicted 2014 annual mean NO_2 concentrations across the study area are presented Figure 6. The NO_2 annual mean contour plots indicate that the 40 µg.m^{-3} objective is not being exceeded at any receptors at Montgomery Road.

6.2.3.2 PM_{10}

Contour plots showing the spatial variation of the predicted 2014 annual mean PM_{10} concentrations across the study area are presented in Figure 7. No exceedance of the Scottish PM_{10} annual mean objective was predicted at any of the residential properties on Montgomery Road.

Figure 6 Modelled NO_2 annual mean concentrations 2014 at 1.5m height – M8 – Montgomery Road, Paisley



Legend:

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

- <36
- 36 - 40
- 40 - 44
- 44 - 48
- 48 - 80.6
- Study area

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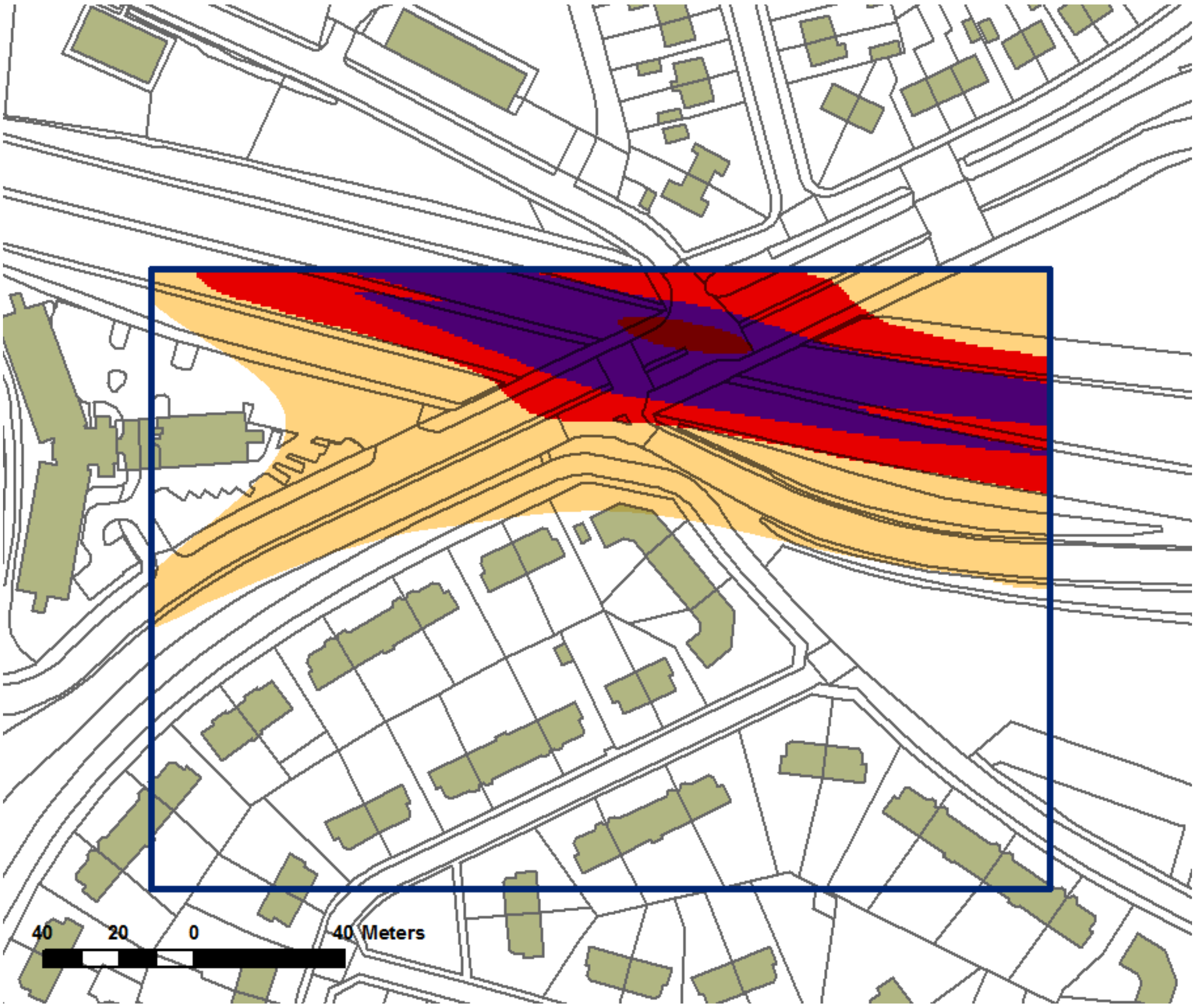
Figure 7 Modelled PM_{10} annual mean concentrations 2014 at 1.5m height – M8 – Montgomery Road, Paisley



N

Legend:

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

- <16
- 16 - 18
- 18 - 20
- 20 - 22
- 22 - 22.3
- Study area

7 Source apportionment Study

Source apportionment is the process whereby the contributions of different pollutant sources to ambient concentrations are quantified. Whilst there were no exceedances of the air quality objectives predicted on Montgomery Road the source apportionment was still undertaken for this study area.

