Glasgow City Council

Local Air Quality Management

Detailed Assessment Report

May 2005

Contents

Executive Summary

Glasgow City Council's Stage IV Report assessed concentrations of NO_2 across the city and concluded that exceedences of the National Air Quality Strategy objectives were likely and the city centre was consequently declared an Air Quality Management Area (AQMA) in 2002. An Air Quality Action Plan was produced for the city centre AQMA in 2004.

Glasgow's 2003 Update and Screening Assessment report identified several locations where exceedences of the objectives were possible for NO_2, PM_{10} and SO_2. This Detailed Assessment examines the locations identified in the Update and Screening Assessment report through the use of monitored and modelled data and assesses whether exceedences of the objectives are likely and whether any further action is required at these locations, for example, the declaration of further AQMA's.

The report considers that exceedences of the annual mean objective for NO_2 are likely at:

- Royston Road
- North Street/Glasgow 1 (air quality monitoring unit, St. Patrick's School)
- Byres Road
- Dumbarton Road
- Parkhead Cross

There is therefore a requirement to declare AQMA's at the above locations for NO_2. 2004 air quality monitoring results also show that the NO_2 annual mean objective is likely to be exceeded at Napiershall Street in 2005, but further assessment of NO_2 is required at this site before determining whether it requires to be declared an AQMA. It has also been assessed through modelling that that the 2010 annual mean objective for PM_{10} is not likely to be met in the city centre at:

- Hope Street
- Renfield Street
- Union Street
- Charing Cross
- Cathedral Street

And outwith the city centre at:

- Dumbarton Road
- Glasgow 1 (air quality monitoring unit, St. Patrick's School)
- Crow Road
- Bridgeton Cross

It should be stressed that the modelled results for PM_{10} cannot be verified at this stage due to a lack of monitoring sites and data for this pollutant. Therefore, the modelled results for PM_{10} must be seen as provisional. Glasgow cannot declare any AQMA's for PM_{10} until further monitoring and verification has been conducted.

Monitored results from the use of SO_2 8-port 'bubblers' indicated that exceedences of SO_2 objectives could occur at a number of locations across the city. However, a collocation study that involved siting an SO_2 bubbler at an automatic monitoring station has shown the results obtained from the bubblers to be inaccurate, with the bubblers significantly overestimating concentrations of SO_2 in the air. Consequently, it has been concluded that Glasgow will meet the objectives for SO_2 and no further action requires to be taken for this pollutant at the present time.

1.0 Introduction

Under the Environment Act 1995, local authorities are required to conduct regular reviews of air quality within their boundaries. These reviews are carried out under the framework of local air quality management and are intended to compare current and future concentrations of air pollutants with the standards and objectives outlined in the National Air Quality Strategy (NAQS) and Air Quality (Scotland) Regulations 2002, as amended.

In the first round of review and assessment Glasgow City Council completed a Stage I report in 1998, Stage II in 2000 and Stage III in 2001. Following the completion of Stages I-III it was concluded that benzene, 1,3-butadiene, lead, PM_{10}, SO_2, CO were unlikely to exceed the objectives within the National Air Quality Strategy (Table 1.). However, the Stage III document indicated that concentrations of NO_2 at certain locations within Glasgow were likely to exceed the objectives and thus required further assessment (Stage IV) and the declaration of an AQMA. Consequently, Glasgow City Council declared Glasgow City Centre an Air Quality Management Area (AQMA) for NO_2.

Glasgow City Council's Stage IV (2003) assessed 'current' and future concentrations of NO_x and NO_2 across the city through air quality monitoring and dispersion modelling. The report confirmed that exceedences of the annual and 1-hour NO_2 objectives were likely at certain locations within Glasgow City Centre. An Air Quality Action Plan for the City Centre Air Quality Management Area was completed in 2004.

In 2003, the second round of Review and Assessment commenced with the completion of Glasgow's Update and Screening Assessment (U&SA). The U&SA document aimed to address any changes that had occurred since the onset of the first round of review and assessment that could impact on local air quality. The document identified several locations (busy roads, junctions and monitoring locations) within Glasgow where exceedences of the NAQS objectives for NO_2, PM_{10} and SO_2 were likely to occur and for which detailed assessments should be conducted. No exceedences were identified for CO, benzene, 1,3-butadiene or lead.

The following report represents the Detailed Assessment of air quality within Glasgow and follows the conclusions of the U&SA. The detailed assessment was carried out following guidance outlined within the Local Air Quality Management Technical Guidance LAQM.TG(03).

Table 1.1 The National Air Quality Strategy Objectives for the seven pollutants in Scotland

Pollutant	Objective		Date to be achieved by
	Concentration	Measured as:	
Benzene	3.25 μg m^{-3}	Running annual mean	31.12.2010
1,3-butadiene	2.25 μg m^{-3}	Running annual mean	31.12.2003
Carbon monoxide	10 mg m^{-3}	Running 8 h mean	31.12.2003
Lead	0.5 μg m^{-3}	Annual mean	31.12.2004
	0.25 μg m^{-3}	Annual mean	31.12.2008
Nitrogen dioxide	200 μg m^{-3} not to be exceeded more than 18 times per year	1 h mean	31.12.2005
	40 μg m^{-3}	Annual mean	31.12.2005
Particulate Matter (PM_{10})	50 μg m^{-3} not to be exceeded more than 35 times per year	24 h mean	31.12.2004
	40 μg m^{-3}	Annual mean	31.12.2004
	50 μg m^{-3} not to be exceeded more than 7 times per year	24 h mean	31.12.2010
	18 μg m^{-3}	Annual mean	31.12.2010
Sulphur dioxide	350 μg m^{-3} not to be exceeded more than 24 times a year	1 h mean	31.12.2004
	125 μg m^{-3} not to be exceeded more than 3 times a year	24 h mean	31.12.2004
	266 μg m^{-3} not to be exceeded more than 35 times a year	15 min mean	31.12.2005

2.0 Overview of Detailed Assessment

The Detailed Assessment follows on from the Updating and Screening Assessment which was completed by Glasgow City Council in 2003. As stated in Local Air Quality Management Technical Guidance LAQM. TG(03), the aim of the Detailed Assessment should be to identify with reasonable certainty whether or not a likely exceedence of standards set within the National Air Quality Strategy will occur at the locations identified in the Updating and Screening Assessment.

The recommended approach to the preparing the Detailed Assessment document (LAQM. TG(03)) is to:

'Use quality-assured monitoring and validated modelling methods to determine current and future pollutant concentrations in areas where there is a significant risk of exceeding an air quality objective'.

'Where a likely exceedence is identified, then the assessment should be sufficiently detailed to determine both its magnitude and geographical extent. Local authorities should not declare an Air Quality Management Area (AQMA) unless a Detailed Assessment has been completed'.

Thus, the following detailed assessment has utilised a validated air-dispersion modelling method and all air quality monitoring data have been subject to stringent quality assurance measures. An overview of Glasgow's air quality monitoring network, air-dispersion model and parameters used are included in the following sections.

3.0 Local Air Quality Monitoring

Glasgow City Council operates an extensive and expanding air quality monitoring programme which assesses concentrations of nitrogen dioxide (NO_2), particulates (PM_{10}), sulphur dioxide (SO_2), carbon monoxide (CO), benzene and lead at various locations across the city. For the purposes of the detailed assessment, the discussion of monitoring locations and data will be restricted to NO_2, PM_{10} and SO_2.

