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Repeat Detailed Assessment of Air Quality

Glasgow Road, Blantyre

Report for South Lanarkshire Council

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Executive summary

Ricardo Energy & Environment have been commissioned by South Lanarkshire Council to undertake a Detailed Assessment of Air Quality at Glasgow Road, Blantyre. This report describes a dispersion modelling study of road traffic emissions, this has been conducted to allow a detailed assessment of NO_2, PM_{10} and $PM_{2.5}$ concentrations at this location.

The assessment has been undertaken to investigate the potential scale and extent of exceedances of Air Quality Objectives within the study area. The Detailed Assessment will allow the Council to decide if an Air Quality Management Area is required.

A Detailed Assessment of NO_2 and PM_{10} concentrations in Blantyre was conducted previously in 2018. The report concluded that an AQMA should be declared for exceedances of the NO_2 annual mean objective at first floor height residential properties. Due to uncertainties in both the traffic activity and NO_2 measurement data used for the assessment, the conclusions of the report were rejected by the Defra LAQM appraisers.

The appraisers recommended that:

- Diffusion tube monitoring should be extended in this area, including the deployment of duplicate tubes to provide greater accuracy.
- A further year's extended monitoring should be used as a basis to review whether there is evidence to justify declaration of an AQMA at this location.
- The Council should consider information based on local traffic assessments to determine whether local traffic flows had temporarily increased due to traffic diverting away from roadworks on the nearby M74 motorway.

Since then, South Lanarkshire Council has deployed additional monitoring at Blantyre including an automatic analyser measuring NO_2, PM_{10} and $PM_{2.5}$; and one additional NO_2 diffusion tube site.

The dispersion modelling study (which used up to date traffic, monitoring and meteorological data for the area around Glasgow Road, Blantyre) indicates that there may be exceedances of the NO_2 annual mean objective occurring at locations where there is relevant human exposure at first floor height above commercial properties in Blantyre town centre. The maximum NO_2 annual mean concentration predicted is 40.8 $\mu g.m^{-3}$ which could be considered as a marginal exceedance of the 40 $\mu g.m^{-3}$ objective.

No exceedances of the PM_{10} or $PM_{2.5}$ annual mean objectives were predicted.

Although not a mandatory requirement for a Detailed Assessment, the report also includes a source apportionment analysis to provide information on which pollutant sources could be targeted when attempting to reduce pollutant concentrations. The primary sources of NOx pollution were diesel cars and LGVs; for PM_{10} and $PM_{2.5}$, the dominant source was the background contribution.

The current modelling indicates that the area of exceedance of the NO_2 annual mean objective is very localised and encompasses up to four residential properties at first floor height on the south side of Glasgow Road close to the junction with Station Road. This conclusion regarding the potential extent of exceedances is uncertain based on the available evidence; as assumptions regarding emission from vehicles using parking bays in the town centre were required to achieve reasonable model agreement with the available NO_2 measurements. It is therefore uncertain if the modelling has represented road traffic emissions throughout the town centre accurately.

On the basis of the uncertainties described above: At this time South Lanarkshire Council do not consider that there is sufficient evidence to confirm if an Air Quality Management Area (for exceedances of the NO_2 annual mean objective) should be declared at the location of the Glasgow Road/Station Road junction in Blantyre.

South Lanarkshire Council now intend to deploy additional NO_2 monitoring in Blantyre to provide additional evidence regarding the potential extent of localised NO_2 exceedances. If appropriate following review of NO_2 measurement data in future years; South Lanarkshire Council will repeat the detailed assessment with the intention that the additional measurement data will support a more robust

modelling assessment and associated model verification. Measures to discourage vehicle idling will also be investigated in the meantime to reduce localised vehicle emissions.

When considering air quality measurement reported in future years; it is likely that the 2020 NO_2 annual mean measurements at roadside sites will reduce when compared with the 2019 measurements. Traffic activity has reduced significantly during the March to June 2020 period due to the COVID-19 lockdown restrictions. National UK Government statistics[1] for the trunk road network over the same time interval indicate that daily traffic reduced to between 30 to 40% of pre-lockdown levels in the initial months of the restrictions. At the time of writing this report (5 months later), daily traffic is estimated to have returned to approximately 90% of pre-lockdown levels.

It is not currently clear when road traffic activity will return to pre-lockdown levels; or if in the coming year average daily traffic will decrease or increase due to various factors associated with the current pandemic guidance in place e.g. increased home working, discouraged use of public transport etc. It may therefore be unclear if another Detailed Assessment is required until measurements from 2021 or beyond are available.

South Lanarkshire Council will continue to review and assess air quality in Blantyre.

[1] https://www.gov.uk/government/statistics/transport-use-during-the-coronavirus-covid-19-pandemic

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1 Introduction

Ricardo Energy & Environment has been commissioned by South Lanarkshire Council to undertake a repeat Detailed Assessment of Air Quality at Glasgow Road in Blantyre, South Lanarkshire.

The Detailed Assessment has been undertaken to investigate the scale and extent of potential exceedances of the Air Quality Objectives for nitrogen dioxide (NO_2) within the study area. The Detailed Assessment will allow the Council to establish if an Air Quality Management Ares (AQMA) is required.

1.1 Previous Detailed Assessment

A Detailed Assessment of NO_2 and PM_{10} concentrations in Blantyre was conducted previously in 2018. The report concluded that an AQMA should be declared for exceedances of the NO_2 annual mean objective at first floor height residential properties. Due to uncertainties in both the traffic activity and NO_2 measurement data used for the assessment, the conclusions of the report were rejected by the Defra LAQM appraisers.

The appraisers recommended that:

- Diffusion tube monitoring should be extended in this area, including the deployment of duplicate tubes to provide greater accuracy.
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Since then, South Lanarkshire Council has deployed additional monitoring at Blantyre including an automatic analyser measuring NO_2, PM_{10} and $PM_{2.5}$; and one additional NO_2 diffusion tube site.

1.2 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), 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(16). Table 1.3.1 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).

1.3 Locations where the air quality 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 present and are likely to be exposed over the averaging period of the objective. Table 1.3.2 summarises examples of where the air quality objectives for NO_2 should and should not apply.

Table 1.3.1: Objectives (Scotland) included in the Air Quality Regulations and subsequent Amendments for the purpose of the Local Air Quality Management

Pollutant	Air Quality Objective Concentration	Measured as
Nitrogen dioxide (NO_2)	200 µg.m^{-3} not to be exceeded more than 18 times a year	1-hour mean
	40 µg.m^{-3}	Annual Mean
Particulate matter (PM_{10})	50 µg.m^{-3} not to be exceeded more than 7 times a year	24-hour mean
	18 µg.m^{-3}	Annual mean
Particulate matter ($PM_{2.5}$)	10 µg.m^{-3}	Annual mean

Table 1.3.2: Where the 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}, $PM_{2.5}$	All locations where members of the public might be regularly exposed. Building façades of residential properties, schools, hospitals, care homes etc.	Building façades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
24-hour mean	PM_{10}	All locations where the annual mean objective would apply, together with hotels. 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-hour mean objectives apply. Kerbside sites (for example, pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where members of the public might reasonably be expected to spend one hour or more. Any outdoor locations where members of the public might reasonably be expected to spend one hour or longer	Kerbside sites where the public would not be expected to have regular access

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1.4 Overview of the Detailed Assessment

The Detailed Assessment, primarily aims to assess the magnitude and spatial extent of any exceedances of the NO_2 annual mean objective at locations where relevant human exposure may occur within the study area in Blantyre, South Lanarkshire. We have also included an assessment of PM_{10} and $PM_{2.5}$ concentrations.

The general approach taken to this Detailed Assessment was:

- Collect and interpret data from previous Review and Assessments reports; recent traffic, monitoring, meteorological and background concentration data for use in a dispersion modelling study
- Use dispersion modelling to produce numerical predications of NO_2, PM_{10}, and $PM_{2.5}$ concentrations at locations where relevant human exposure is likely and use dispersion modelling to produce contour plots representing the modelled spatial variation in annual mean NO_2, PM_{10}, and $PM_{2.5}$ concentrations
- Recommend if South Lanarkshire Council should declare an AQMA at any location within the study area, suggest its spatial extent and number of people that are likely to be affected.
- The modelling methodologies provided for Detailed Assessments outlined in Defra Technical Guidance LAQM.TG(16) were used throughout this study.

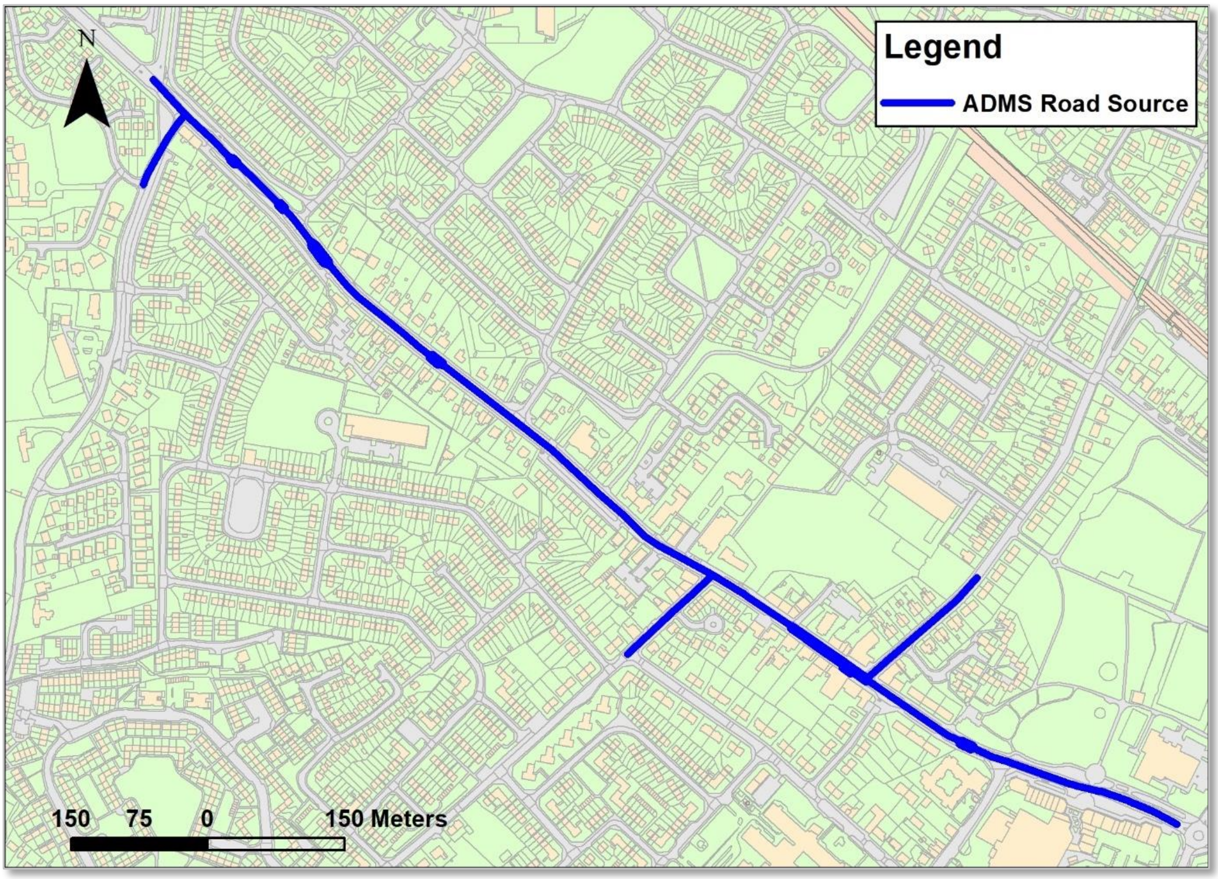
2 Detailed Assessment Study Area

This assessment is primarily concerned with road traffic emissions along sections of the A724 Glasgow Road in Blantyre where relevant human exposure is present close to the road. It also includes short sections of Station Road, Stonefield Road and Bardykes Road that intersect with Glasgow Road.

The study area comprises a mix of residential and commercial properties. Residential properties are present at ground floor and at first and second floor height above commercial properties in the town centre. The study area, including the roads modelled is presented in Figure 2.1 below. The size of the study area is approximately 1.2 km by 1.5km

Slow moving traffic regularly occurs on the section of Glasgow Road that passes through Blantyre town centre throughout the daytime, this section of Glasgow Road also has high sided buildings which may limit the dispersion of vehicle emissions.

Figure 2.1: Detailed Assessment Study Area



3 Review of recent NO_2, PM_{10} and $PM_{2.5}$ measurements

South Lanarkshire Council currently measures NO_2, PM_{10} and $PM_{2.5}$ in Blantyre at one automatic analyser and three NO_2 diffusion tube sites. The automatic site has been operational since late 2018. Maps showing the locations of the measurement sites are presented in Figure 3.1 and 3.

Site details and the NO_2 annual mean concentrations measured during recent years are presented in Table 3.1. In summary:

- NO_2 data capture was low at the automatic analyser during 2019, measurements were not available from 1st August to 20th December, 2019. A short-term to long-term adjustment has been applied to derive an estimated NO_2 annual mean concentration.
- At Tube 32, located close to the Station Road/Glasgow Road junction, annual mean NO_2 concentrations have consistently been in excess of the 40µg.m^{-3} objective since 2016.
- Measured NO_2 annual mean were much less than the 40 µg.m^{-3} objective at all other diffusion tube sites.

Full details of any short-term to long-term adjustment , bias adjustment factors applied to the diffusion tube results, and QA/QC procedures are available in the South Lanarkshire Council 2020 LAQM Annual Progress Report.