The source apportionment for the assessment should:

- Confirm that any exceedances of the NO_2 and PM_{10} annual mean objective are due to road traffic.
- Determine the extent to which different vehicle types are responsible for the emission contributions to NOx/NO_2 and PM_{10} concentrations.
- Quantify what proportion of each pollutant is due to background emissions, or local emissions from busy roads in the local area. This will help determine whether local traffic management measures could have a significant impact on reducing emissions in the area of exceedance, or, whether national measures may be more effective in achieving the air quality objectives at this location.

To calculate the proportion of total pollutant concentrations attributable to various types of vehicles, the EfT was used; whereby emission sources were effectively switched on or off; e.g. for calculating the contribution from HGVs all other sources were set to zero. This allowed derivation of new emission rates for the road segments which were then modelled in ADMS-Roads to obtain the contribution of each source to ambient NO_2 concentrations at the worst-case specified receptor locations i.e. the locations where the highest concentrations were predicted.

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

- Background
- Cars
- Light Goods Vehicles
- Heavy Goods Vehicles
- Buses

The respective contributions from the above sources have been modelled at a selection of the receptor locations across the study area; this includes the locations where the highest NO_2 and PM_{10} annual mean concentrations were predicted. Table 9 and Table 10 summarise the relevant NOx contributions from the above sources at the worst-case receptor locations. The PM_{10} results are presented in Table 11 and 12. The source apportionment results are presented visually using segmented bar charts in Figure 8 to 13.

Examination of the source apportionment results indicate that:

- Background NOx concentrations account for a significant proportion, up to 58.2% of total NOx concentrations within the study area; whereas background PM_{10} accounts for up to a more significant 95.4% of the total concentration at each receptor.
- At all receptor locations the highest proportion of road NOx and PM_{10}, following the background contribution, is attributable to cars movements.
- The proportion of NOx and PM_{10} emissions from HGV and LGV movements is much higher than buses at all receptor locations included in the source apportionment study.

Table 9 NOx source apportionment – Contribution by vehicle type (µg.m^{-3}) (excludes motorcycles)

Receptor location	Total NOx	Background	Road NOx	Cars	HGV	Buses	LGV
R1	33.7	19.6	14.1	8.2	3.3	2.5	0.2
R2	45.6	19.6	26.0	12.7	5.4	3.2	4.6
R3	55.7	19.6	36.1	18.0	7.9	3.5	6.8
R4	38.7	19.6	19.0	9.8	4.0	1.6	3.7
Renfrew 15	60.6	19.6	40.9	20.3	9.1	3.8	7.7
Renfrew 63	60.2	19.6	40.6	19.6	9.0	4.7	7.2

Table 10 NOx source apportionment – Contribution by vehicle type (% of total NOx)

Receptor location	Total NOx	Background	Road NOx	Cars	HGV	Buses	LGV
R1	100%	50.7%	49.3%	25.3%	10.3%	4.0%	9.6%
R2	100%	35.2%	64.8%	32.3%	14.1%	6.3%	12.1%
R3	100%	43.0%	57.0%	27.9%	11.9%	7.0%	10.2%
R4	100%	58.2%	41.8%	24.3%	9.7%	7.4%	0.4%
Renfrew 15	100%	32.4%	67.6%	33.6%	15.0%	6.3%	12.7%
Renfrew 63	100%	32.6%	67.4%	32.6%	15.0%	7.9%	12.0%

Table 11 PM_{10} source apportionment – Contribution by vehicle type (µg.m^{-3}) (excludes motorcycles)

Receptor location	Total PM_{10}	Background	Road NOx	Cars	HGV	Buses	LGV
R1	15.3	14.4	0.9	0.6	0.2	0.0	0.2
R2	16.1	14.4	1.8	1.1	0.3	0.1	0.3
R3	15.6	14.4	1.3	0.8	0.2	0.1	0.2
R4	15.1	14.4	0.7	0.5	0.1	0.1	0.0
Renfrew 15	16.4	14.4	2.0	1.2	0.3	0.1	0.4
Renfrew 63	16.4	14.4	2.0	1.2	0.3	0.1	0.4

Table 12 PM_{10} source apportionment – Contribution by vehicle type (% of total NOx)