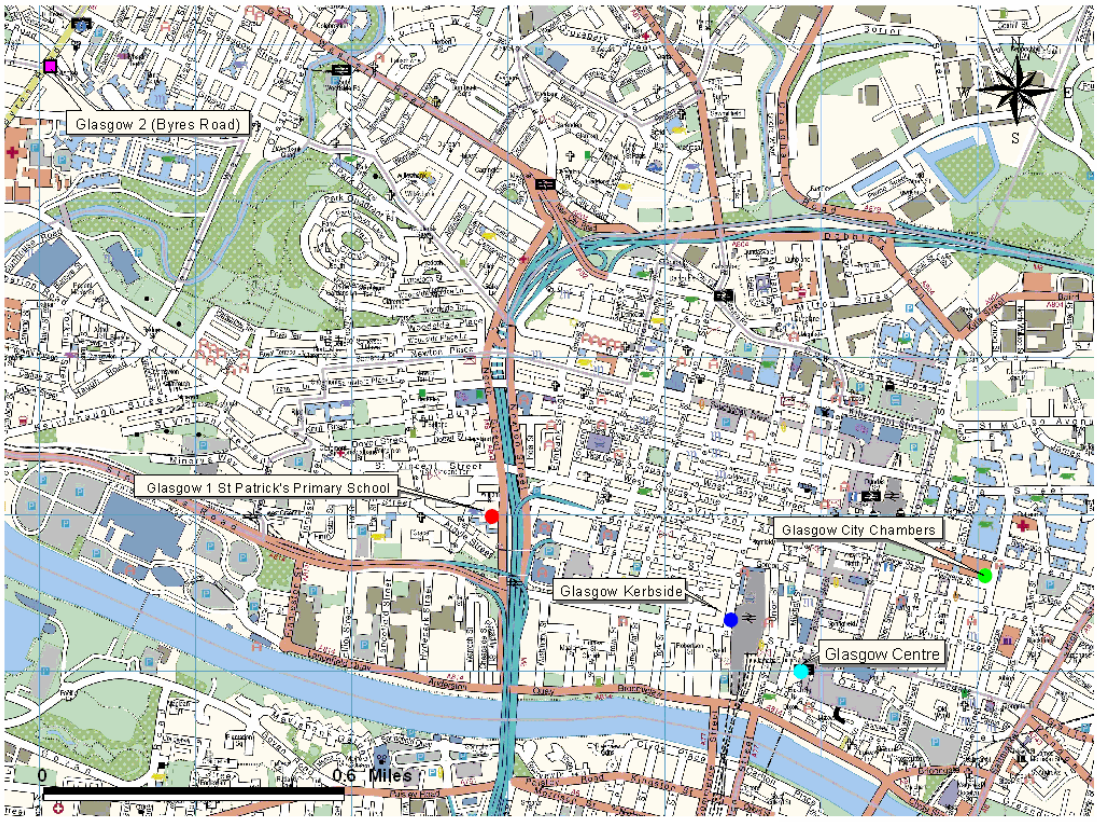
3.1 Pollutant Monitoring Programmes

3.1.1 Nitrogen Dioxide (NO_2)

The NO_2 monitoring network represents the most expansive air-quality network operated by Glasgow City Council. Monitoring of NO_2 is undertaken through the application of automatic chemiluminescent analysers and NO_2 diffusion tubes that are distributed throughout the city.

Glasgow City Council utilise six automatic chemiluminescent analysers to assess concentrations of NO_2 at various locations across the city. Three of these sites are operated by DEFRA and constitute part of the Automatic Urban and Rural Network (AURN). The other three automatic analysers are Glasgow City Council's three mobile air quality units. These six sites are described briefly in Section 3.2 and their locations presented in Figure 3.1.

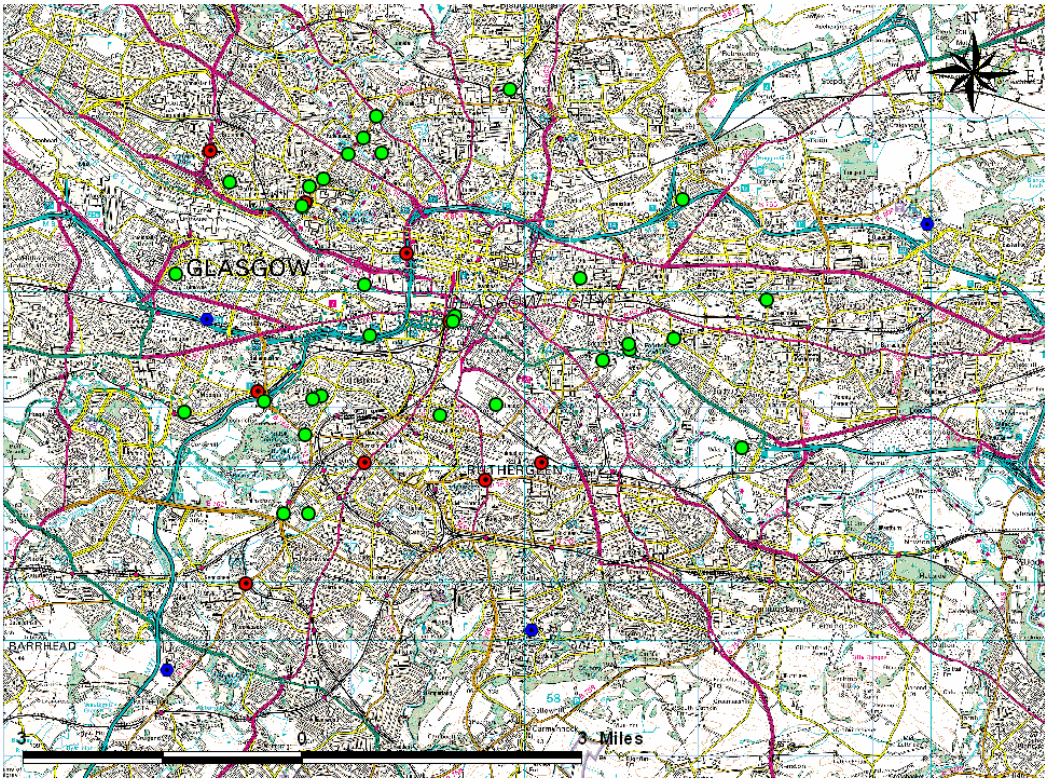
Figure 3.1 Locations of automatic air quality monitoring units in operation within Glasgow



In addition to chemiluminescent samplers, Glasgow City Council operates an extensive NO_2 diffusion tube network. The network consists of more than one hundred diffusion tubes that are distributed throughout the city. A large percentage of these tubes are located within Glasgow city centre, which has been declared an Air Quality Management Area (AQMA) for NO_2 (Glasgow City Council Air Quality Action Plan 2004) due to high incidence of traffic congestion.

However, Glasgow City Council also operates diffusion tubes that are located outwith the city centre and Glasgow's present AQMA for NO_2. Consequently, it is the concentrations of NO_2 detected by these tubes that will be the focus of this detailed assessment. The locations of diffusion tubes located outwith the city centre are presented in Figure 2.

Figure 3.2 NO_2 diffusion tubes located outwith Glasgow's AQMA



3.1.2 Particulate Matter (PM_{10})

In contrast to NO_2, Glasgow City Council monitors concentrations of PM_{10} at relatively few sites across Glasgow, as monitoring requires the use of automatic samplers. Glasgow currently utilise five sites where concentrations of PM_{10} are measured continuously using Tapered Element Oscillating Microbalance (TEOM) analysers. Two of these sites Glasgow Centre and Glasgow Kerbside are operated by DEFRA and constitute part of the Automatic Urban and Rural Network

(AURN, whilst the other three automatic analysers are located in Glasgow City Council's three mobile air quality units Section 3.2 and Figure 3.1).

Results from these analysers are not directly comparable to the air quality standards, which are based on measurements made with gravimetric samplers. Measurements from TEOM samplers are found to underestimate gravimetric samplers by between 15–30% and so a correction factor must be applied to TEOM results. The guidance advice on what this factor should be is:

'Measurements of PM_{10} concentrations carried out using a TEOM or β-attenuation instrument, operated with a heated manifold, should be adjusted by multiplying the data by 1.3 to estimate gravimetric equivalent concentrations.'

This factor has been applied to all PM_{10} data determined by TEOM analysers.

In addition to TEOM analysers, Glasgow City Council's Public Health Unit operates a mobile gravimetric PM10 sampler (partisol). This unit is used to monitor ambient concentrations of PM10 at various locations of interest, such as along the route of the proposed M74 extension and close to landfills.