Table 3.1: NO_2 annual mean measurements

Site	Site Type	East	North	Data Capture 2019 (%)	2016	2017	2018	2019
SLC09 Automatic site Blantyre	Roadside	268916	657605	58%				27.6 (28.7)
DT32 233 Glasgow Road	Roadside	268902	657591	100%	**56.0**	**49.6**	**54.2**	**47.3**
DT33 283 Glasgow Road	Roadside	268754	657689	100%	33.0	23.5	25.5	22.6
DT36 Bardykes Road (West End Bar)	Kerbside	268175	658191	100%			25.4	26.6

Exceedances of the annual mean objective in **bold.** Annualised value in parentheses.

PM_{10} and $PM_{2.5}$ concentrations also measured at the Blantyre automatic analyser. Annual mean concentrations measured during 2019 were well below the Scottish objectives for both PM_{10} and $PM_{2.5}$. The 2019 measurement data are presented in Tables 4.2 and 4.3.

Table 3.2: PM_{10} annual mean measurements

Site	Site Type	East	North	Data Capture 2019 (%)	2018	2019
SLC09 Blantyre	Roadside	268916	657605	96%	-	10.9

Table 3.3: $PM_{2.5}$ annual mean measurements

Site	Site Type	East	North	Data Capture 2019 (%)	2018	2019
SLC09 Blantyre	Roadside	268916	657605	96%	-	6.1

Figure 3.1: NO_2 measurement site locations in Blantyre town centre

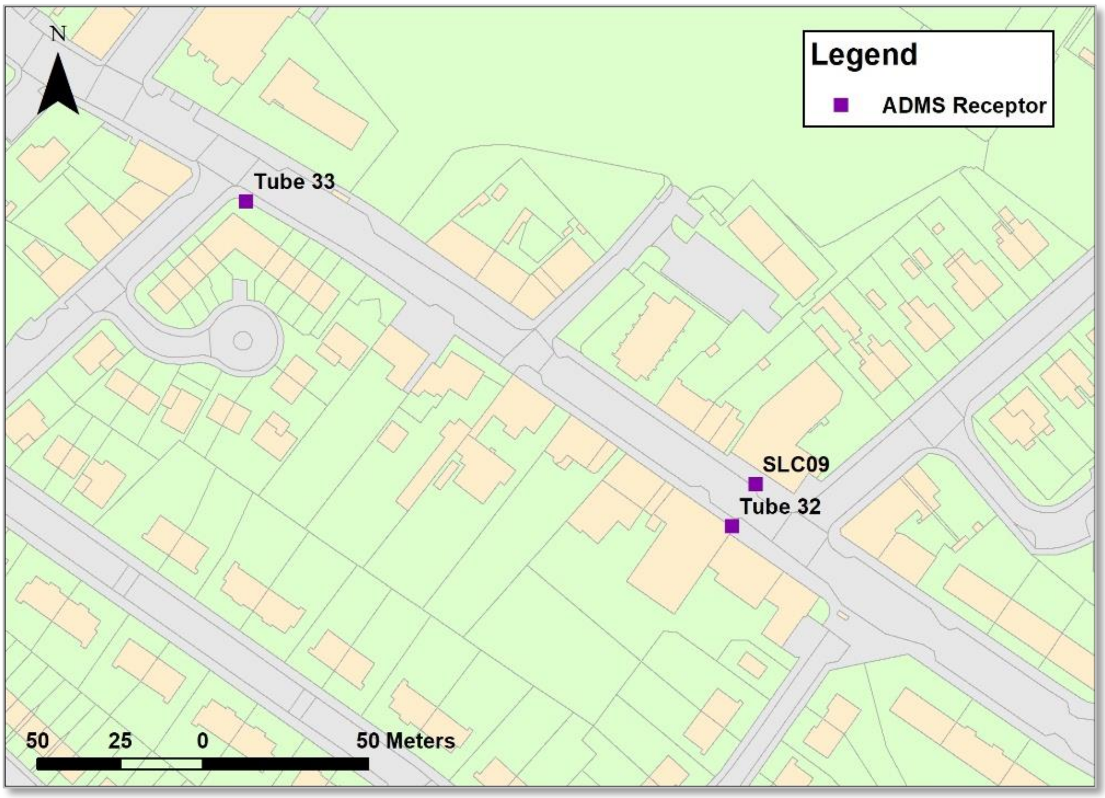


Figure 3.2: Diffusion tube site located at junction of Glasgow Road/Bardykes Rd, Blantyre

4 Dispersion Modelling Assessment

4.1 Modelling method and supporting information

4.1.1 Overview

NO_2, PM_{10} and $PM_{2.5}$ annual mean concentrations have been modelled within the study area using the atmospheric dispersion model ADMS Roads (version 5.0).

The model has been verified, and where necessary refined, by comparing modelled with measured concentrations. Further information on model verification is provided in Section 4.1.8 and Appendix 3.

The modelling methods recommended in the Defra Technical Guidance LAQM.TG(16) have been used throughout this study. 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.

4.1.2 Road traffic activity data

4.1.2.1 Average flow, speed and fleet split

Average daily traffic flow and vehicle type fleet split data were collated from the following sources:

- The freely available 2018 Department for Transport (DfT) traffic counts on Glasgow Road close to Blantyre town centre.
- A 2018 survey of Station Road and Stonefield Road, conducted by Tracsis plc on behalf of South Lanarkshire Council
- 2018 AADT traffic flows were projected forward to 2019 using a South Lanarkshire specific growth factor derived using the TEMPro V7.2[2] trip ends model.
- An automatic traffic count on Hunthill Road on 20th June 2019, conducted by Streetwise Services Ltd. on behalf of South Lanarkshire, was used for traffic data on Bardkyes Road

Average vehicle speeds were estimated based on local knowledge and observations of typical congestion in the area. Appendix 1 summarises the traffic flow and fleet split 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.

4.1.2.2 Congestion

Traffic is known to be slow moving along Glasgow Road, congestion occurs regularly throughout the day close to the junction with Station Road, and there is frequent, temporary parking along the roadside to allow access to local amenities.

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 was available for the assessment. The LAMQ.TG(16) guidance states that the preferred approach to representing the increase in vehicle emissions during peak periods is to calculate the emission rate for the affected roads for each hour of the day or week, using average speeds and traffic flow observations for each hour of the day. The hourly specific emission rates can then be used to calculate a 24-hour diurnal emission profile which can be applied to that section of road.

In this case there was insufficient hourly resolution average speed data to calculate a 24-hour diurnal emission profile; we were however able to calculate an average diurnal traffic flow profile. To account

[2] https://www.gov.uk/government/publications/tempro-downloads

for speed reductions during peak traffic periods, assumed average daily speeds were reduced at road sections where slow moving traffic is known to occur regularly. Typical journey time estimates (between the start and end nodes of ADMS road links) accessed using the Google Distance Matrix API were also used to calculate indicative traffic speeds, this helped inform our assumptions at some locations in the town centre.

4.1.2.3 Vehicle emission factors

The latest version of the Emissions Factor Toolkit[3] (EFT V9.0) 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 pollutants/kilometre/second is generated for input into the dispersion model. In the latest version of the EFT, NO_x emission factors previously based on DFT/TRL functions have been replaced by factors from COPERT 5 v0.1067. These emission factors are widely used for the purpose of calculating emissions from road traffic in Europe. Defra recognises 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 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 form 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 5 emissions factors contained in the EFT will be unavoidably carried forward into this modelling assessment.

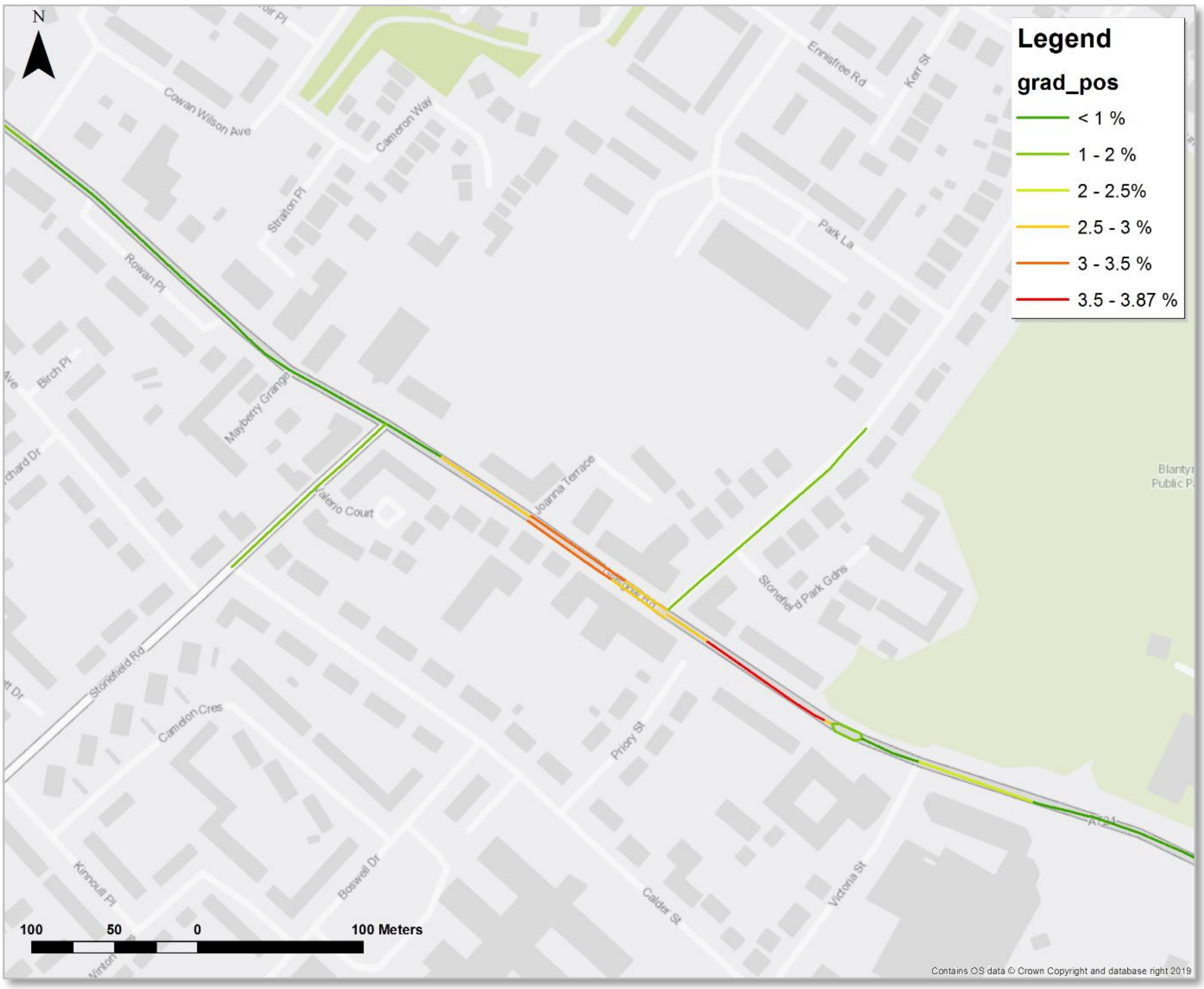
4.1.2.4 Gradients

Glasgow Road in central Blantyre is on a slight gradient (up to 3.9%) which will have an effect on vehicle emissions when ascending and descending through the town centre. When calculating vehicle emissions, gradient effects have been included for all road links in the model domain using the gradient input option in the EFTv9.0.

ADMS link gradients across the model domain were calculated using GIS spatial analysis of LIDAR Composite Digital Terrain Model (DTM) datasets at 0.5m resolution[4]. A map showing the range of calculated link gradients throughout the model domain is presented in Figure 4.1.

[3] https://laqm.defra.gov.uk/review-and-assessment/tools/emissions-factors-toolkit.html
[4] https://remotesensingdata.gov.scot/data#/map

Figure 4.1: Road link gradients calculated using GIS analysis of LIDAR DTM datasets



4.1.3 Surface roughness and street canyons

A surface roughness of 0.5m was used in the modelling to represent the urban area within the model domain. A limit for the Monin-Obukhov length of 10m was applied to represent a small town. For the meteorological measurement site, a roughness value of 0.3 m was used.

Some sections of the Glasgow Road in Blantyre have high sided buildings present. To simulate the effect of this, road links were modelled as several street canyons using the advanced street canyon module in ADMS-Roads.

The 'Advanced street canyon' modelling option in ADMS Roads modifies the dispersion of pollutants from a road source according to the presence and properties of canyon wall or one or both sides of the road. It differs from the ADMS Roads 'basic canyon' model in the following ways[5]:

- The model has been formulated to consider a wider range of canyon geometries, including canyon asymmetry;
- the concentrations predicted by the model vary with height within the canyon;
- Emissions may be restricted to a subset of the canyon width so that they may be specified only on road lanes and not on pedestrian areas; and,
- Concentrations both inside and outside a particular street canyon are affected when running this model option.

[5] CERC(2015) ADMS –Roads Air Quality Management System Version 4.0 User Guide

Accurate and up to date digital representations of building footprints and relative heights were available from the latest Ordnance Survey Mastermap Topography Layer® GIS datasets. Building heights, building footprints, road centreline geometry and road widths from the accurate OS mapping data were all used for the advanced canyon calculations.

4.1.4 Meteorological data

Hourly sequential meteorological data (wind speed, direction etc.) for 2019 from the Glasgow Bishopton site was used for the modelling assessment. The meteorological measurement site is located approximately 30km to the North East of the study area and has excellent data quality for the period of interest.

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

4.1.5 Background concentrations

Background pollutant concentrations for a modelling study within an urban environment in Scotland can be sourced from either a local urban background monitoring location, or the background maps provided by the Scottish Government[6] or Defra. The background maps provide estimates of annual mean background concentrations of key pollutants at a resolution of 1 x 1km for Scotland projected from a base year of 2015 and can be projected forward to future years up to 2030. UK wide $PM_{2.5}$ background maps are available from the Defra LAQM support website.

NOx, PM_{10} and $PM_{2.5}$ emissions are projected to decline over time as emissions are reduced by national policy implementation.