Receptor location	Total NOx	Background	Road NOx	Cars	HGV	Buses	LGV
R1	100.0%	94.0%	6.0%	3.6%	1.0%	0.3%	1.1%
R2	100.0%	89.1%	10.9%	6.5%	1.8%	0.6%	2.0%
R3	100.0%	91.9%	8.1%	4.9%	1.2%	0.5%	1.4%
R4	100.0%	95.4%	4.6%	3.4%	0.8%	0.4%	0.0%
Renfrew 15	100.0%	87.8%	12.2%	7.3%	2.0%	0.6%	2.3%
Renfrew 63	100.0%	87.9%	12.1%	7.3%	1.9%	0.8%	2.2%

Figure 8 Montgomery Road, Paisley - NOx source apportionment (expressed in µg.m^{-3})

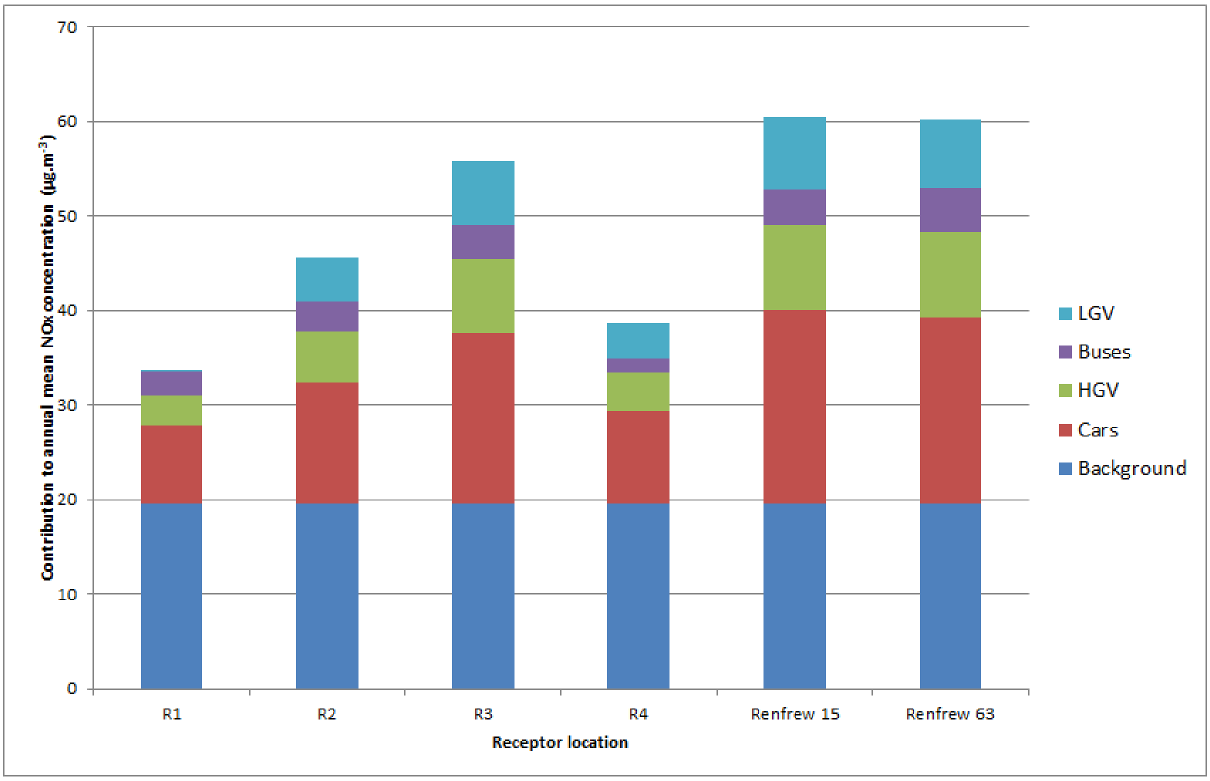


Figure 9 Montgomery Road, Paisley - NOx source apportionment (expressed as a percentage)