3.1.3 Sulphur Dioxide (SO_2)

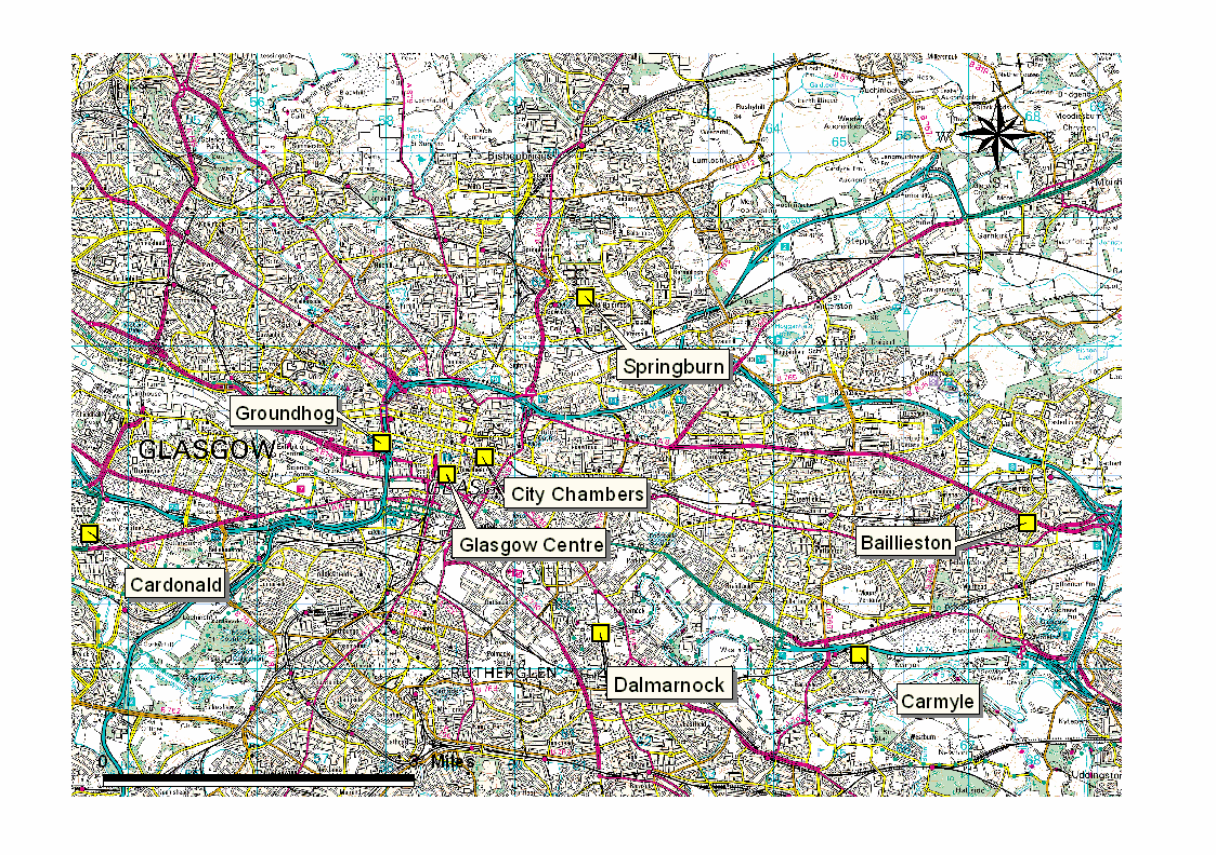
Due to the widespread burning of coal in Glasgow in the early–mid twentieth century and the episodes of extreme pollution that resulted (Smogs), a smoke and SO_2 monitoring network has operated in Glasgow since the 1950's and at one time consisted of more than 40 sites. However, following the introduction of smoke control zones across Glasgow and the subsequent improvements in air quality (smoke and SO_2), the number of these sites has declined steadily.

Currently, concentrations of SO_2 across Glasgow are monitored by two automatic analysers and six 8-port SO2 bubblers. Automatic SO_2 analysers are located at Glasgow Centre (AURN) and Glasgow City Council's Groundhog mobile air quality monitoring unit located at St Patrick's Primary School (Anderston) (Figure 3.1). The 8-port SO_2 bubblers are located at various locations across the city, the positions of which are listed in Table 3.1 and presented in Figure 3.3

Table 3.1 Locations of Glasgow's 8-port SO_2 bubblers

Site Name	Grid Reference
Baillieston	267893 664289
Carmyle	265314 662223
Dalmarnock	261272 662497
Springburn	261085 667754
Glasgow City Chambers	259527 665297
Cardonald	253419 664092

Figure 3.3 Locations of Glasgow's 8-port SO_2 bubblers



3.2 Automatic Monitoring Units

As mentioned above, Glasgow City Council currently operates six automatic air quality monitoring units. Three of these units form part of DEFRA's Automatic Urban and Rural Network and the remaining three are owned by Glasgow City Council. Brief descriptions of each of these sites are provided below.

3.2.1 Automatic Urban and Rural Network (AURN) Monitoring Units

Glasgow City Chambers (Montrose St)

The site is located on the 2nd floor of Glasgow City Chambers in Cochrane Street (259527 665297) and samples air from a height of approximately 8 metres. Cochrane Street is a street canyon, and the site is classified as urban background. Automatic NO_x and CO analysers are in operation at the site, which also forms part of Glasgow City Council's Smoke, SO_2 and metal monitoring networks.

Glasgow Centre (St Enoch)

The Glasgow Centre AURN is located in St Enoch Square, an open, pedestrianised area (258943 665027) and is classed as an urban centre location. The unit is located approximately 20 m from Argyle Street and monitors concentrations of NO_x, SO_2, O_3, PM_{10}, $PM_{2.5}$, and CO.

Glasgow Kerbside (Hope Street)

Glasgow Kerbside is positioned at the southern end of Hope Street next to Central Station (258696 665166) close to the junction with Argyle Street. The site is located in a street canyon, close to a taxi rank, with its inlet located < 1 m from the road. Consequently, this location is classed as a kerbside location.

Automatic analysers monitoring concentrations of NO_x, CO, PM_{10} and VOC's are currently in operation at the site.

3.2.2 Glasgow City Council's Automatic Air Quality Monitoring Locations

Glasgow City Council own and operate three 'mobile air quality monitoring units' named Glasgow 1 (previously referred to as the 'Groundhog'), Glasgow 2 (previously referred to as the 'Rollalong') and Glasgow 3 (previously referred to as the 'Background').

Glasgow 1 (St Patrick's Primary School)

The Glasgow 1 (the 'Groundhog') has monitored air quality at various locations across Glasgow since it was introduced in 1999. In 2001, the unit was relocated to St Patrick's Primary School, Anderston (Figure 3.1) where it has remained ever since. The unit is located approximately 50 m from M8 motorway and monitors concentrations of NO_x, CO, SO_2 and PM_{10}.

Glasgow 2 (Byres Road)

The Glasgow 2 ('Rollalong') monitoring unit has been located at the corner of University Avenue and Byres Road since April 2004, and was previously located at Townhead close to the M8 motorway (see U&SA 2003). The site is located close to a busy junction and monitors concentrations of NO_x, CO and PM_{10}.

Glasgow 3 (Waulkmillglen Reservoir)

The Background represents Glasgow City Council's newest automatic air quality monitoring unit and went into operation at Waulkmillglen reservoir, just outside the south-west boundary of the city in 2002. The site is located several hundred meters from major roads and is used to monitor background concentrations of NO_x, CO, O_3 and PM_{10}.

During 2003 and the start of 2004, Glasgow City Council's air quality monitoring units experienced significant power and communication problems. These problems were addressed through the relocation of Glasgow 2 to Byres Road from Townhead (Power Supply) and the purchase of new communication software for data collection. Whilst all efforts were made to recover air quality data from the units, technical difficulties resulted in very low capture rates for

all three ‘ units’. Consequently, data from these sites are not included in the detailed assessment and work is ongoing to improve data capture rates.

4.0 Emissions and Air Quality Modelling

Local Air Quality Management Technical Guidance LAQM. TG(03) states that a validated modelling method must be used to determine current and future concentrations of pollutants in areas where there is a significant risk of exceeding an air quality objective.

In the following Detailed Assessment, the Emissions Inventory Toolkit (EMIT) and ADMS-Urban software packages both produced by Cambridge Environmental Research Consultants (CERC), were used to calculate emissions of pollutants and to conduct air dispersion modelling respectively.