In this case there is no urban background measurement site located nearby, so the background maps were used. For the assessment year of 2019, the Scottish NOx and PM_{10} and UK $PM_{2.5}$ background maps were used to provide estimated background annual mean concentrations of each pollutant for the 1km grid squares covering the study area.

The sector contributions from road traffic emissions on A Class Roads were subtracted from the total background concentrations to avoid double counting of Road NO_x and PM from the road sources being explicitly modelled. The brake & tyre wear and road abrasion contributions were also discounted from the PM_{10} and $PM_{2.5}$ maps as these particulate emissions are calculated along with tailpipe emissions when calculating vehicle emission rates.

For both PM_{10} and $PM_{2.5}$ the mapped background concentrations were greater than the 2019 concentration measured at the roadside automatic analyser. This indicates that the background maps overestimate particulate concentrations at this location. To resolve this, we used estimated background PM_{10} and $PM_{2.5}$ values from another adjacent 1km background map square.

Table 4.1.1: Defra background maps

Grid Square	NO_x	PM_{10}	$PM_{2.5}$
267500, 657500	-	9.2	5.9
267500, 658500	13.8	-	-

[6] Background maps available at: http://www.scottishairquality.co.uk/data/mapping?view=data

4.1.6 Treatment of modelled NO_x road contribution

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

The Defra NO_x/NO_2 calculator[7] was used to calculate NO_2 for comparison from the NO_x concentrations predicted by ADMS-Roads. The model requires input of the background NO_x, the modelled road contribution and accounts for the proportion of NO_x released as primary NO_2. For the Blantyre, South Lanarkshire area in 2019 with the "All other UK urban traffic" option in the model, the NO_x/NO_2 model estimates that 28 % of NO_x from local road vehicles is released as primary NO_2.

4.1.7 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 comparison studies on behalf of local authorities and Defra.

4.1.8 Mapping data

Ordnance survey Master Map datasets were used in the assessment. This enabled accurate road widths and the distance of the housing to the kerb to be determined using a GIS.

4.2 Model Verification

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. It is considered best practice to verify modelled pollutant predictions from road traffic against local monitoring data (classified as roadside sites) where available. This helps to identify how the model is performing at the various monitoring locations.

The verification process also involves checking and refining the model input data to try and reduce uncertainties and produce model outputs that are in acceptable agreement with the monitoring results. This can be followed by adjustment of the model results if required to gain good agreement. LAQM.TG(16) 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 Box 7.15 of LAQM.TG(16) has been used in this case. Modelled road NO_x concentrations were verified using 2019 measurements at two of the available roadside diffusion tube measurements and the automatic analyser.

Tube 36 on Bardykes Road was excluded from the verification process as it is classified as a kerbside site; there was also significant uncertainty regarding the available traffic data for Barkdyes Road as it was from a one day survey from a count location some distance away from the diffusion tube site.

Following the initial model runs, it was clear that the current model set-up was not producing results that achieved acceptable overall agreement with the available measurements. The main unusual factor in this case is the significant difference in NO_2 measured on opposite sides of Glasgow Road only a few metres apart. Diffusion tube DT32 on the south side of Glasgow Road is located straight across the

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

road from the automatic analyser. The 2019 NO_2 annual mean measurements at DT32 was 47.3 µg.m^{-3}; whereas the annual mean at the automatic site was 27.6 µg.m^{-3}, a difference of nearly 20 µg.m^{-3}. The initial ADMS Roads model set up was not simulating this difference in concentrations between opposite sides of the road satisfactorily; further consideration of the local situation was required followed by several refinements to the model set up as follows:

- All existing model set up including road geometry, meteorological parameters and receptor locations were double checked.
- The traffic flow in the relevant area was divided into eastbound and westbound lanes (using DfT traffic data), as the westbound AADT was slightly higher than the eastbound AADT.
- The advanced street canyons set up was customised to represent the height of each individual building along the streets.
- Gradient effects were included when calculating vehicle emissions.
- Congestion from stop-start traffic activity was accounted for by adjusting the average speed of the links at known locations where congestion typically occurs.

The above measures were still insufficient to achieve acceptable model agreement on both sides of Glasgow Road when modelling emissions from traffic on the road carriageways. There are however multiple parking bays on either side of the road.

Local knowledge reports that the parking bay where diffusion tube DT32 is located is used constantly during the day. Vehicle idling could therefore provide an explanation for the high NO_2 measurements at this location – that specific parking bay is there predominantly for use of the funeral undertakers who sometimes cone it off when a funeral is due to take place; so that the hearse can use the bay at that time. At other times, the parking bay is used regularly when customer visit the post office (which is part of the Londis shop) and the Agnew's take away/sandwich shop throughout the day. The bay is constantly used for this purpose.

Having expended all other model set up options, emissions from the parking bay were simulated by adding a road link representing localised vehicle idling (Figure 4.2). Emissions rates were determined using the method recommend by the model developers CERC for modelling queueing traffic. A time varying file was used to represent the parking bay emissions only occurring during a proportion of peak hours when the local shops, post office and undertakers would be open. Inclusion of this additional source did lead to better model agreement. With this additional source of emissions included, acceptable model agreement was attained.

A domain wide/global adjustment factor of **1.0596** was applied to modelled road NO_x concentrations; NO_2 annual mean concentrations were then calculated using the Defra NO_x/NO_2 calculator.

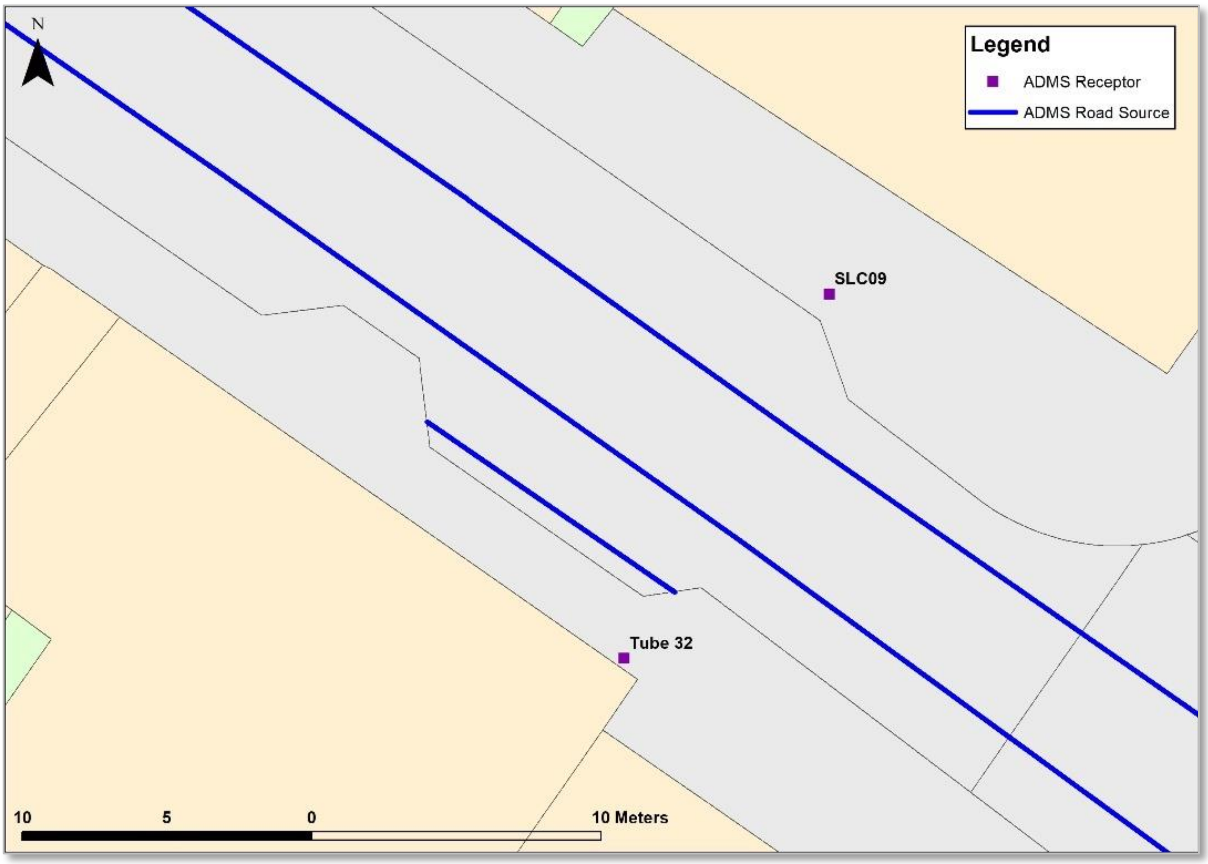
Model uncertainty using the global adjustment factor was evaluated by calculating the root mean square error (RMSE) of the modelled vs measured annual mean NO_2 concentrations. In this case the calculated RMSE was 4 µg.m^{-3} after adjustment, and the mean absolute error (MAE) was 3.3 µg.m^{-3}, both of which are within the suggested value (10% of the objective being assessed) in the LAQM.TG16) guidance. The model has therefore performed reasonably well for use within this type of impact assessment.

Using the domain wide/global adjustment factor does however lead to a 3.5 µg.m^{-3} underestimation of NO_2 annual mean concentrations at the DT32 diff tube site where the highest concentrations have been measured. Applying the global road NOx adjustment factor will potentially lead to missing locations where people may be exposed to annual mean NO_2 concentrations in excess of the 40µg.m^{-3} objective.

To eliminate the risk of this, we have provided an alternative set of worst-case results using a site specific road NOx adjustment factor. An adjustment factor of **1.19** has been used to produce worst-case NO_2 concentrations at receptor locations, this value was calculated using model agreement at diffusion tube DT32 only.

After the NO_x/NO_2 conversion calculator was used no further adjustments were made to the data. Model agreement for modelled vs measured NO_2 monitoring data after adjustment is presented in Figure 4.3.

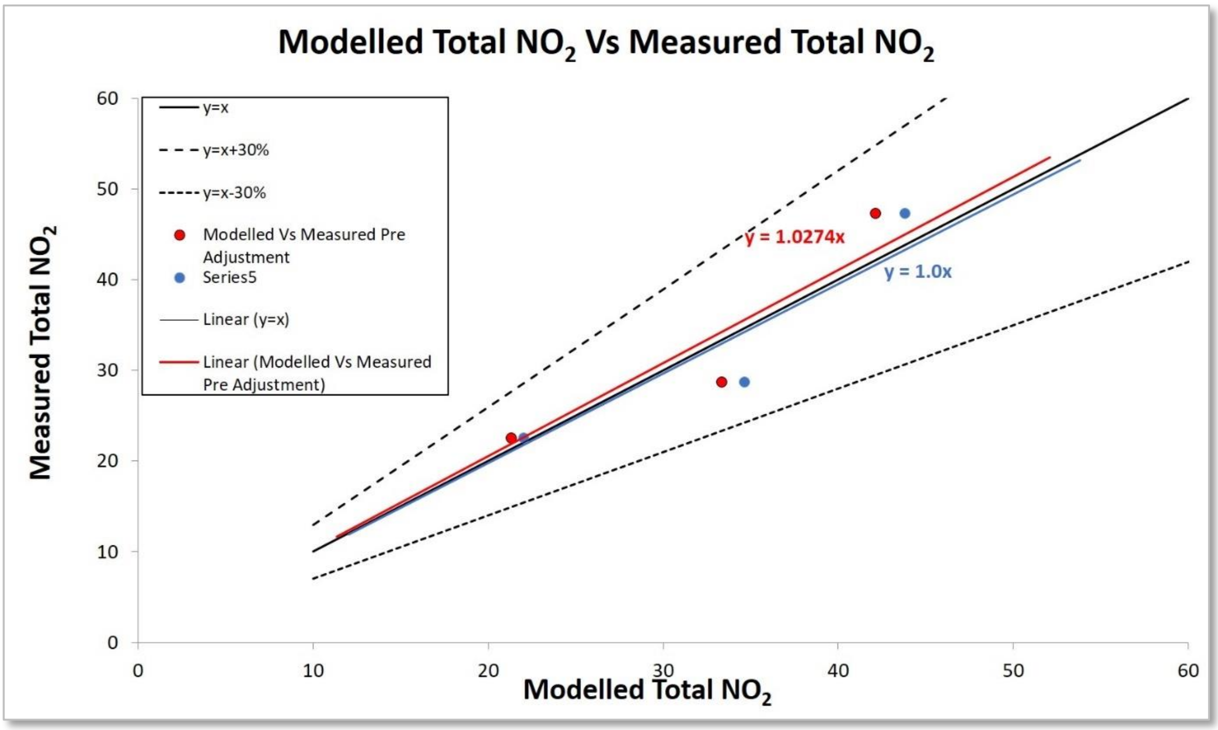
Figure 4.2: Parking bay road link added near Tube 32



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 this context. Further information on the verification process including the linear regression analysis is provided in Appendix 3.

For PM_{10} and $PM_{2.5}$; the model was found to over-predict concentrations at the automatic analyser. This indicates that background concentration may be overestimated at this location. No adjustment was applied and background concentrations for each were added to the modelled contribution to calculate total annual mean concentrations.

Figure 4.3: Modelled vs. measured annual mean NO_2 concentrations 2019



4.3 Model Results

4.3.1 NO_2 concentrations

4.3.1.1 NO_2 annual mean contour plots

Annual mean NO_2 concentrations have been predicted across a grid of points covering the entire study area. 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 gridded point results were then interpolated to produce contour plots representing the spatial variation of predicted annual mean concentrations across the study area.

Contour plots representing the predicted 2019 annual mean NO_2 concentrations across the study area at ground floor level (1.5m) are presented in Figure 4.4 and Figure 4.5 and at 1st floor height (4m) in Figure 4.6.

Please note the contour plots have been created using the global/domain wide road NOx adjustment factor so may represent a slight underestimate of NO_2 annual mean concentrations. We have presented ‘worst-case’ results (derived using a site specific road NOx adjustment factor) at receptor locations in the next section of the report.