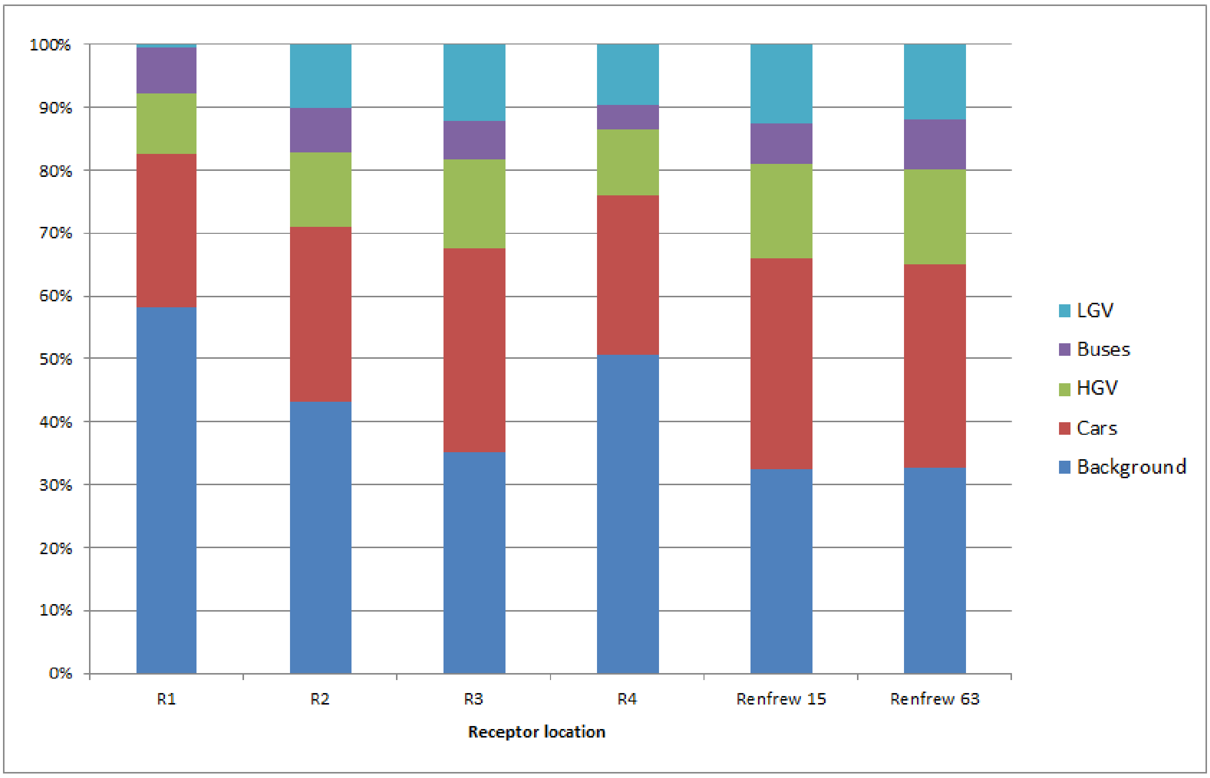


Figure 10 Montgomery Road, Paisley – PM_{10} source apportionment (expressed in µg.m^{-3})