4.1 Determination of Emissions from Road Sources (EMIT)

Road traffic emissions were calculated using EMIT on the basis of a standard emission rate per vehicle and incorporated information of vehicle type, age and speed, with total emissions per road segment therefore based on total traffic flow and percentage of each vehicle category on the road.

Data of Road traffic flows were taken from the Saturn road traffic model which has been validated against traffic counts. The Saturn model generates data of traffic volumes (passenger carrying units (pcus)) and average speeds (kph) between 'monitoring' nodes across the city. The monitoring nodes were sections of road on which the traffic flows and speeds were measured and generally represented sections of road within junctions.

Positions of road traffic monitoring nodes were provided as maps representing sections of the city. Node numbers corresponding to junctions and sections of road were then identified in order to determine traffic flow (pcus) and speeds on roads/ junctions being investigated in the detailed assessment.

Projections of traffic flows between each node for 2005 were undertaken by MVA Consultants and provided for three monitoring periods AM, PM and INT. AM was monitored between 8-9am, PM between 5-6pm and INT between 2-3pm.

In order to use the traffic flow information provided by MVA the flows had to be converted from pcus into an annual average daily traffic flow (AADT). The AADT is broken down into three categories; motorcycles, light vehicles (cars and light goods vehicles) and heavy vehicles (buses and heavy goods vehicles).

The process to convert from pcus to AADT is described in four stages:

The pcu traffic flow was broken down into vehicle categories provided by Glasgow City Council, i.e. 0.53% motorcycles, 91.25% light vehicles and 8.55% heavy vehicles.

The pcu flow was converted to vehicle flow using conversion factors provided by Glasgow City Council, i.e. 0.4 motorcycles, 1.0 light vehicles and between 1.5 and 2.0 for heavy vehicles. The factors reflected the number of passenger's equivalent that each vehicle type carries.

The vehicle flow for the monitoring period (AM, PM or INT) is converted to a 12-hour flow. This is calculated using figures provided by Glasgow City Council that found that on average during a 12-hour (7 am to 7pm) monitoring period the AM (8-9am) was 9.642% of the total 12-hour traffic flow. Likewise the INT (2-3pm) was 8.585% and PM (5-6pm) was 11.05% of the total 12-hour traffic flow.

Finally, the 12-hour traffic flow counts were converted to an AADT flow. Monitoring data of traffic flows at 28 junctions throughout the city showed that on average the AADT flow is 26% higher than the 12-hour flow. Technical guidance LAQM.TG(03) states that on average the AADT flow is 15% higher than the 12-hour flow outwith London. Given that Glasgow City Centre is a bustling location in the evenings then the 26% conversion is more accurate. The 12-hour flows were therefore factored by 1.26 to convert to AADT flow.

The AADT was calculated for the three monitoring periods AM, PM and INT. The AADT calculated varied depending on the respective starting point. Of the three AADT calculated, the flow was generally higher when calculated for a starting base of AM pcu flow. The AADT calculated from the AM pcu flow was therefore used to estimate traffic flows on road sections as these represented the worst-case scenario.

Emissions per road were calculated using the EURO Scaled 03 emission factors contained within the EMIT database. Relevant vehicle composition (e.g. Urban 05) for each road section were selected from the default vehicle fleet compositions contained within the EMIT database. The composition corresponds to the percentage vehicles of each fleet corresponding to default European engine classifications. The composition of each vehicle type is built into the EMIT database for each year i.e. in 2010 the vehicle fleet in Glasgow will contain a higher percentage of 'cleaner' engines than in 2005 as new vehicles adopt cleaner technology.

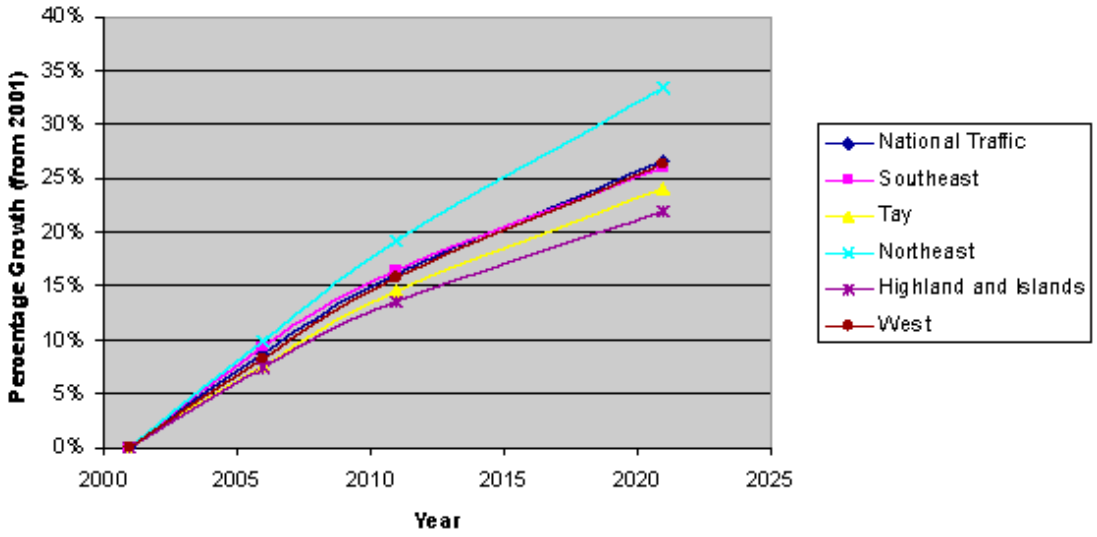
Emissions to air from motor vehicles were therefore calculated by EMIT as a product of the emissions factor at given speed for each vehicle category, assuming number of vehicles in each engine category and the distance travelled per vehicle.

4.1.1 Projected Traffic Growth

In the following assessment, concentrations of PM_{10} in the vicinity of busy roads and junctions are modelled for 2010 in addition to 2005. This is in order to assess concentrations at a date relative to the new National Air Quality Strategy Objectives for PM_{10} (31/12/10).

The volume of road transport on both major and minor roads is predicted to grow significantly in Glasgow in the coming years, and consequently estimates of traffic flow on each road section being modelled are required for 2010. The Scottish Executive's predicted road transport growth factors for the West of Scotland (Figure 4.1) were applied to predict traffic flows in 2010.

Figure 4.1 Background Traffic Growth by Region



* *Taken from Review of Local Transport Strategies and RTRA Reports*

4.1.2 Traffic Speed

As stated in LAQM.TG(03), the *'estimation' of appropriate traffic speed is important for modelling of road traffic sources. Unfortunately, it is usually difficult to obtain data on speeds that would be ideal for air quality studies'.*

Speed estimates for Detailed Assessment work must be link specific with links being broken down to their key elements.

Estimates of traffic speed at given sections of roads and junctions included in this detailed assessment have drawn on various sources of information, including the Saturn model, the speed limit for each road and local knowledge. This has also incorporated possible slow speeds during congestion and complex changing speeds close to junctions and roundabouts. Consequently, all of the busy roads and junctions modelled have been split into a large number of links with appropriate speeds for each.

4.2 Dispersion Modelling (ADMS-Urban)

Following the creation of sources and calculation of emissions within EMIT, each road traffic source database was exported to ADMS-Urban as a line source including geo-referenced road vertices, the flow and composition of traffic to enable dispersion modelling to be conducted.

4.2.1 Model Description

Dispersion modelling was conducted using ADMS-Urban, an advanced modelling tool that is approved for use in Detailed Assessment modelling studies (LAQM.TG(03)). The model has been subject to extensive verification including comparisons with data from the UK's Automatic Urban Network. Technical details of the model validation references are available at http://www.cerc.co.uk.