The NO_2 annual mean contours indicate that the $40\mu g.m^{-3}$ objective is being exceeded at ground level within the street canyon at the junction of Station Road and Glasgow Road. At this location mainly commercial properties are present at ground floor level so the annul mean objective is not applicable.

The results also indicate that there may be NO_2 concentrations of up to $40\mu g.m^{-3}$ at 1st floor height where residential properties are present at 1st floor level.

Figure 4.4: Modelled annual mean NO_2 concentrations (µg.m^{-3}) at 1.5 m height

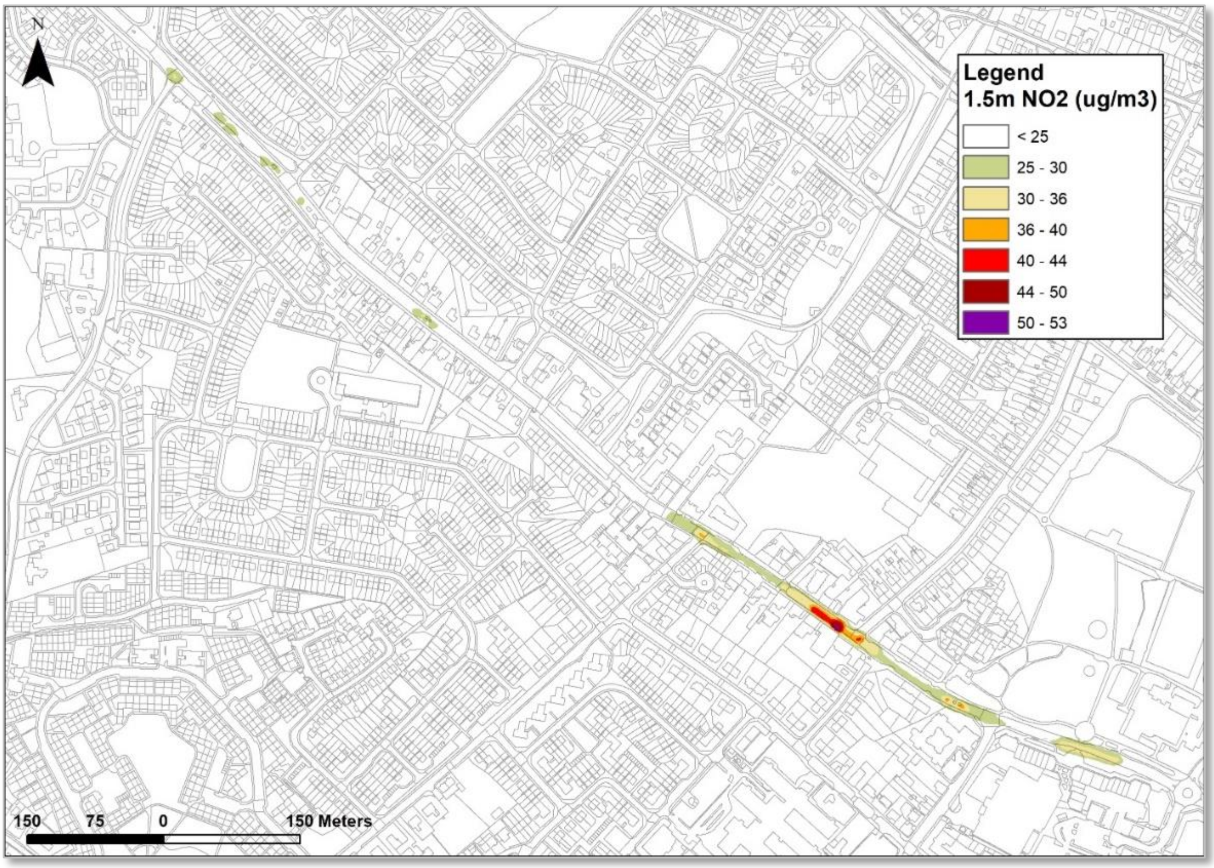


Figure 4.5: Modelled annual mean NO_2 concentrations (µg.m^{-3}) at 1.5 m height in the town centre

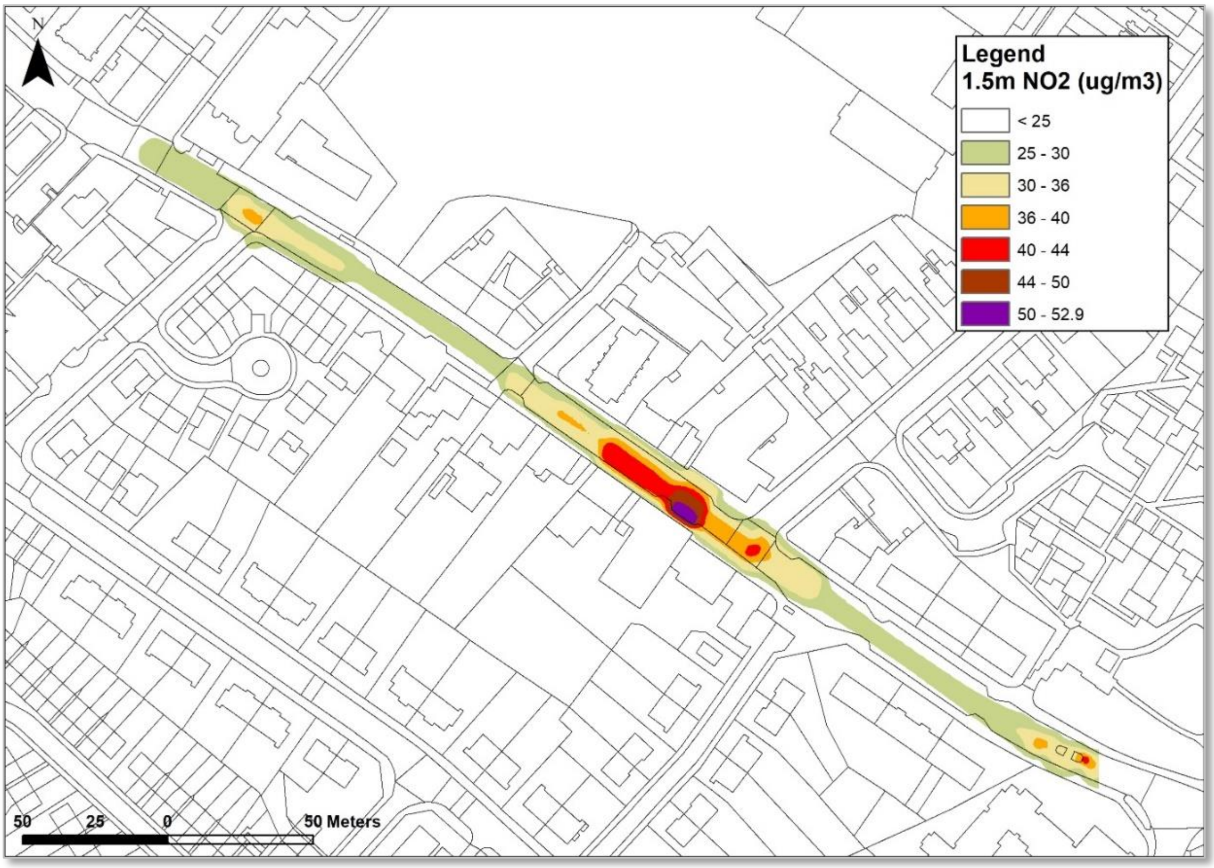


Figure 4.6: Modelled annual mean NO_2 concentrations (µg.m^{-3}) at 4 m height.

4.3.1.2 NO_2 results at receptor locations

The adjusted model has been used to predict NO_2 concentrations at a selection of discrete receptors within the study area in addition to the diffusion tube sites. The receptors are located at the facade of buildings in the model domain where relevant exposure exists within the pollution hotspots identified from the modelled contour plots. The receptors have been modelled at both ground level (1.5m) and first floor level (4m). The locations of the selected receptors are presented in Figures 9 and 10.

The predicted annual mean NO_2 concentrations at each of the specified receptors are presented in Table 4.3.1 with exceedances of the 40µg.m^{-3} objective highlighted in red.

We have presented results using both the global/domain wide road NOx adjustment factor (which may represent a slight underestimate of NO_2 annual mean concentrations); and 'worst-case' results (derived using a site specific road NOx adjustment factor for diffusion tube DT32). Please see model verification section above for further information.

An annual mean NO_2 concentration in excess of the 40µg.m^{-3} objective is predicted at the 'Glasgow Road 5' receptor location when we apply the 'worst-case' road NOx adjustment factor. This receptor is located very close to diffusion tube DT32 but is at first floor (4 m) height, where a residential property is present.

Figure 4.7: Receptor locations – East of study area (Town Centre)

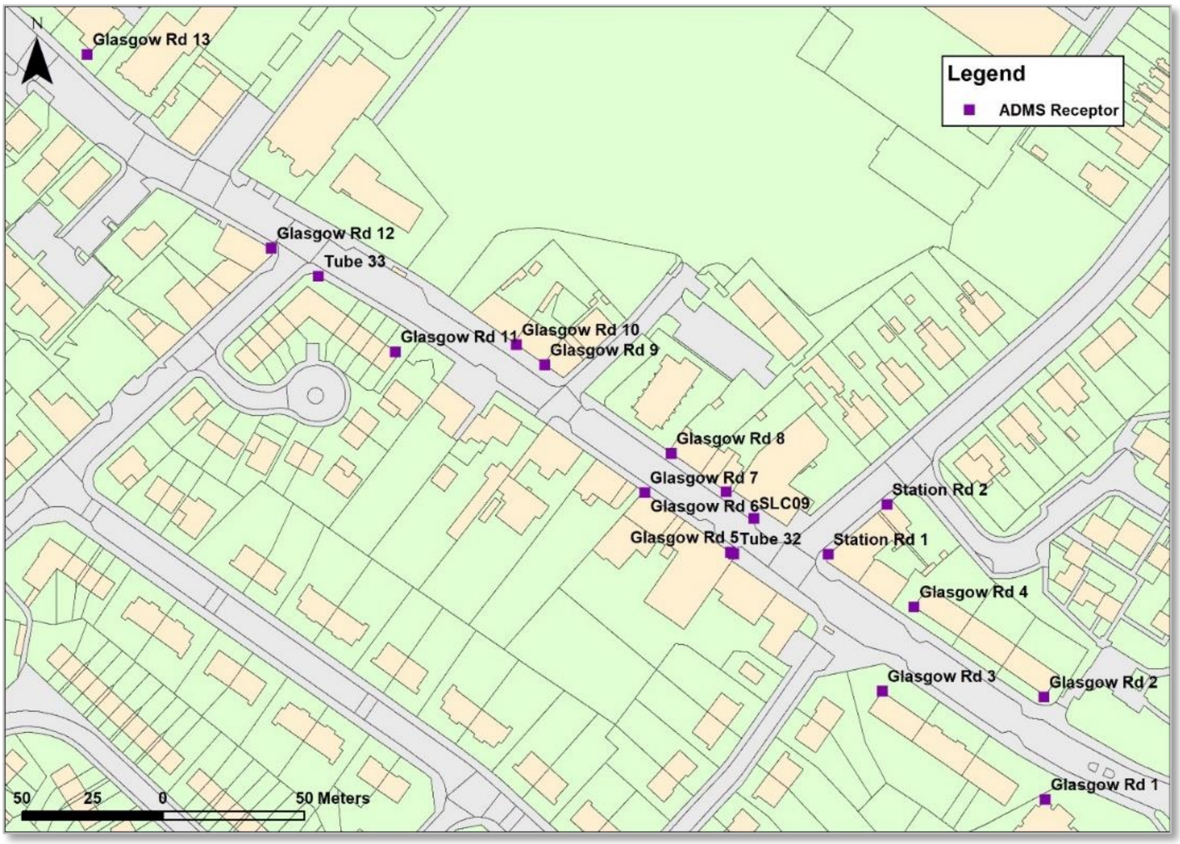


Figure 4.8: Receptor locations – West of study area

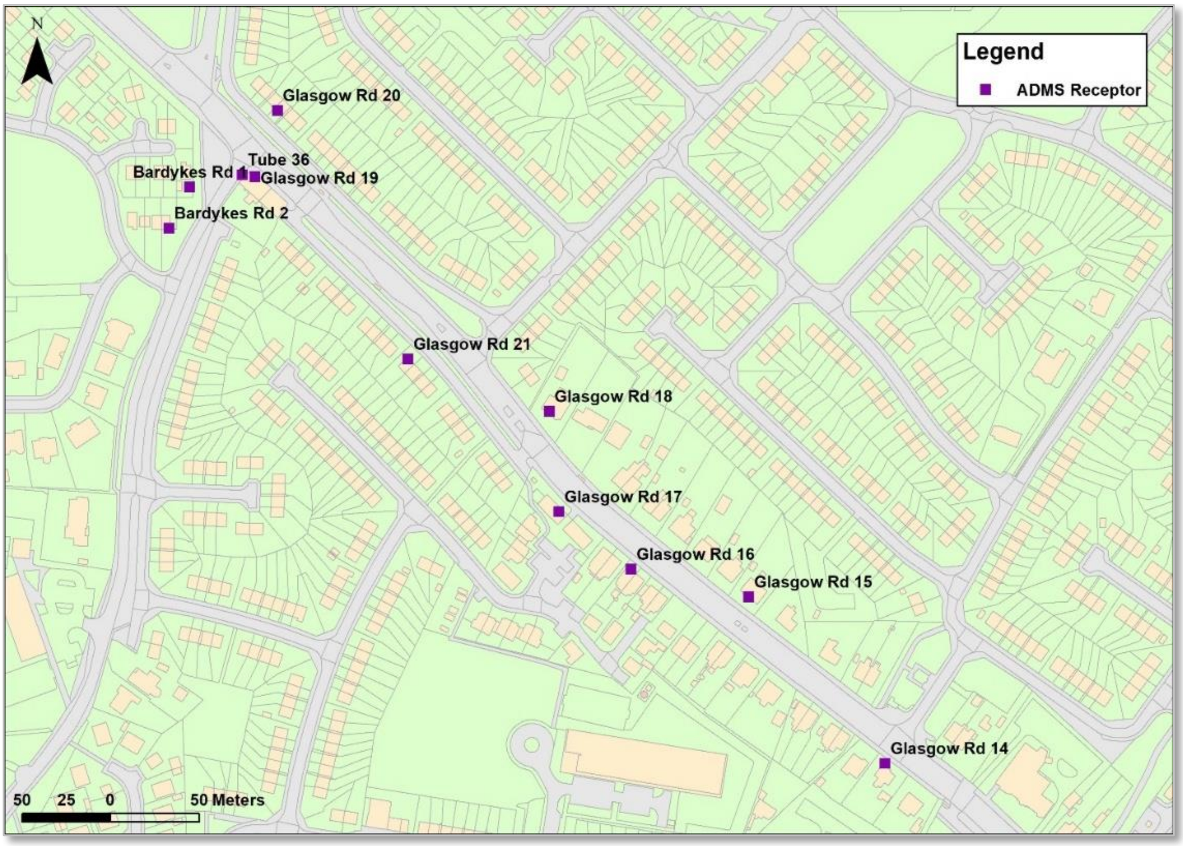


Table 4.3.1: Predicted annual mean NO_2 concentrations at specified receptors 2019