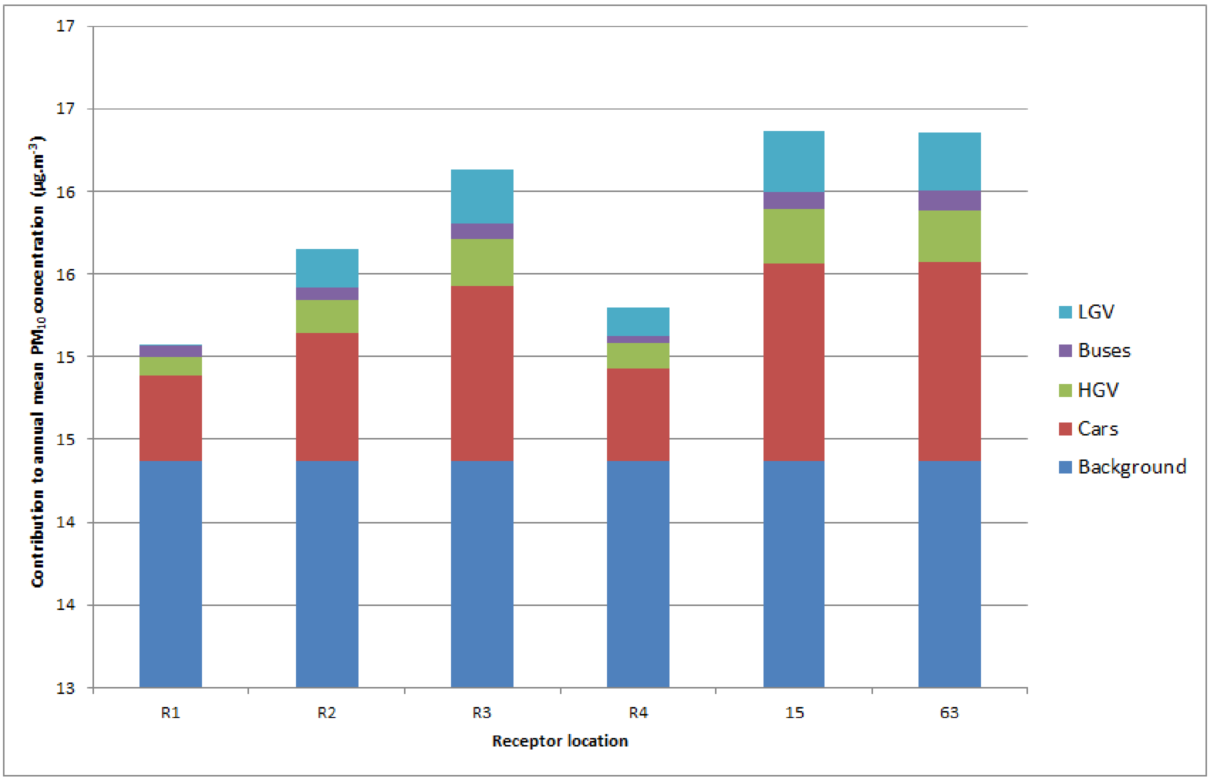
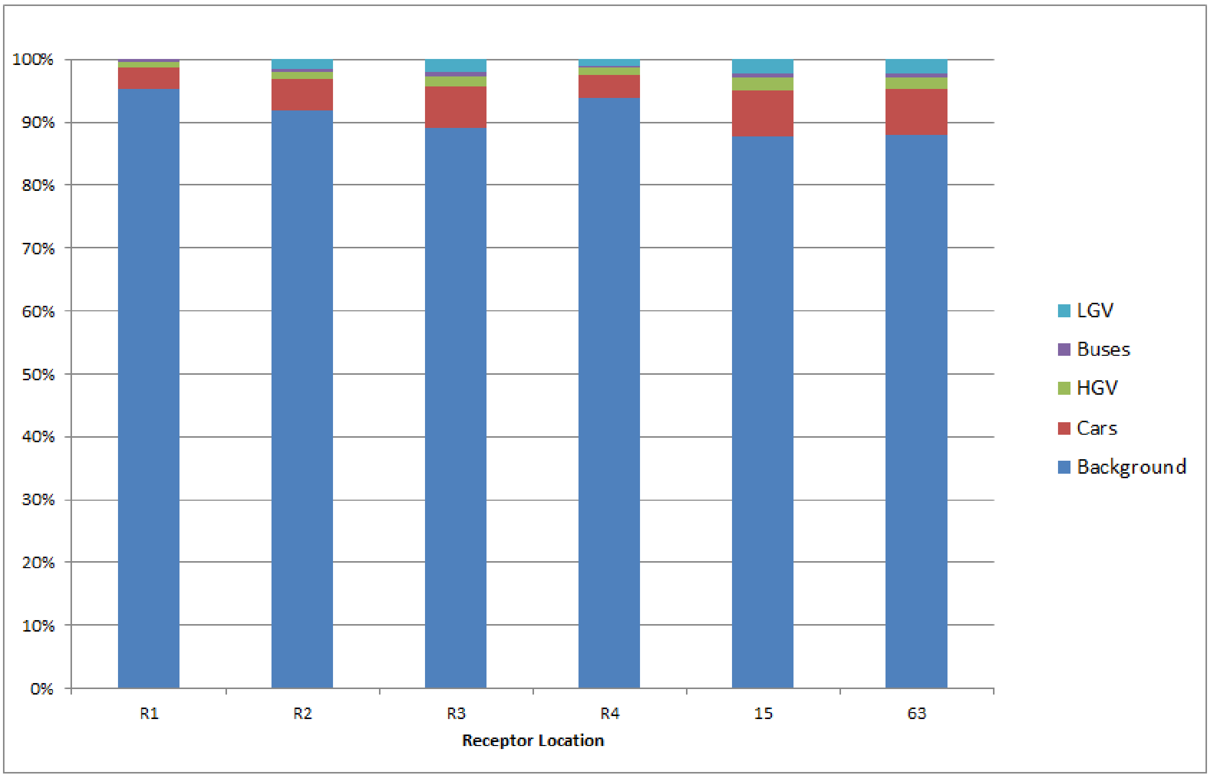


Figure 11 Montgomery Road, Paisley – PM_{10} source apportionment (expressed as a percentage)



8 Summary and conclusions

This report describes a dispersion modelling study of road traffic emissions at Montgomery Road, Paisley and the surrounding road network which has been conducted to allow a Detailed Assessment of NO_2 and PM_{10} concentrations at this location. This report also includes a source apportionment analysis of road traffic emissions. A combination of the available diffusion tube monitoring data and atmospheric dispersion modelling using ADMS-Roads has been used to conduct the study. The study utilises the latest available traffic and meteorological data for 2014.

The modelling study has indicated that there were no exceedances of the NO_2 and PM_{10} annual mean objectives occurring at any residential receptors on Montgomery Road during 2014, even at worst-case receptors.

Based on the available traffic data, the source apportionment study indicates that:

- Background NOx concentrations account for a significant proportion, up to 58.2% of total NOx concentrations within the study area; whereas background PM_{10} accounts for up to a more significant 95.4% of the total concentration at each receptor.
- At all receptor locations the highest proportion of road NOx and PM_{10}, following the background contribution, is attributable to cars movements.
- The proportion of NOx and PM_{10} emissions from HGV and LGV movements is much higher than buses at all receptor locations included in the source apportionment study.