4.2.2 Model Setup

General Settings

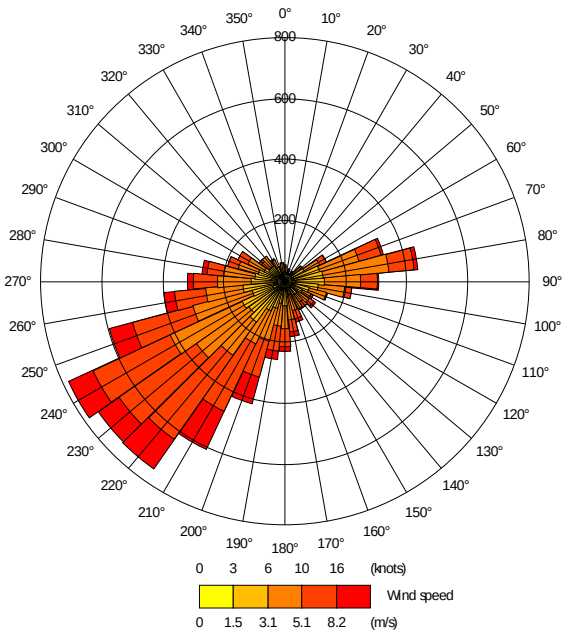
The intelligent gridding setting contained within ADMS-Urban was utilised in all model runs, and the NO_x-NO_2 correlation was used to predict NO_2 concentrations.

Meteorological data

Weather data used in the modelling study was obtained from the nearest Meteorological station at 'Glasgow International Airport' (Bishopton) to the south west of Glasgow. The station is located in a suburban area and is approximately 59 m above sea level.

Meteorological data from 1999 was utilised for all modelling and a wind rose of the year's data is presented below in Figure 4.2.

Figure 4.2 Bishopton Wind Rose 1999



Background Ambient Concentrations

In order to 'accurately' model local emissions, background ambient concentrations of pollutants that are advected from out-with the modelling area must be taken into consideration.

When modelling concentrations of PM_{10}, year specific background concentrations were determined for each site from the empirically-derived national background maps (1x1 km grid squares) available through UK National Air Quality Archive website (http://www.airquality.co.uk/archive/index.php). These were included directly in modelling scenarios.

A background file incorporating data of pollutant concentrations from a background location were included in all NO_2 modelling scenarios.

Road width and canyon heights

Streets and junctions assessed in the current study were assessed for road width and canyon heights. Road widths were determined through measurement of digital maps to the closest metre, whilst the presence and extent of street canyons was determined through local knowledge.

Public exposure

In terms of public exposure, LAQM.TG(03) states that:

'the quality of the air at locations which are situated outside of buildings or other natural or man-made structures, above or below ground, and where members of the public are regularly present. Reviews and assessments should thus be focussed on those locations where members of the public are likely to be regularly present and are likely to be exposed over the averaging period of the objective. Authorities should not consider exceedences of the objectives at any location where relevant public exposure would not be realistic'.

Table 4.1 lists examples of locations relevant to human exposure where the Air Quality Objectives should apply in terms of the set averaging period (e.g. annual mean, 24 h-mean etc)

Table 4.1 Examples of locations where the Air Quality Objectives should apply

Averaging Period	Objectives should apply at:
Annual mean **NO_2 and PM_{10}**	All locations where members of the public might be regularly exposed. Building facades of residential properties, schools, hospitals, libraries etc.
24-hour mean **PM_{10} and SO_2**	All locations where the annual mean objective would apply. Gardens of residential properties.
1-hour mean **NO_2 and SO_2**	All locations where the annual mean and 24 hour mean objectives apply. Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where the public might reasonably be expected to spend 1-hour or more. Any outdoor locations to which the public might reasonably expected to spend 1-hour or longer.
15-min mean **SO_2**	All locations where members of the public might reasonably be exposed for a period of 15 minutes or longer.

Consequently specified points relevant to human exposure were assessed in model runs of each source investigated in the current assessment.

4.2.3 Model Verification

In general, the main uncertainty in modelling studies is the quality of data input into the model. Thus, in this study data of prevailing weather conditions, background pollutant concentrations, street canyons, road traffic composition, flows, speeds and subsequent emissions will have a significant effect on the predicted ground level pollutant concentrations.

$\underline{NO_2}$

In order to validate the ground level pollutant concentrations predicted by the model, it is important to compare model results with concentrations detected at monitoring locations. Therefore, wherever possible, concentrations of NO_2 predicted by the model were compared with results from NO_2-diffusion tubes for 2004. The amount of monitoring data available is insufficient to accurately verify the model; however, the comparison does provide an estimate of model performance. The results of the verification exercise for NO_2 are presented in Table 1. below, and model outputs are presented in Appendix 4.

Table 4.2. Verification study comparison of monitored and modelled [NO_2] 2004

Location	Monitored annual mean [NO_2] 2004	Modelled annual mean [NO_2] 2004	% Difference Modelled/ monitored [NO_2]
Byres Rd NO_2 Diffusion Tube	42	40.96	-2.48
Royston Road NO_2 diffusion Tube 1	45	39.42	-12.27
Royston Road NO_2 Diffusion Tube 2	39	37.57	-3.52
Parkhead Cross Diffusion Tube (Westmuir Street)	50	41.02	-18.24
North Street Diffusion Tube	43	49.63	14.26
Bridge Street/ Norfolk Street	36	39.68	10.22
Coburg Street	29	37.28	28.55
Oxford Street	28	34.94	24.79

Comparison of modelled annual mean [NO_2] with monitoring results (Table 4.2) indicates that the model is under-predicting at some locations and over-predicting at others. The variation between modelled and monitored concentrations ranges from an 18.24% under-prediction at Westmuir Street, to a 28.55% over-prediction at Coburg Street.

Potential explanations for the variations between modelled and monitored annual mean NO_2 concentrations include the data included in the model runs and the data-capture rates at monitoring locations.

Due to the relative low number of comparisons made, and the range of results, variations between modelled and monitored results cannot be considered to be representative of all locations and thus a correction factor cannot be applied.

PM_{10}

Due to the limited availability of PM_{10} data outlined in Chapter 3, it is unfeasible to conduct a reliable verification of modelled PM_{10} concentrations in Glasgow at this time. Of the two automatic PM_{10} analysers for which data is currently available, one (Glasgow Centre) is located in an Urban Background location, whilst the other (Glasgow Kerbside) is located in a street canyon and is strongly influenced by emission from an adjacent taxi rank. Thus, neither of these sites is representative of the other locations being modelled in the current study.

Consequently, caution has been applied to decisions made on modelled PM_{10} concentrations until a reliable verification exercise can be conducted.

4.2.4 Modelling Improvements

Whilst every attempt has been made to ensure the quality of the data used in modelling studies is of a high standard, Glasgow City Council is currently undertaking measures to improve the accuracy of data used. This has included the introduction of a weather station at Dalmarnock in July/ August 2004.

Monitoring and modelling results

The following three chapters detail air quality monitoring results for NO_2, PM_{10} and SO_2 in Glasgow together with outputs from air-dispersion modelling conducted at sites where potential exceedences of the National Air Quality Strategy objectives were identified by Glasgow City Council's Updating and Screening Assessment (2003).

Each Chapter provides a brief summary of the sites for which air-dispersion modelling was conducted and the predicted background concentrations for relevant years.

5.0 Nitrogen Dioxide

Glasgow City Council's Updating and Screening Assessment (2003) identified that emissions from motor vehicles represent the predominant source of NO_2 within Glasgow.

There are two air quality objectives set for NO_2 in the Air Quality (Scotland) Regulations, an annual mean and a 1-hour mean. Details of these objectives are presented in Table 1.1.

In 2001, Glasgow's City centre was declared as an Air Quality Management Area (AQMA) for NO_2, and actions being undertaken to address elevated concentrations within the area are outlined in the Air Quality Action Plan (2004). In the second round of Review and Assessment, Glasgow City Council's Updating and Screening Assessment identified numerous locations out-with the city centre where exceedences of the Objectives for NO_2 could potentially occur. The vast majority of these locations were in the vicinity of road sources and fell into three categories, namely (1) monitoring locations where exceedences had already been identified and busy roads (2) and junctions (3) where exceedences of the Objectives were likely.

In addition, Glasgow's Updating and Screening Assessment concluded that the impact of the proposed M74 extension would require to be assessed in detail. Table 5.1 lists sites that the U&SA identified as requiring further assessment.