Receptor	Easting	Northing	Height (m)	NO_2 annual mean ($\mu g.m^{-3}$)	NO_2 worst case annual mean ($\mu g.m^{-3}$)
Glasgow Rd 1	269014.4	657502.9	1.5	16.5	17.5
Glasgow Rd 2	269013.91	657539.12	1.5	18.0	19.1
Glasgow Rd 3	268956.72	657541.31	1.5	16.8	17.8
Glasgow Rd 4	268967.94	657571.06	1.5	17.0	18.0
Glasgow Rd 5	268902.94	657590.38	4	37.7	40.8
Glasgow Rd 6	268901.44	657611.81	4	25.9	27.8
Glasgow Rd 7	268872.59	657611.5	4	30.6	33.0
Glasgow Rd 8	268881.91	657625.38	4	20.5	21.8
Glasgow Rd 9	268837.22	657656.75	4	16.6	17.5
Glasgow Rd 10	268827.09	657663.81	1.5	19.5	20.8
Glasgow Rd 11	268784.25	657661.31	1.5	16.2	17.1
Glasgow Rd 12	268740.34	657697.94	4	19.4	20.6
Glasgow Rd 13	268675.12	657766.56	1.5	16.4	17.3
Glasgow Rd 14	268533.47	657858.19	1.5	15.4	16.2
Glasgow Rd 15	268456.38	657952.31	1.5	13.7	14.3
Glasgow Rd 16	268389.97	657967.88	1.5	16.1	17.0
Glasgow Rd 17	268349.19	658000.38	4	15.1	15.8
Glasgow Rd 18	268343.72	658057.06	1.5	13.6	14.2
Glasgow Rd 19	268177.5	658189.62	1.5	19.0	20.2
Glasgow Rd 20	268190.12	658227	1.5	13.3	13.8
Glasgow Rd 21	268263.88	658086.56	1.5	13.1	13.6
Station Rd 1	268937.56	657589.62	4	16.6	17.5
Station Rd 2	268958.38	657607.31	1.5	13.2	13.7
Bardykes Rd 1	268140.62	658183.75	1.5	11.9	12.3
Bardykes Rd 2	268128.94	658160.31	4	11.2	11.5

4.3.1.3 Predicted NO_2 concentrations in comparison with the 1-hour short-term objective

It is difficult to accurately predict if the NO_2 1-hour mean objective is being exceeded using dispersion modelling. LAQM.TG(16) states that if an annual mean NO_2 concentration in excess of 60µg.m^{-3} is measured, an exceedance of the 1-hour mean objective may be occurring.

Annual mean NO_2 concentrations in excess of 60µg.m^{-3} are not predicted at any locations where anyone is likely to spend an hour or more within the study area; it is therefore considered unlikely that the short term NO_2 objective is being exceeded at locations where there is relevant exposure.

4.3.2 PM_{10} concentrations

4.3.2.1 PM_{10} annual mean contour plots

Contour plots showing the spatial variation of the predicted 2019 annual mean PM_{10} concentrations across the study area at ground floor level (1.5m) are presented in Figure 4.9 and Figure 4.10.

The contours indicate that the Scottish 18 $\mu g.m^{-3}$ annual mean PM_{10} objective is not being exceeded at any locations at ground level; it can also therefore be concluded there will no exceedances at 1st floor height.

Figure 4.9: Modelled PM_{10} concentrations ($\mu g.m^{-3}$) in Blantyre at 1.5 m height

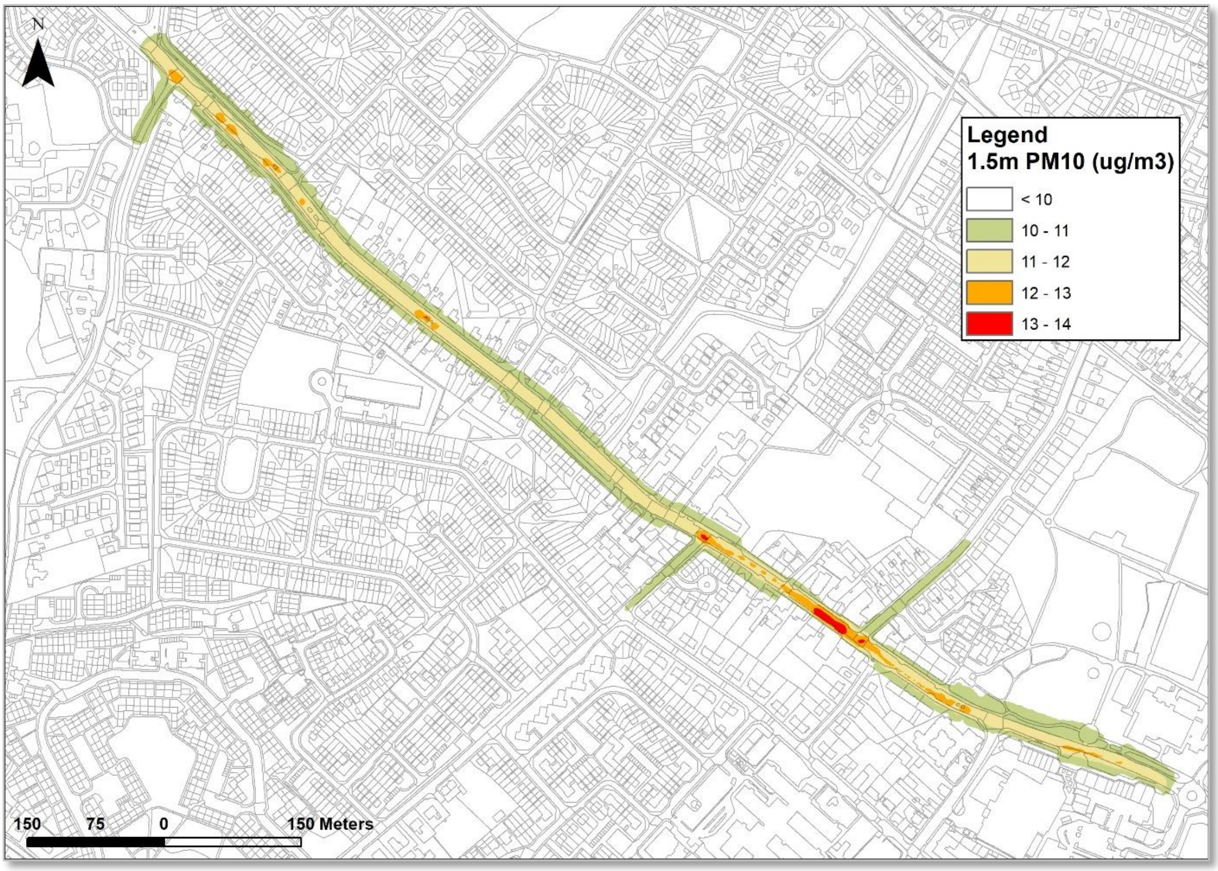


Figure 4.10: Modelled PM_{10} concentrations ($\mu g.m^{-3}$) at 1.5m height in the town centre

4.3.2.2 PM_{10} results at receptor locations

The predicted annual mean PM_{10} concentrations at each of the specified receptors are presented in Table 4.3.2. No annual mean PM_{10} concentrations in excess of the 18 $\mu g.m^{-3}$ objective were predicted at any of the modelled receptor locations.

Table 4.3.2: Predicted annual mean PM_{10} concentrations at specified receptors 2019

Receptor	Easting	Northing	Height (m)	PM_{10} annual mean ($\mu g.m^{-3}$)
Glasgow Rd 1	269014.38	657502.88	1.5	10.1
Glasgow Rd 2	269013.91	657539.12	1.5	10.6
Glasgow Rd 3	268956.72	657541.31	1.5	10.4
Glasgow Rd 4	268967.94	657571.06	1.5	10.5
Glasgow Rd 5	268902.94	657590.38	4	12.2
Glasgow Rd 6	268901.44	657611.81	4	11.3
Glasgow Rd 7	268872.59	657611.5	4	11.8
Glasgow Rd 8	268881.91	657625.38	4	10.5
Glasgow Rd 9	268837.22	657656.75	4	10.4
Glasgow Rd 10	268827.09	657663.81	1.5	10.9
Glasgow Rd 11	268784.25	657661.31	1.5	10.4
Glasgow Rd 12	268740.34	657697.94	4	10.6
Glasgow Rd 13	268675.12	657766.56	1.5	10.4
Glasgow Rd 14	268533.47	657858.19	1.5	10.3
Glasgow Rd 15	268456.38	657952.31	1.5	10.0
Glasgow Rd 16	268389.97	657967.88	1.5	10.4
Glasgow Rd 17	268349.19	658000.38	4	10.2
Glasgow Rd 18	268343.72	658057.06	1.5	10.0
Glasgow Rd 19	268177.5	658189.62	1.5	10.8
Glasgow Rd 20	268190.12	658227	1.5	9.9
Glasgow Rd 21	268263.88	658086.56	1.5	9.9
Station Rd 1	268937.56	657589.62	4	10.2
Station Rd 2	268958.38	657607.31	1.5	9.9
Bardykes Rd 1	268140.62	658183.75	1.5	9.7
Bardykes Rd 2	268128.94	658160.31	4	9.6

4.3.3 $PM_{2.5}$ concentrations

The highest concentrations of $PM_{2.5}$ were predicted in the town centre. A contour plot showing the spatial variation of the predicted 2019 annual mean $PM_{2.5}$ concentrations across the study area at ground floor level (1.5m) is presented in Figure 13. Table 5.4.3 presents modelled $PM_{2.5}$ concentrations at receptor locations.

The contours indicate that the Scottish 10 µg.m^{-3} annual mean $PM_{2.5}$ objectives is not being exceeded at any locations at ground level, so $PM_{2.5}$ concentrations are not expected to exceed 10 µg.m^{-3} at 1st floor height.

Figure 4.11: Modelled $PM_{2.5}$ concentrations (µg.m^{-3}) at 1.5m height in the town centre

Table 4.3.3: Predicted annual mean $PM_{2.5}$ concentrations at specified receptors 2019

Receptor	Easting	Northing	Height (m)	$PM_{2.5}$ annual mean ($\mu g.m^{-3}$)
Glasgow Rd 1	269014.38	657502.88	1.5	6.4
Glasgow Rd 2	269013.91	657539.12	1.5	6.6
Glasgow Rd 3	268956.72	657541.31	1.5	6.6
Glasgow Rd 4	268967.94	657571.06	1.5	6.6
Glasgow Rd 5	268902.94	657590.38	4	7.7
Glasgow Rd 6	268901.44	657611.81	4	7.1
Glasgow Rd 7	268872.59	657611.5	4	7.5
Glasgow Rd 8	268881.91	657625.38	4	6.7
Glasgow Rd 9	268837.22	657656.75	4	6.6
Glasgow Rd 10	268827.09	657663.81	1.5	6.8
Glasgow Rd 11	268784.25	657661.31	1.5	6.5
Glasgow Rd 12	268740.34	657697.94	4	6.7
Glasgow Rd 13	268675.12	657766.56	1.5	6.6
Glasgow Rd 14	268533.47	657858.19	1.5	6.5
Glasgow Rd 15	268456.38	657952.31	1.5	6.3
Glasgow Rd 16	268389.97	657967.88	1.5	6.5
Glasgow Rd 17	268349.19	658000.38	4	6.4
Glasgow Rd 18	268343.72	658057.06	1.5	6.3
Glasgow Rd 19	268177.5	658189.62	1.5	6.8
Glasgow Rd 20	268190.12	658227	1.5	6.3
Glasgow Rd 21	268263.88	658086.56	1.5	6.3
Station Rd 1	268937.56	657589.62	4	6.4
Station Rd 2	268958.38	657607.31	1.5	6.3
Bardykes Rd 1	268140.62	658183.75	1.5	6.2
Bardykes Rd 2	268128.94	658160.31	4	6.1

4.4 Population exposure and modelling uncertainties

Within Detailed Assessments, local authorities are required to estimate the number of people exposed to pollutant concentrations above the objectives, and the maximum pollutant concentration (measured or modelled) at a relevant receptor location.

In this case, an exceedance of the NO_2 annual mean objective has been predicted at one first floor height receptor location where there is likely to be relevant exposure. This is at the 'Glasgow Rd 5' receptor which is placed at the first floor height residential properties above the Co-Op Blantyre Funeralcare office on the southern side of Glasgow Road.