In light of this Detailed Assessment of air quality in Montgomery Road, Paisley based on 2014 monitoring data, **Renfrewshire Council is not required to declare an Air Quality Management Area for this area.**

Appendices

Appendix 1 – Traffic Data

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

Traffic data for the assessment was available from a local survey commissioned by Renfrewshire Council. The one week traffic surveys conducted in January 2015 provided information on daily average flow and fleet split for Montgomery Road. In addition, traffic data from surveys carried out by Transport of Scotland for the M8 along with the Department for Transport data have been used.

Table A1.1 Montgomery Road, Paisley 2014 - Annual Average Daily Flows

Street	%Cars	%LGV	%HGV	%Bus	%MC	AADF 2014
M8 slip road westbound / junction A741	79.36	14.4	5.17	0.7	0.37	12,186
Montgomery Road	90.5	8.3	0.8	0	0.4	242
A741	83.2	11.5	2.8	2.3	0.2	27,196
M8 westbound	79.36	14.4	5.17	0.7	0.37	40,121
M8 eastbound	79.36	14.4	5.17	0.7	0.37	55,086

LGV – Light Goods Vehicles

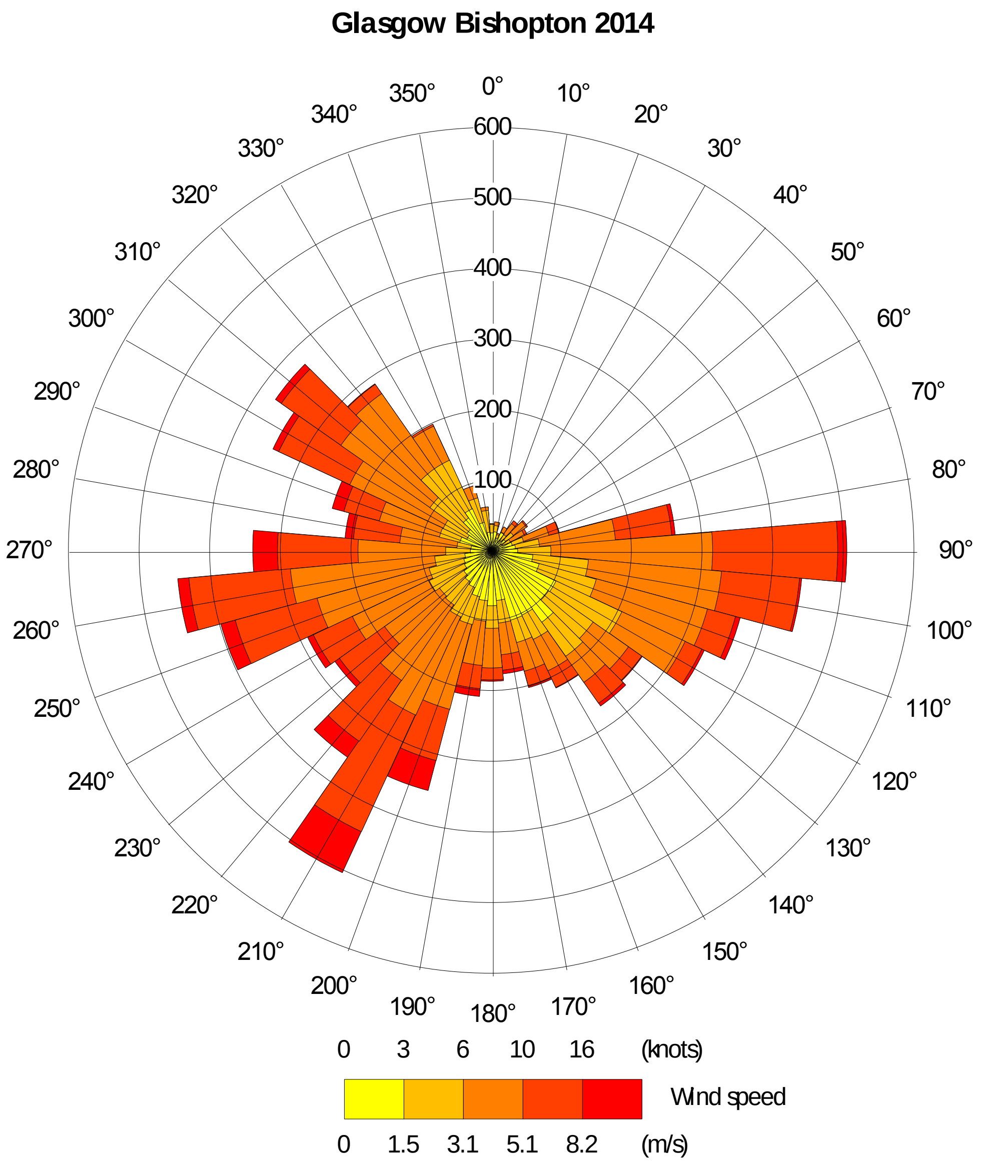
HGV – Heavy Goods Vehicles (Articulated and Rigid)

MC – Motorcycles

Appendix 2 – Meteorological dataset

The wind rose for the Glasgow Bishopton meteorological measurement site is presented in Figure A2.1.