Table 5.1 Glasgow locations assessed for exceedences of the NAQS Objectives for NO_2 together with predicted background concentrations for 2005

Category	Location	Background [NO_2] 2005 ($\mu g\ m^{-3}$)
Monitoring locations	Byres Road	35.5
	Royston Road	37.4
	Bridge St/ Norfolk St.	39.4
	North St.	38.3
Busy Roads/ Junctions	Dumbarton Road at Partick	36.9
	Great Western Road at Kelvinbridge	34.2
	Paisley Road at Cessnock	36.9
	Parkhead Cross	34.4
	Calder St. / Aikenhead Rd	32.7

5.1 NO_2 Monitoring Data

Glasgow City Council monitors ambient concentrations of NO_2 at numerous location across the city, through the application of diffusion tubes and automatic analysers (Section 3.1.1). Concentrations detected at all sites have been compared against the National Air Quality Strategy Objectives (Table 1.1) and are presented in Tables 5.1-5.9 and Figures 5.1-5.2.

5.1.1 Quality Assurance/ Quality Control NO_2 Diffusion Tube Monitoring

NO_2 diffusion tubes represent a simple, effective and low cost method of monitoring ambient concentrations of nitrogen dioxide in a large number of locations, with Glasgow City Council's NO_2 diffusion tube network currently consisting of more than 100 tubes spread throughout the city. However, data of NO_2 concentrations provided by diffusion tubes is limited to fairly long-term exposure. Tubes are generally exposed for periods of a month, annual mean concentrations determined and compared with the annual mean objective. Furthermore, the accuracy of diffusion tubes can vary depending on the preparation methodology, handling procedures and the identity of the analyzing laboratory.

Diffusion tubes utilised by Glasgow City Council are prepared and analysed by Glasgow City Council's Scientific Services. The tubes are stored in a cool location prior to use and end caps only removed as when placed at the monitoring location.

In order to determine bias-correction factors for diffusion tube results, triplicate tubes are co-located with the automatic NO_2 analysers located at Glasgow Centre (Urban Background), Glasgow Kerbside (Kerbside) and Glasgow City Chambers (Urban Centre). Concentrations detected by these tubes were compared against those recorded through chemiluminscent detection over the same sampling period and a bias-correction factor determined using the guidance outlined in LAQM.TG(03). A summary of the bias-correction factor calculated for sites in Glasgow in 2004 is given in Table 5.2.

Table 5.2 Determination of Bias-correction factor for 2004

Site name	NO_2 Diffusion Tube [Annual Mean] ($\mu g\ m^{-3}$) DM	NO_2 Chemiluminscent Detection [Annual Mean] ($\mu g\ m^{-3}$) CM	Bias correction Factor (CM/DM)
Glasgow Centre	43.4	32.0	0.737
Glasgow Kerbside	90.8	68.0	0.749

Diffusion tube results presented in the following Tables have been subject to adjustment with the relevant correction factor for each year and monitoring location.

5.1.2 Diffusion Tube Monitoring Data

Table 5.3 NO_2 levels detected by diffusion tube at kerbside sites outwith the city centre

Location	Grid ref.	Annual Mean NO_2 (µg m^{-3})		Projected 2005 annual mean (µg/ m^{-3})	
Year/ Base Year		'03	'04	'03	'04
Mosspark Boulevard	255392 663286	34	30	32	29
Thornliebank Road	255193 659969	27	25	26	24
Mosside Road	257235 662064	35	31	33	30
Royston Road	260278 666186	49	45	47	44
Bridge St./ Norfolk St.	258702 664480	45	36	43	35
Aikenhead Road	259323 661763	36	30	34	29
Balshagray Avenue	254566 667431	39	31	37	30
North Street	257971 665654	47	43	45	42
Dumbarton Road	256209 666525	43	34	40	33
Dougrie Road 1	259586 658996	-	19	-	18
Dougrie Road 2	259879 659059	-	18	-	18
Anniesland X	254646 668820	-	39	-	38
Lawrence St	256295 666816	-	23	-	23
Coburg St	258760 664473	-	29	-	28

Table 5.4 NO_2 levels detected by diffusion tube at roadside sites outwith the city centre

Location	Grid ref.	Annual Mean NO_2 (µg m^{-3})		Projected 2005 annual mean (µg m^{-3})	
Year/ Base Year		'03	'04	'03	'04
Hillcrest Road (UK)	256485 663205	30	18	29	17
Hillcrest Road	256485 663205	22	17	21	17
Dumbreck Road	255497 663126	27	25	26	24
St Andrews Drive	256214 662536	25	20	23	20
Haggs Road	256263 661781	29	25	27	25
Pollokshaws Road	255839 661189	29	26	28	26
Dunn Street	261328 663817	41	32	39	31
Byres Road	256530 666939	50	42	48	41
Queen Margaret Drive	257440 668016	32	26	31	26
Westmuir Street	262559 664181	43	50	41	49
Finnieston Street	257235 665108	43	34	40	33
Napiershall Street	257774 666795	-	54	-	53
Dougrie Road 3	260204 659127	-	21	-	20
Queen Margaret Drive 2	257216 667639	-	30	-	29
Queen Margaret Drive 3	256941 667363	-	37	-	37
Cooperswell Street	256154 666478	-	23	-	23
Castle Street, Partick	256160 666452	-	25	-	25
Royston Road 2	260430 666263	-	39	-	39
Oxford Street	258731 664590	-	28	-	27

Table 5.5 NO_2 levels detected by diffusion tube at urban background sites outwith the city centre

Location	Grid ref	Annual Mean NO_2 (µg m^{-3})		Projected 2005 annual mean (µg m^{-3})	
Year/ Base Year		'03	'04	'03	'04
Sutherland Ave. (UK)	256343 663153	24	15	23	14
Kinning Park (Stanley Street)	257335 664239	53	32	51	32
Ascaig Crescent	254119 662931	25	15	24	15
Belmont Street	257535 667378	38	24	36	23
Mallaig Place	253984 665299	32	23	31	22
Govanhill Street	258545 662882	39	23	37	22
Drumhead Road	263744 662327	27	17	26	17
Caledonia Road	259504 663055	32	21	31	20
Westercraigs	260943 665225	36	23	34	22
Inveresk Lane	264162 664854	30	21	29	20
Maxwellton Road	262705 666577	45	32	43	31
Kippen Street	259727 668476	27	17	26	17
Broomhill Road	254904 666873	37	21	35	21
Celtic Park 1	261799 663987	32	21	31	21
Celtic Park 2	261788 664091	31	19	30	19
Sacone SW	263920 664570	-	19	-	19
Castlemilk	260156 659189	26	15	25	14
Craigton Rd	254515 664510	48	28	46	27
Invergarrie Road	253824 658589	22	13	21	13
Easterhouse	266933 666154	36	23	34	22

Table 5.6 NO_2 levels detected by diffusion tube at kerbside sites within the city centre

Location	Grid ref	Annual Mean NO_2 (µg m^{-3})		Projected 2005 annual mean (µg m^{-3})	
Year/ Base Year		'03	'04	'03	'04
Hope Street (UK)	258730 665322	101	67	97	65
Argyle Street	258846 665088	85	70	81	69
George Square	259246 665442	65	49	62	47
Union Street	258833 665210	73	68	69	66
Glasgow Cross	259658 664868	44	43	42	42
Bath Street	258215 665864	53	45	51	44
Glassford Street	259361 665250	58	61	55	59
Briggait	259420 664703	46	37	43	36
St Vincent Street	258844 665446	84	75	80	73
N. Hanover Street	259375 665900	52	39	49	38
Castle Street	260100 665579	54	45	51	44
Hope Street 2 (mid)	258730 665405	68	64	65	62
Hope Street 3 (north)	258857 665913	61	49	58	48
Montrose Street	259543 665332	53	37	51	37
Cochrane Street (1)	259524 665294	46	43	43	42
Cochrane Street (2)	259430 665316	46	38	43	37
Ingram Street	259524 665253	41	37	39	36
Renfield Street	258954 665873	63	51	59	50
George Street	259551 665380	50	41	48	40
Broomielaw	258561 664931	55	45	52	44
Carrick Street	258319 665076	-	31	-	30
DundasVale Street	258828 666289	-	32	-	31

Values presented in red indicate exceedences of NAQS objectives

Table 5.7 NO_2 levels detected by diffusion tube at roadside sites within the city centre