Examination of the NO_2 annual mean contour plot at 1st floor height (Figure 4.6) indicate that the maximum concentrations may be occurring at up to four of the first floor height flats at that section of buildings on the south side of Glasgow Rd. Using an average household occupancy[8] of 2.25; this equates to up to 9 people that may be exposed to NO_2 annual mean concentrations in excess of the 40 $\mu g.m^{-3}$ objective. The current modelling therefore indicates that the area of exceedance is very localised.

The following uncertainties should be considered along with the model results and associated conclusions:

- An exceedance of the NO_2 annual mean objective is only predicted at the 'Glasgow Rd 5' receptor when we apply a worst-case Road NOx adjustment factor. This worst-case/precautionary approach has been applied as using a domain wide/global average adjustment factor leads to a 3.5 $\mu g.m^{-3}$ underestimation of NO_2 annual mean concentrations at the DT32 diff tube site where the highest concentrations have been measured. Applying the global road NOx adjustment factor will potentially lead to missing locations where people may be exposed to annual mean NO_2 concentrations in excess of the 40 $\mu g.m^{-3}$ objective.
- As described in the model verification section above; even after extensive model refinement, the ADMS Roads model set up was not simulating the difference in measured NO_2 concentrations between opposite sides of the road very well. Assumptions regarding emission from vehicles using the parking bays were required to achieve better model agreement. It is therefore uncertain if the model has represented emissions throughout the town centre accurately, as there are other locations where parking bays are present but additional emissions were not modelled. Deploying additional NO_2 diffusion tube measurements at other locations in the town centre will help provide additional information regarding the extent of exceedances of the NO_2 annual mean objective and the number of people who may be exposed.
- Data capture at the automatic analyser during 2019 was 58% due to operational issues for over four months. The NO_2 annual mean was calculated using the recommended short-term to long-term adjustment. There is therefore some uncertainty associated with the measured NO_2 annual mean at this location.

[8] Scottish Government (2020) Census data – Average household size; available at www.statistics.gov.scot

5 Source apportionment

5.1 Source apportionment methodology

Source apportionment is the process whereby the contribution of different pollutant sources to ambient concentrations are quantified. This aims to allow the Local Authority to target specific sources when attempting to reduce pollutant concentrations.

The source apportionment aims to:

- Confirm that exceedances of the NO_2 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
- Quantify what proportion of total NOx 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 NO_2 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 source apportionment analysis was carried out at a selection of model receptor locations where the highest NO_2 annual mean concentrations were measured; Glasgow Road 5, Glasgow Road 6, Glasgow Road 7 and Glasgow Road 8. The following sources were considered:

- Background concentrations
- Petrol Cars
- Diesel Cars
- Petrol LGV
- Diesel LGV
- HGV Rigid
- HGV Artic
- Buses
- Motorcycles

5.2 Source apportionment results

5.2.1 NO_x

The analysis identified road traffic emissions were the predominant source of NO_x in Blantyre with diesel cars being the main road source particularly along Glasgow Road, where there is often slow moving traffic and parking vehicles. The results are presented in Figure 14, Table 5.2.1.16.2.1.1 and Table 6.2.1.2.

Examination of the results indicate that:

- Diesel cars are the most predominant contributor to local NOx concentrations (25 – 31 %)
- Background concentrations were more significant at Glasgow Road 6 and 8 (29 – 38 %).
- HGV (12-13%) and bus (16-17%) contributions were higher at Glasgow Road 5 and 7, on the west-bound side of the road

The locations where the highest pollutant concentrations are being measured and modelled are at locations where traffic is known to be regularly slow moving and within a high sided street canyon topography. This indicates that any measures that can improve traffic flow at these locations where pollutant dispersion is poor will help to reduce annual mean concentrations.

Figure 5.1: NO_x source apportionment – Contribution by vehicle type (% of total NO_x)

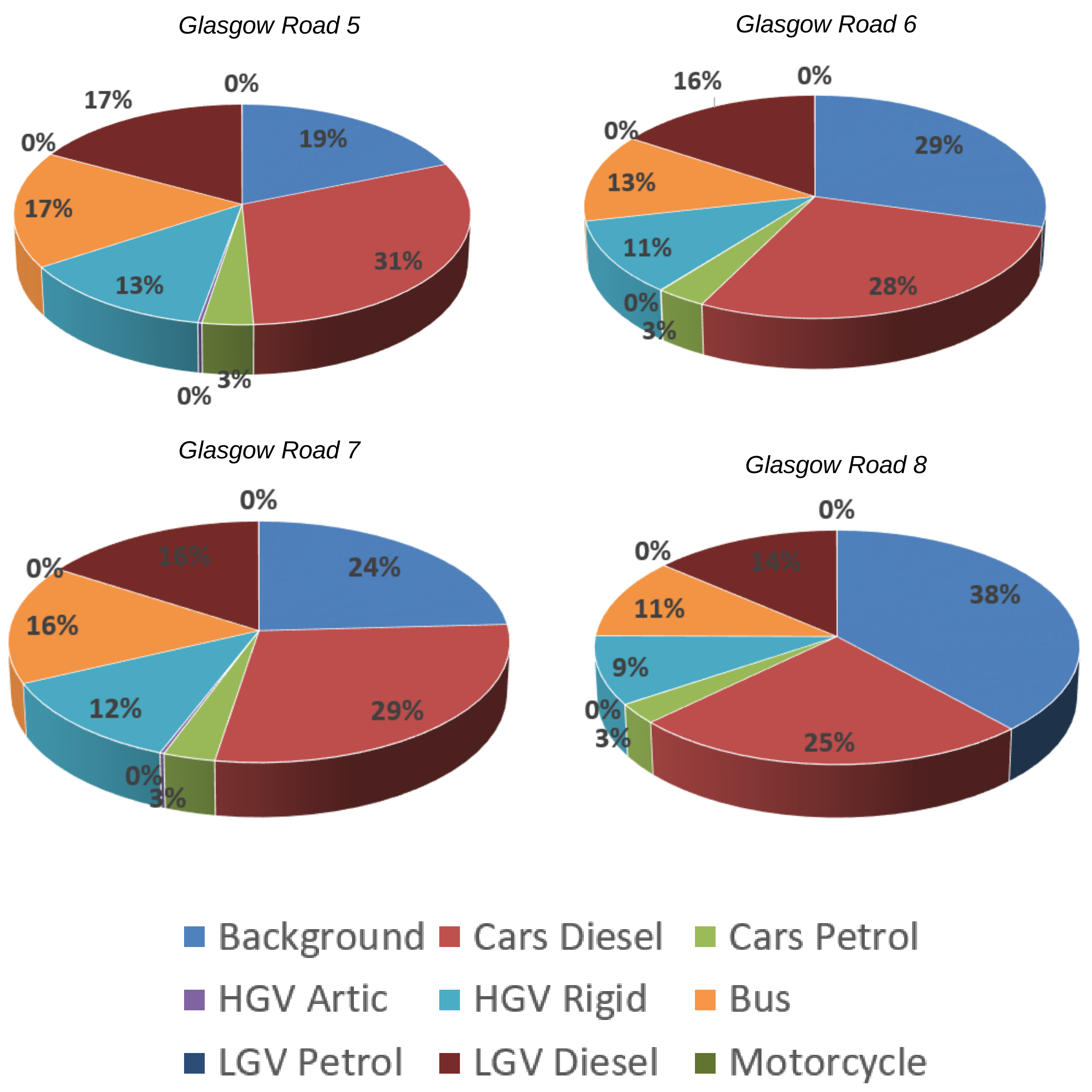


Table 5.2.1.1: NO_x source apportionment – Contribution by vehicle type ($\mu g.m^{-3}$)

Receptor location	Total NOx	Background	Road NOx	Diesel Cars	Petrol Cars	HGV Artic	HGV Rigid	Buses	LGV Petrol	LGV Diesel	Motorcycle
Glasgow Rd 5	73.9	13.8	60.1	22.4	2.4	0.2	9.5	12.6	0.0	12.5	0.0
Glasgow Rd 6	47.4	13.8	33.5	13.3	1.5	0.0	5.1	6.0	0.0	7.4	0.0
Glasgow Rd 7	57.6	13.8	43.7	16.3	1.8	0.1	6.9	9.2	0.0	9.1	0.0
Glasgow Rd 8	36.3	13.8	22.4	8.9	1.0	0.0	3.4	4.0	0.0	5.0	0.0

Table 5.2.1.2: NO_x source apportionment – Contribution by vehicle type (% of total NO_x)

Receptor location	Total NOx	Background	Road NOx	Diesel Cars	Petrol Cars	HGV Artic	HGV Rigid	Buses	LGV Petrol	LGV Diesel	Motorcycle
Glasgow Rd 5	100%	18.7%	81.3%	30.3%	3.3%	0.3%	12.9%	17.0%	0.0%	17.0%	0.0%
Glasgow Rd 6	100%	29.2%	70.8%	28.0%	3.2%	0.0%	10.8%	12.7%	0.0%	15.6%	0.0%
Glasgow Rd 7	100%	24.0%	76.0%	28.3%	3.1%	0.2%	12.1%	16.0%	0.0%	15.8%	0.0%
Glasgow Rd 8	100%	38.1%	61.9%	24.5%	2.8%	0.0%	9.4%	11.1%	0.0%	13.7%	0.0%

5.2.2 PM_{10}

The analysis identified background concentrations were the predominant source of PM_{10} in Blantyre. The results are presented in Figure 15, Table 6.2.2.3 and Table 6.2.2.4Table 5.2.2.4.

Examination of the results indicate that:

- Diesel and Petrol cars were the most predominant source of road PM_{10} (7 – 14 %)
- Background concentrations are the main contributor to total PM_{10} concentrations (76 – 88 %)
- Buses and HGVs contributed less than the other fleet types (< 6 %)

Figure 5.2: PM_{10} source apportionment – Contribution by vehicle type (% of total PM_{10})

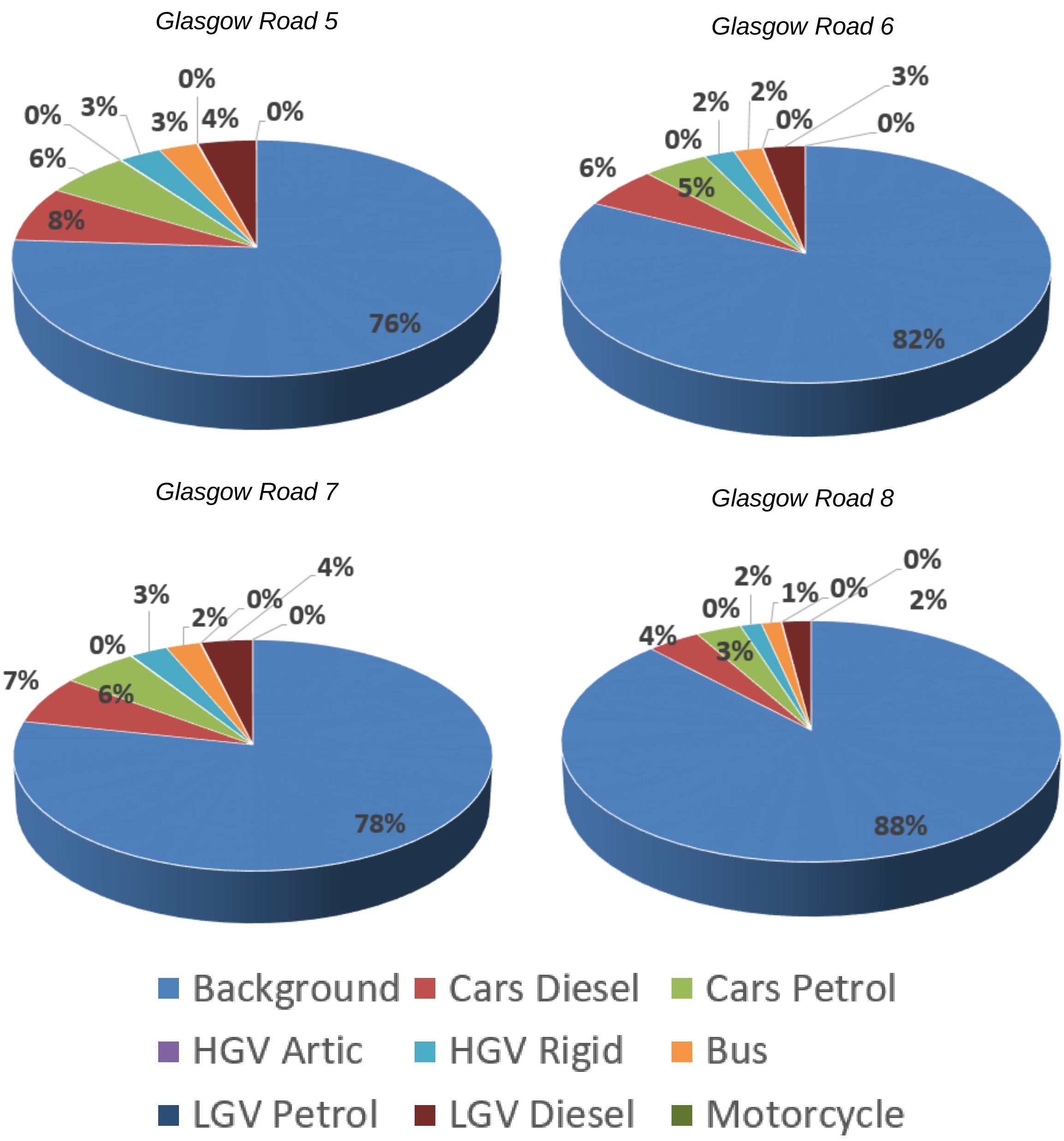


Table 5.2.2.3: PM_{10} source apportionment – Contribution by vehicle type ($\mu g.m^{-3}$)

Receptor location	Total PM_{10}	Background	Road PM_{10}	Diesel Cars	Petrol Cars	HGV Artic	HGV Rigid	Buses	LGV Petrol	LGV Diesel	Motorcycle
Glasgow Rd 5	12.2	9.2	3.0	0.9	0.8	0.0	0.4	0.3	0.0	0.5	0.0
Glasgow Rd 6	11.3	9.2	2.0	0.6	0.5	0.0	0.2	0.2	0.0	0.3	0.0
Glasgow Rd 7	11.8	9.2	2.6	0.8	0.7	0.0	0.3	0.3	0.0	0.4	0.0
Glasgow Rd 8	10.5	9.2	1.3	0.4	0.3	0.0	0.2	0.1	0.0	0.2	0.0

Table 5.2.2.4: PM_{10} source apportionment – Contribution by vehicle type (% of total PM_{10})

Receptor location	Total PM_{10}	Background	Road PM_{10}	Diesel Cars	Petrol Cars	HGV Artic	HGV Rigid	Buses	LGV Petrol	LGV Diesel	Motorcycle
Glasgow Rd 5	100%	75.6%	24.4%	7.5%	6.2%	0.1%	3.0%	2.8%	0.1%	4.2%	0.0%
Glasgow Rd 6	100%	82.0%	18.0%	5.6%	4.7%	0.0%	2.2%	2.1%	0.1%	3.0%	0.0%
Glasgow Rd 7	100%	77.9%	22.1%	6.7%	5.6%	0.1%	2.8%	2.5%	0.1%	3.8%	0.0%
Glasgow Rd 8	100%	87.7%	12.3%	3.8%	3.2%	0.0%	1.5%	1.4%	0.0%	2.0%	0.0%

5.2.3 $PM_{2.5}$

The analysis identified background concentrations were the predominant source of $PM_{2.5}$ in Blantyre. The results are presented in Figure 16, Table 6.2.3.5 and Table 6.2.3.6.