Figure A2.1: Meteorological dataset wind rose



Appendix 3 – Model Verification

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.

As stated in Section 6 above, the model was verified using annual mean NO_2 measurements from the various NO_2 diffusion tube sites within the study area. It is appropriate to verify the ADMS Roads model in terms of primary pollutant emissions of nitrogen oxides ($NOx = NO + NO_2$). The model has been run to predict annual mean Road NOx concentrations during the 2014 calendar year at the diffusion tube sites. 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 latest 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, some refinements were made to the model input to improve the overall model performance.

The modelled NOx concentrations in this study were verified using the 2014 measurements from two of the diffusion tubes on Montgomery Road, tube numbers 15 and 63. Following various refinements to the model input, tube number 64 was excluded from model verification as it became apparent that it was a clear outlier; the model was overestimating the NO_2 annual mean at this location. Inclusion of this measurement point when deriving a NOx adjustment factor would skew the model agreement at the tube sites where the measured annual mean was in excess of the 40 $\mu g.m^{-3}$ objective,

A reason why the model may not agree well at tube site 64 may be the site topography; the tube is located at a higher elevation than the adjacent motorway slip road which ascends from the motorway carriageway to meet ground level beside Montgomery Road.

This approach means the model has a much lower RMSE than if tube 64 was included in the adjustment factor calculation; there is therefore less uncertainty in the model results at the locations where concentrations are close to the objective. The measured annual mean at tube 64 was 32.3 $\mu g.m^{-3}$, this location is therefore of less concern that where higher concentrations were measured.

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.

A primary adjustment factor (PAdj) of 1.7556 based on model verification using 2014 monitoring results was applied to all modelled Road NOx data prior to calculating an NO_2 annual mean. A plot comparing modelled and monitored NO_2 concentrations before and after adjustment is presented in Figure A3.2. After the NOx/NO_2 model was run no further adjustments were made to the data.

Model uncertainty can be estimated by calculating the root mean square error (RMSE). In this case the calculated RMSE was 0.47 $\mu g.m^{-3}$ after adjustment which is within the suggested value (10% of the objective being assessed) in LAQM.TG(09). The model has therefore performed sufficiently well for use within this assessment.

There is no PM_{10} measurement site within the study area. Therefore the automatic monitoring site located at Cockels Loan in Renfrew approximately 1km east, along the M8, has been used to verify the model. The same adjustment factor of 1.096 as used in the Renfrew M8 study[6] has been applied to all modelled PM_{10} concentrations before adding the background concentrations.