Location	Grid ref.	Annual Mean NO_2 (µg m^{-3})		Projected 2005 annual mean (µg m^{-3})	
Year/ Base Year		'03	'04	'03	'04
Hope Street 1 (south)	258730 665322	81	67	77	66
Gordon Street	258766 665347	87	64	82	63
Heilan'man's Umbrella north	258770 665117	80	73	76	71
Heilan'man's Umbrella south	258769 665106	84	73	79	72
Saltmarket	259545 664739	42	37	40	37
High Street	259732 664991	54	48	51	47
Dobbies loan	259302 666289	39	37	37	37

Values presented in red indicate exceedences of NAQS objectives

Table 5.8 NO_2 levels detected by diffusion tube at urban centre sites within the city centre

Location	Grid ref	Annual Mean $[NO_2]$(µg m^{-3})		Projected 2005 annual mean $[NO_2]$ (µg m^{-3})	
Year/ Base Year		'03	'04	'03	'04
M^{c}Leod Street (UK)	260077 665481	50	33	48	32
M^{c}Leod Street	260077 665481	46	32	44	32

Values presented in red indicate exceedences of NAQS objectives

5.1.3 Automatic Monitoring Data

Table 5.9 Annual mean NO_2 concentrations measured at AURN sites

location	Measured Annual Mean (µg m^{-3})		Projected 2005 Annual Mean (µg m^{-3})	
	2003	2004	Base 2003	Base 2004
Glasgow Chambers	50	49	48	48
Glasgow Centre	38	36	37	35
Glasgow Kerbside	75	68	71	66

Values presented in red indicate exceedences of NAQS objectives

Figure 5.1 Annual mean NO_2 concentrations measured at AURN sites

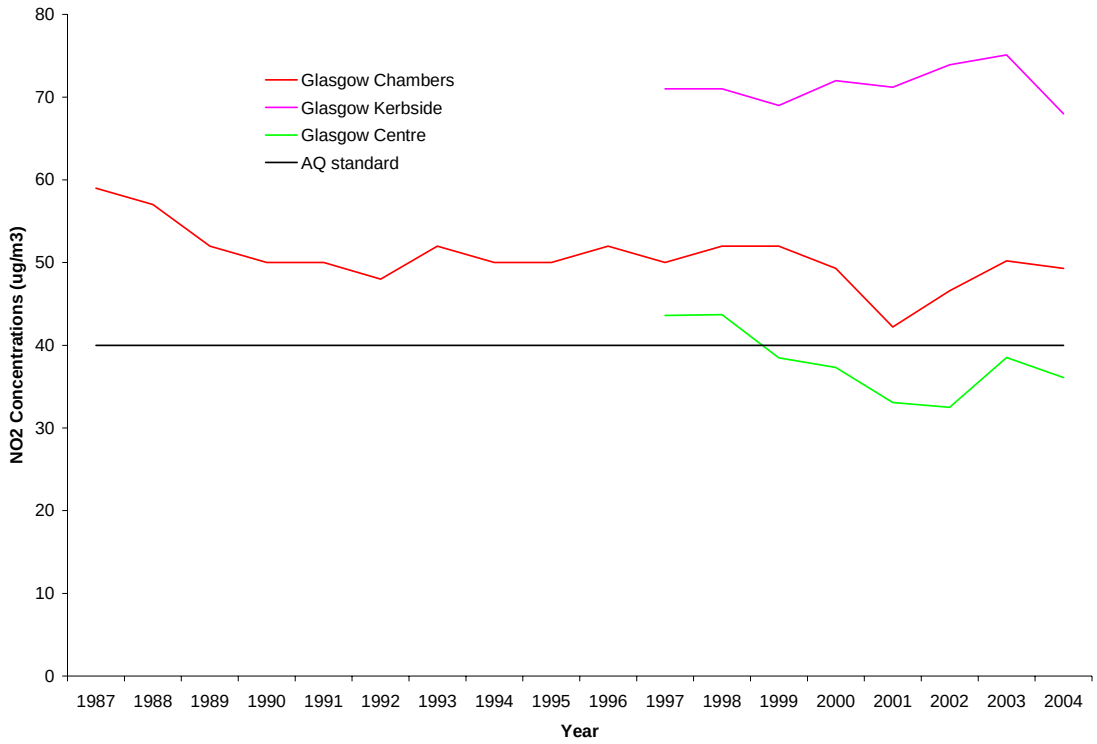
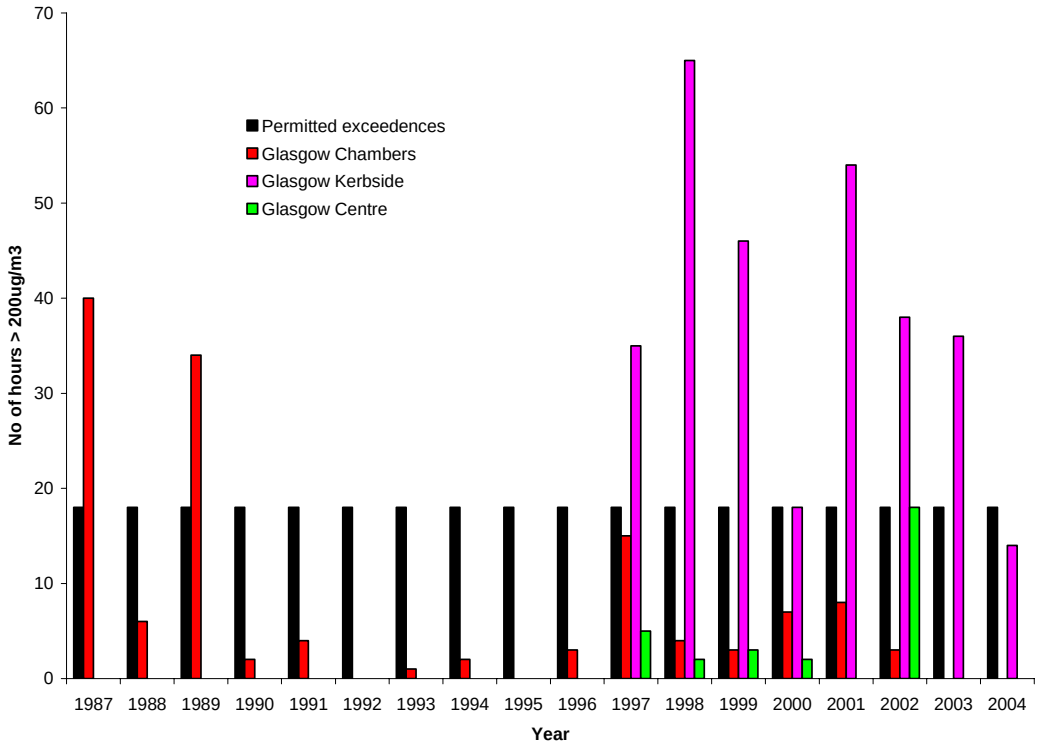


Figure 5.2 Number of exceedences of 1-hour mean objective for NO_2, Glasgow AURN stations



5.1.4 NO_2 Monitoring Summary

In summary, the results from the air quality monitoring of NO_2 in Glasgow indicated that the NAQS annual mean objective for NO_2 is likely to be exceeded at numerous locations within Glasgow in 2005.

Monitoring results from NO_2 diffusion tubes located outwith Glasgow City Centre in 2004 (Tables 5.3-5.5) identified exceedences of the annual mean objective at Royston Road 1, North Street, Byres Road, Westmuir Street and Napiershall Street (introduced end 2003). Projected annual mean concentrations of NO_2 at all five of these sites also indicated potential exceedences of the objective in 2005. However, all five of these locations are classified as Kerbside or Roadside and are therefore not truly representative of human exposure. In 2004, no exceedences of the annual mean objective were recorded at NO_2 diffusion tube located at urban background sites.