Examination of the results indicate that:

- Diesel and Petrol cars were the most predominant source of road $PM_{2.5}$ (7 – 13 %)
- Background concentrations are the main contributor to total $PM_{2.5}$ concentrations (77 – 88 %)
- Buses and HGVs contributed less than the other fleet types (< 6 %)

Figure 5.3: $PM_{2.5}$ source apportionment – Contribution by vehicle type (% of total $PM_{2.5}$)

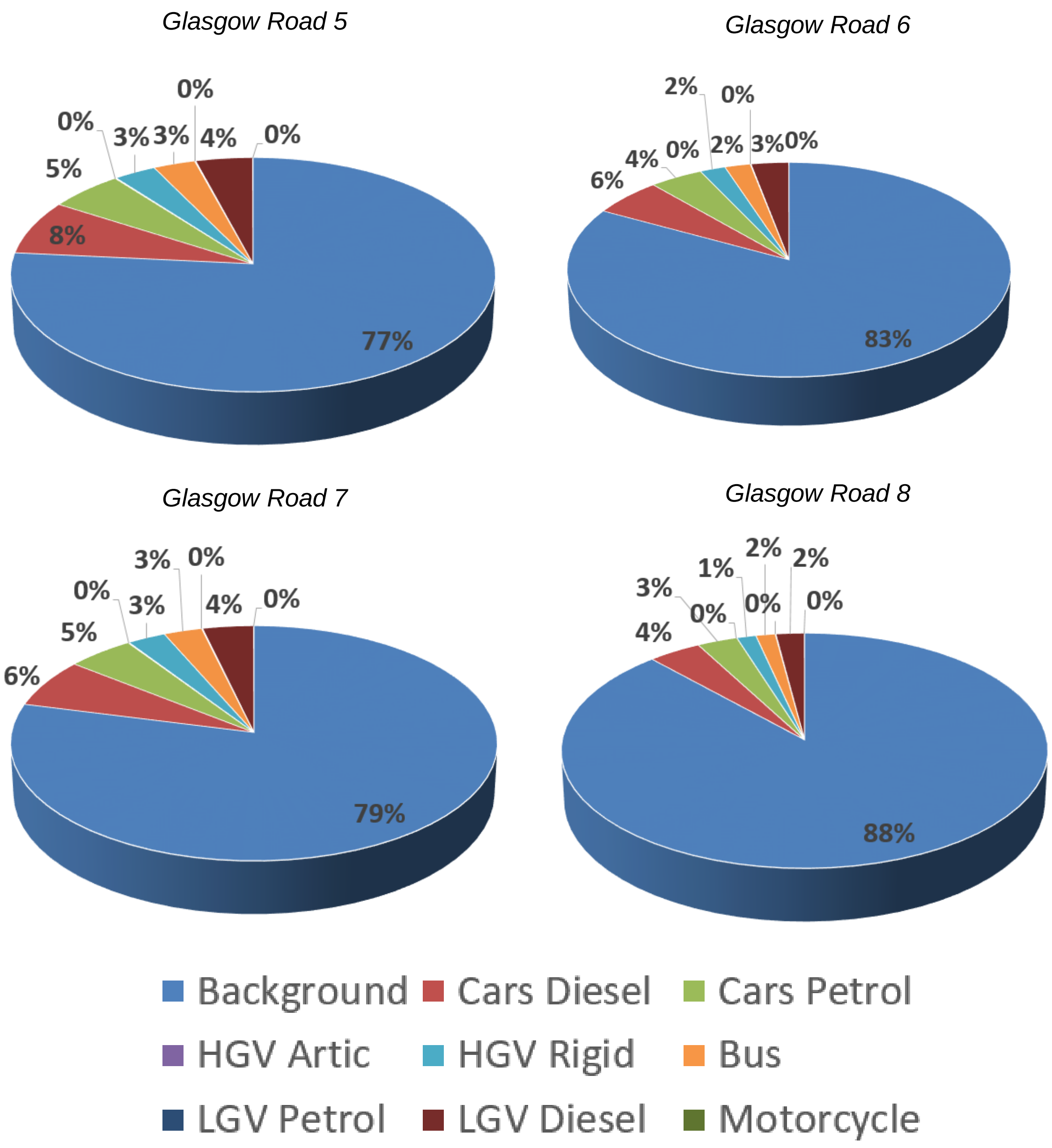


Table 5.2.3.5: $PM_{2.5}$ source apportionment – Contribution by vehicle type ($\mu g.m^{-3}$)

Receptor location	Total $PM_{2.5}$	Background	Road $PM_{2.5}$	Diesel Cars	Petrol Cars	HGV Artic	HGV Rigid	Buses	LGV Petrol	LGV Diesel	Motorcycle
Glasgow Rd 5	7.7	5.9	1.8	0.6	0.4	0.0	0.2	0.2	0.0	0.3	0.0
Glasgow Rd 6	7.1	5.9	1.2	0.4	0.3	0.0	0.1	0.1	0.0	0.2	0.0
Glasgow Rd 7	7.5	5.9	1.6	0.5	0.4	0.0	0.2	0.2	0.0	0.3	0.0
Glasgow Rd 8	6.7	5.9	0.8	0.3	0.2	0.0	0.1	0.1	0.0	0.1	0.0

Table 5.2.3.6: $PM_{2.5}$ source apportionment – Contribution by vehicle type (% of total $PM_{2.5}$)

Receptor location	Total $PM_{2.5}$	Background	Road $PM_{2.5}$	Diesel Cars	Petrol Cars	HGV Artic	HGV Rigid	Buses	LGV Petrol	LGV Diesel	Motorcycle
Glasgow Rd 5	100%	76.2%	23.8%	7.5%	5.5%	0.1%	3.1%	3.1%	0.1%	4.1%	0.0%
Glasgow Rd 6	100%	82.6%	17.4%	5.6%	4.2%	0.0%	2.0%	2.0%	0.1%	3.0%	0.0%
Glasgow Rd 7	100%	78.6%	21.4%	6.7%	4.9%	0.1%	2.8%	2.8%	0.1%	3.7%	0.0%
Glasgow Rd 8	100%	88.0%	12.0%	3.9%	2.9%	0.0%	1.4%	1.4%	0.0%	2.1%	0.0%

6 Conclusion

This report describes a dispersion modelling study of road traffic emission in the Glasgow Road, Blantyre area; this has been conducted to allow a detailed assessment of NO_2, PM_{10} and $PM_{2.5}$ concentrations at this location.

Although we have attempted to minimise uncertainty in this dispersion modelling study as much as possible, the model results should be considered in context with the uncertainties regarding model input data discussed in this report.

It is clear that annual mean NO_2 concentrations measured at diffusion tube DT32, located close to the Station Road/Glasgow Road junction, have consistently been significantly in excess of the 40 $\mu g.m^{-3}$ objective since 2016. Data capture at the automatic analyser located on the opposite side of the road was however very low during 2019 indicating that there is some uncertainty associated with the annualised estimate of measured NO_2 annual mean at this location.

The dispersion modelling study (which used up to date traffic, monitoring and meteorological data for the area around Glasgow Road, Blantyre) indicates that there may be exceedances of the NO_2 annual mean objective occurring at locations with relevant exposure at first floor height above commercial properties in Blantyre town centre. The maximum NO_2 annual mean concentration predicted is 40.8 $\mu g.m^{-3}$ which could be considered as a marginal exceedance of the 40 $\mu g.m^{-3}$ objective.

The current modelling indicates that the area of exceedance of the NO_2 annual mean objective is very localised and encompasses up to four residential properties at first floor height on the south side of Glasgow Road close to the junction with Station Road. This conclusion regarding the potential extent of exceedances is uncertain based on the available evidence; as assumptions regarding emission from vehicles using parking bays in the town centre were required to achieve reasonable model agreement with the available NO_2 measurements. It is therefore uncertain if the modelling has represented road traffic emissions throughout the town centre accurately.

No exceedances of the PM_{10} or $PM_{2.5}$ annual mean objectives were predicted.

On the basis of the uncertainties described above: At this time South Lanarkshire Council do not consider that there is sufficient evidence to confirm if an Air Quality Management Area (for exceedances of the NO_2 annual mean objective) should be declared at the location of the Glasgow Road/Station Road junction in Blantyre.

South Lanarkshire Council now intend to deploy additional NO_2 monitoring in Blantyre to provide additional evidence regarding the potential extent of localised NO_2 exceedances. If appropriate following review of NO_2 measurement data in future years; South Lanarkshire Council will repeat the detailed assessment with the intention that the additional measurement data will support a more robust modelling assessment and associated model verification. Measures to discourage vehicle idling will also be investigated in the meantime to reduce localised vehicle emissions.

When considering air quality measurement reported in future years; it is likely that the 2020 NO_2 annual mean measurements at roadside sites will reduce when compared with the 2019 measurements. Traffic activity has reduced significantly during the March to June 2020 period due to the COVID-19 lockdown restrictions. National UK Government statistics[9] for the trunk road network over the same time interval indicate that daily traffic reduced to between 30 to 40% of pre-lockdown levels in the initial months of the restrictions. At the time of writing this report (5 months later), daily traffic is estimated to have returned to approximately 90% of pre-lockdown levels.

It is not currently clear when road traffic activity will return to pre-lockdown levels; or if in the coming year average daily traffic will decrease or increase due to various factors associated with the current pandemic guidance in place e.g. increased home working, discouraged use of public transport etc. It May therefore be unclear if another Detailed Assessment is required until measurements from 2021 or

[9] https://www.gov.uk/government/statistics/transport-use-during-the-coronavirus-covid-19-pandemic

beyond are available. South Lanarkshire Council will continue to review and assess air quality in Blantyre.

7 Acknowledgements

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Appendices

Appendix 1: Traffic data

Appendix 2: Meteorological dataset

Appendix 3: Model verification

A1 Traffic Data

Table A1.1 summarises the Annual Average Daily Flows (AADT) of traffic and fleet compositions used to calculate vehicle emissions for each road link.

Traffic data for the assessment was available from the combination of DfT traffic counts for Glasgow Road and local surveys commissioned by South Lanarkshire Council. These sources provided daily average flow and detailed fleet split i.e. cyclist and motorcycle, car, LGV, rigid HGV, articulated HGV and buses.