[6] Detailed Assessment of Air Quality – Renfrew M8, 2015

Figure A3.1 Comparison of modelled Road NOx Vs Measured Road NOx

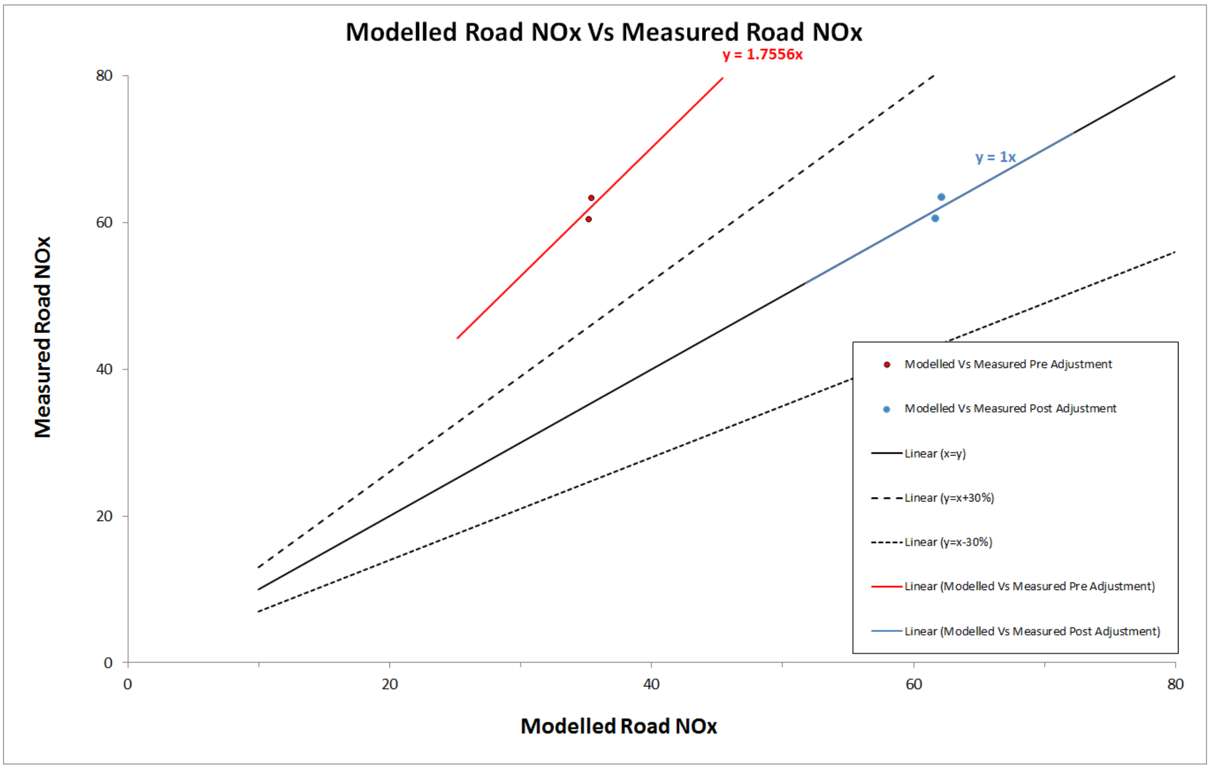
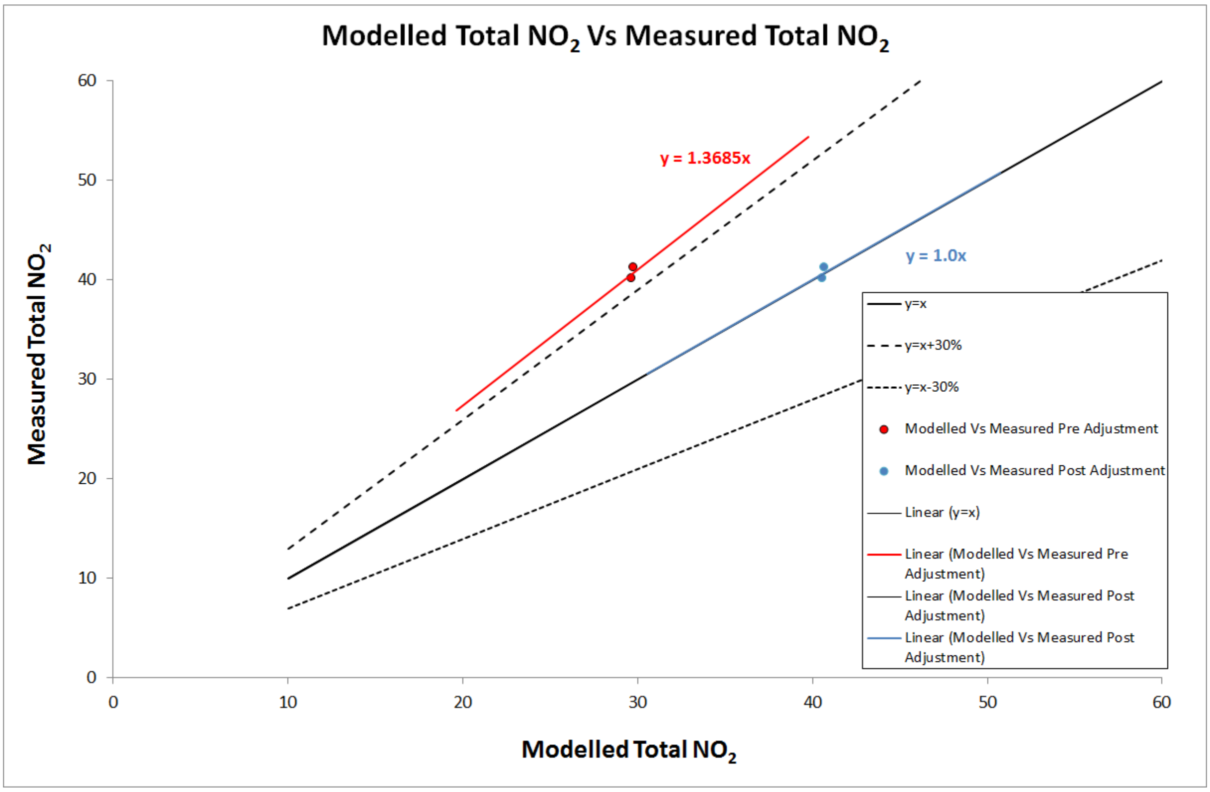


Figure A3.2 Comparison of modelled vs. monitored NO_2 annual mean 2014



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