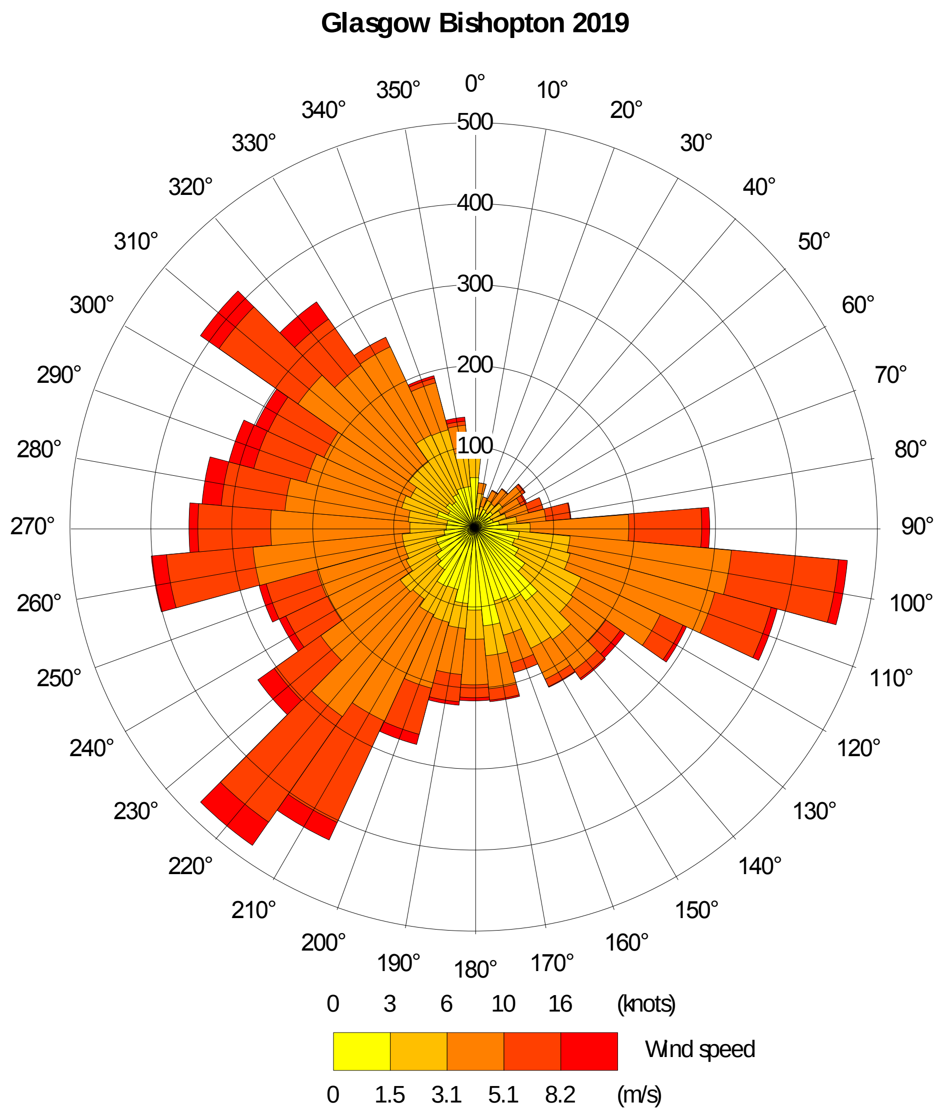
Table A1.1: South Lanarkshire 2019 – Annual Average Daily Flows and Vehicle Type Split (%)

Street name	Cyclist/ Motorcycle	Car	LGV	Rigid HGV	Articulated HGV	Bus	AADT
Glasgow Road	0.22	77.64	15.3	3.77	0.05	3.02	12849
Glasgow Road (Eastbound)	0.21	77.45	15.0	3.96	0.02	3.33	6165
Glasgow Road (Westbound)	0.22	77.83	15.6	3.58	0.09	2.73	6684
Station Road	0.41	89.17	7.07	3.04	0.10	0.21	5107
Stonefield Road	0.64	92.27	4.81	2.03	0.10	0.15	5608
Bardykes Road	0.0	75.49	14.65	8.95	0.03	0.87	6577

A2 Meteorological datasets

The wind rose for the Glasgow Bishopton 2019 meteorological measurement site is presented below.

Figure A2.1: Meteorological dataset wind rose



A3 Model Verification

The approach outlined in Box 7.15 of LAQM.TG(16) has been used in this case. Modelled road NO_x concentrations were verified using 2019 measurements at two of the available roadside diffusion tube measurements and the automatic analyser.

Tube 36 on Bardykes Road was excluded from the verification process as it is classified as a kerbside site; there was also significant uncertainty regarding the available traffic data for Barkdyes Road as it was from a one-day survey from a count location some distance away from the diffusion tube site.

Following the initial model runs, it was clear that the current model set-up was not producing results that achieved acceptable overall agreement with the available measurements. The main unusual factor in this case is the significant difference in NO_2 measured on opposite sides of Glasgow Road only a few metres apart. Diffusion tube DT32 on the south side of Glasgow Road is located straight across the road from the automatic analyser. The 2019 NO_2 annual mean measurements at DT32 was 47.3 $\mu g.m^{-3}$; whereas the annual mean at the automatic site was 27.6 $\mu g.m^{-3}$, a difference of nearly 20 $\mu g.m^{-3}$. The initial ADMS Roads model set up was not simulating this difference in concentrations between opposite sides of the road satisfactorily; further consideration of the local situation was required followed by several refinements to the model set up as follows:

- All existing model set up including road geometry, meteorological parameters and receptor locations were double checked.
- The traffic flow in the relevant area was divided into eastbound and westbound lanes (using DfT traffic data), as the westbound AADT was slightly higher than the eastbound AADT.
- The advanced street canyons set up was customised to represent the height of each individual building along the streets.
- Gradient effects were included when calculating vehicle emissions.
- Congestion from stop-start traffic activity was accounted for by adjusting the average speed of the links at known locations where congestion typically occurs.

The above measures were still insufficient to achieve acceptable model agreement on both sides of Glasgow Road when modelling emissions from traffic on the road carriageways. There are however multiple parking bays on either side of the road.

Local knowledge reports that the parking bay where diffusion tube DT32 is located is used constantly during the day. Vehicle idling could therefore provide an explanation for the high NO_2 measurements at this location – that specific parking bay is there predominantly for use of the funeral undertakers who sometimes cone it off when a funeral is due to take place; so that the hearse can use the bay at that time. At other times, the parking bay is used regularly for popping into the post office (which is part of the Londis shop) and the Agnew's take away/sandwich shop throughout the day. The bay is constantly used for this purpose.

Having expended all other model set up options, emissions from the parking bay were simulated by adding a road link representing localised vehicle idling. Emissions rates were determined using the method recommend by the model developers CERC for modelling queueing traffic. A time varying file was used to represent the parking bay emissions only occurring during a proportion of peak hours when the local shops, post office and undertakers would be open. Inclusion of this additional source did lead to better model agreement. With this additional source of emissions included, acceptable model agreement was attained.

A domain wide/global adjustment factor of **1.0596** was applied to modelled road NO_x concentrations; NO_2 annual mean concentrations were then calculated using the Defra NO_x/NO_2 calculator.

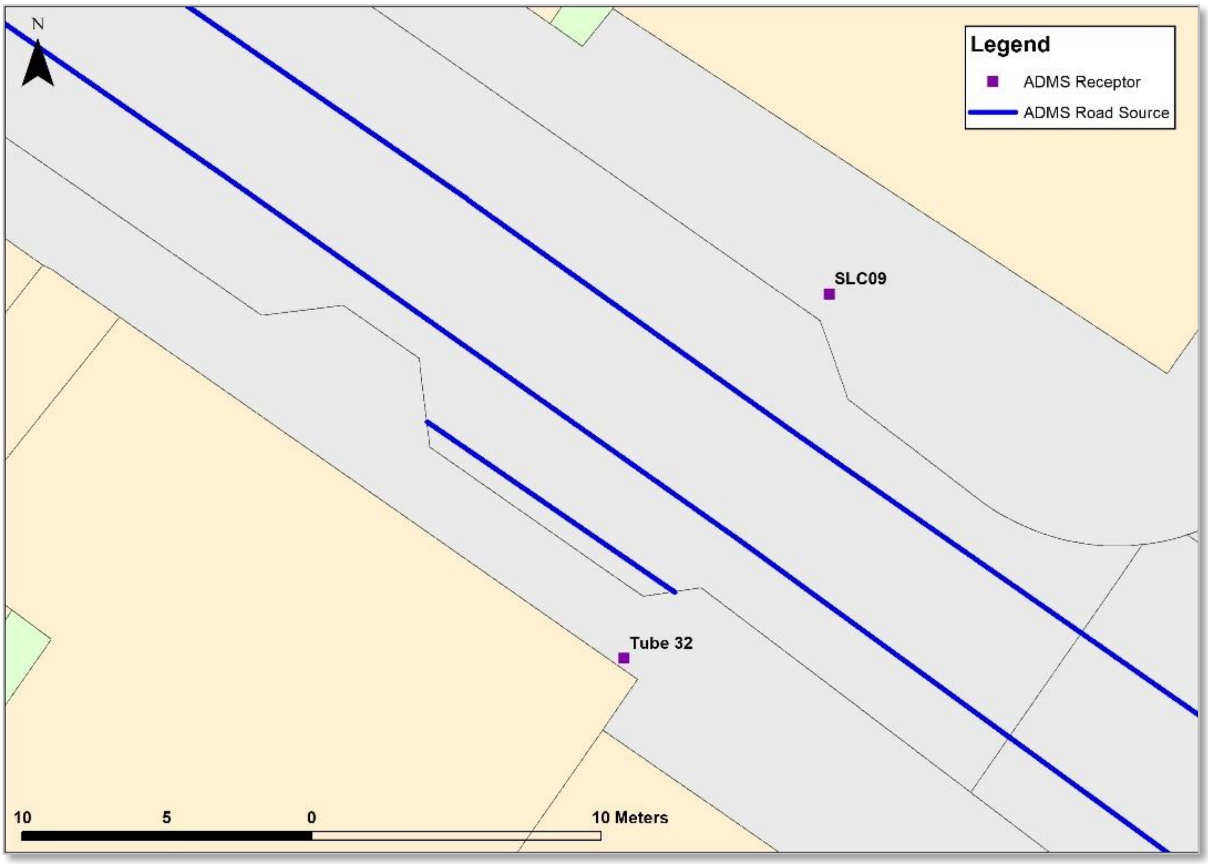
Model uncertainty using the global adjustment factor was evaluated by calculating the root mean square error (RMSE) of the modelled vs measured annual mean NO_2 concentrations. In this case the calculated RMSE was 4 $\mu g.m^{-3}$ after adjustment, and the mean absolute error (MAE) was 3.3 $\mu g.m^{-3}$, both of which are within the suggested value (10% of the objective being assessed) in the LAQM.TG16) guidance. The model has therefore performed reasonably well for use within this type of impact assessment.

Using the domain wide/global adjustment factor does however lead to a 3.5 µg.m^{-3} underestimation of NO_2 annual mean concentrations at the DT32 diff tube site where the highest concentrations have been measured. Applying the global road NOx adjustment factor will potentially lead to missing locations where people may be exposed to annual mean NO_2 concentrations in excess of the 40µg.m^{-3} objective.

To eliminate the risk of this, we have provided an alternative set of worst-case results using a site specific road NOx adjustment factor. An adjustment factor of **1.19** has been used to produce worst-case NO_2 concentrations at receptor locations, this value was calculated using model agreement at diffusion tube DT32 only.

After the NO_x/NO_2 conversion calculator was used no further adjustments were made to the data. Model agreement for modelled vs measured NO_2 monitoring data after adjustment is presented in Figure 4.3.

Figure A3.1: Parking bay road link added near Tube 32



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 this context. Further information on the verification process including the linear regression analysis is provided in Appendix 3.

For PM_{10} and $PM_{2.5}$; the model was found to over-predict concentrations at the automatic analyser. This indicates that background concentration may be overestimated at this location. No adjustment was applied and background concentrations for each were added to the modelled contribution to calculate total annual mean concentrations.

Figure A3.2: Linear regression - Measured vs modelled Road NO_x before and after adjustment

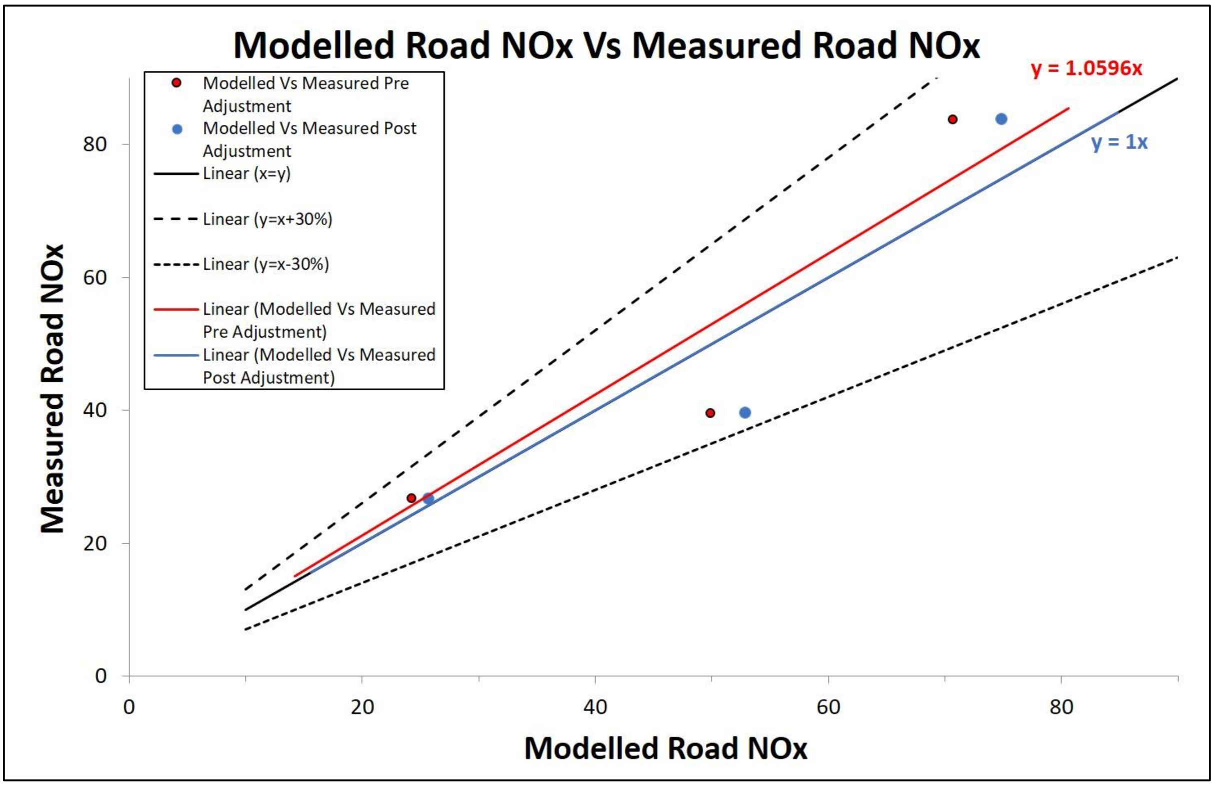


Table A3.1: Measured vs modelled NO_2 post adjustment

Measurement site	Measured NO_2 ($\mu g.m^{-3}$)	Modelled NO_2 ($\mu g.m^{-3}$)
Tube 32	47.34	43.8
Tube 33	22.57	22.0
Blantyre Automatic Analyser	28.7	34.7
	RMSE	**4.01**

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