Results from NO_2 diffusion tubes located within Glasgow City Centre in 2004 reported widespread exceedences of the annual mean objective. These exceedences are also predicted to continue in 2005. Furthermore, NO_2 monitoring results from all three AURN stations located within Glasgow City Centre in 2004 indicated continuing exceedences of the annual mean objective at Glasgow City Chambers and Glasgow Kerbside. No exceedences of the 1-hour mean objective for NO_2 were recorded at any of the AURN stations located in Glasgow City Centre in 2004. As Glasgow City Centre was declared as an AQMA for NO_2 in 2001, exceedences of the NAQS objectives for NO_2 within this area are not discussed further in this document.

5.2 Air Dispersion Modelling – Road Traffic Emissions

Glasgow City Council's Updating and Screening Assessment (2003) identified nine busy roads/ junctions outwith Glasgow City Centre where there was a potential for exceedence of the NAQS objectives for NO_2. Predicted annual and 1-hour mean concentrations of NO_2 at these locations were assessed using the air-dispersion modelling tools and data outlined in Section 4.2.

The following sections outline the results of these modelling studies and summarise the predicted maximum annual mean concentrations identified at each site and annual mean concentrations predicted at locations relevant for human exposure. In addition, the maximum 99.79th percentile of hourly mean NO_2 concentrations detected at each location is stated.

Royston Road

Royston road is a busy road located to the north east of Glasgow City Centre, just outside the current AQMA for NO_2. The modelling results for Royston Road (2005) are presented in A.1.1, A.1.2 and summarised in Table 5.10

Table 5.10 Predicted concentrations of NO_2 at various locations on Royston Road (2005)

Receptor name	X(m)	Y(m)	Predicted Annual mean [NO_2] ($\mu g\ m^{-3}$)
Max [NO_2]			47.46
Royston Road DT1	260278	666186	38.14
Royston Road DT2	260430	666263	37.51
Location 1	260359	666246	42.36
Location 2	260448	666273	39.89
Location 3	260537	666277	36.81

DT: Diffusion Tube

The maximum annual mean NO_2 concentration predicted at Royston Road during 2005 was 47.46 $\mu g\ m^{-3}$, above the NAQS objective of 40 $\mu g\ m^{-3}$. However, examination of the contour plot presented in A.1.1 demonstrated that the maximum annual mean NO_2 concentration is predicted to occur on the road at the junction with Springburn Road, a location that is not relevant to human exposure. Further assessment of the contour plot indicated that the annual mean NO_2 concentrations predicted at locations relevant to human exposure are significantly lower than the predicted maximum, but are in several cases exceeding (42.36 $\mu g\ m^{-3}$) or close to exceeding the NAQS annual mean objective for NO_2.

In contrast, the maximum 99.79th percentile of hourly NO_2 concentrations predicted at Royston Road (2005) was 124.47 $\mu g\ m^{-3}$, indicating that there is unlikely to be an exceedence of the 1-hour objective for NO_2 in the Royston Road area.

Byres Road

Byres Road is a busy thoroughfare in the west end of the City, joining Dumbarton Road and Great Western Road. Results from the air-dispersion modelling conducted for Byres Road 2005 are presented within Appendix 1 and summarised in Table 5.11

Table 5.11 Predicted concentrations of NO_2 at various locations at Byres Road (2005)

Receptor name	X(m)	Y(m)	Predicted Annual mean [NO_2] ($\mu g\ m^{-3}$)
Max [NO_2]			43.79
Byres Road DT	256530	666939	40.89
Location 1	256483	666916	38.34
Location 2	256504	666944	38.06
Location 3	256322	666692	36.29

DT: Diffusion Tube

The results from the NO_2 modelling study at Byres Road 2005, predicted maximum annual mean concentrations of NO_2 in the range 42.32-43.79 $\mu g\ m^{-3}$ at the junctions of Byres Road with Dumbarton Road, University Avenue and Great Western Road. Predicted annual mean NO_2 concentrations at most locations relevant for human exposure along Byres Road, were generally lower than 39.38 $\mu g\ m^{-3}$. However, the model predicted NO_2 concentrations in the range 39.38 – 40.85 $\mu g\ m^{-3}$ at properties close to the junctions of University Avenue, Great Western Road and Dumbarton Road, indicating the potential for exceedences of the NAQS objective at these locations.

The maximum 99.79th percentile of the hourly mean predicted at Byres Road for 2005 was 122.19 μg m^{-3}, indicating that there is unlikely to be an exceedence of the 1-hour objective for NO_2 in the Byres Road area.

Paisley Road

Paisley road is a busy road located on the south-west edge of Glasgow City Centre, south of the river Clyde and just outside the current AQMA for NO_2. The road passes directly under the M8 at its eastern edge and is strongly influenced by vehicles coming off the motorway. Results from the air-dispersion modelling conducted for Byres Road 2005 are presented within Appendix 1and summarised in Table 5.12

Table 5.12 Predicted concentrations of NO_2 at various locations at Paisley Road (2005)

Receptor name	X(m)	Y(m)	Predicted Annual mean [NO_2] (μg m^{-3})
Max [NO_2]			43.79
Location 1	258098	664682	38.47
Location 2	258123	664644	39.79
Location 3	257511	664636	36.11
Location 4	257396	664609	36.52

The results from air-dispersion modelling at Paisley Road 2005, predicted a maximum annual mean NO_2 concentration of 43.79 μg m^{-3} close to where the M8 passes over Paisley Road (A.3.1). The closest residential properties to this area are located at Riverview Drive, where annual mean concentrations are predicted to be 37.93-39.40 μg m^{-3}. Moving west along Paisley Road, annual mean concentrations of NO_2 are predicted to be lower, with elevated concentrations largely restricted to the road. However, annual mean NO_2 concentrations in the range 37.93-39.40 μg m^{-3} are predicted to occur at numerous properties along Paisley Road West. Although the annual mean is predicted to be close to the objective, further monitoring will be required for Paisley Road to validate the modelled data before an AQMA can be declared.

The maximum 99.79th percentile of hourly means predicted for Paisley Road (2005) was 121.90 μg m^{-3}, suggesting that there is unlikely to be an exceedence of the 1-hour mean objective for NO_2 in the Paisley Road area.

Great Western Road

Great Western road is a busy road located to the north-west of Glasgow City Centre, outside the current AQMA for NO_2. The road runs parallel to Maryhill road and has junctions with Byres Road, Queen Margaret Drive and Hyndland. Results from the air-dispersion modelling conducted for Great Western Road 2005 are presented within Appendix 1 and summarised in Table 5.13

Table 5.13 Predicted concentrations of NO_2 at various locations at Great Western Road (2005)

Receptor name	X(m)	Y(m)	Predicted Annual mean [NO_2] ($\mu g\ m^{-3}$)
Max [NO_2]			42.86
Location 1	255059	668555	35.13
Location 2	255647	668149	35.19
Location 3	256187	667732	31.34
Location 4	256893	667292	35.87
Location 5	257326	667071	37.91

The results from air-dispersion modelling at Great Western Road 2005, predicted a maximum annual mean NO_2 concentration of 42.86 $\mu g\ m^{-3}$ towards the western end of the road (A.4.1). Maximum concentrations were predicted on the road itself, with maximum ambient concentrations at the closest residential properties predicted to range from 36.96 to 38.93 $\mu g\ m^{-3}$. Further east along Great Western Road, elevated annual mean concentrations of NO_2 (40.89-42.86 $\mu g\ m^{-3}$) are also predicted at the busy junctions with Hyndland Road/ Cleveden Road and Byres Road/ Queen Margaret Drive. However, annual mean NO_2 concentrations at relevant locations close to these junctions are predicted to predominantly range from 33.03-36.96 $\mu g\ m^{-3}$, with a few sites predicted to reach 36.96 to 38.93 $\mu g\ m^{-3}$.

The maximum 99.79th percentile of hourly means predicted for Great Western Road (2005) was 119.77 $\mu g\ m^{-3}$, suggesting that there is unlikely to be an exceedence of the 1-hour mean objective for NO_2 in the Great Western Road area.

Bridge Street/ Norfolk Street

Bridge Street/ Norfolk Street is a busy junction located directly to the south of Glasgow City Centre, just outside the current AQMA for NO_2. The decision to model this location was prompted by the diffusion tube results from 2002; these indicated that the site was potentially failing the NAQS annual mean objective for NO_2. Results from the air-dispersion modelling conducted for Bridge Street/ Norfolk Street 2005 are presented within Appendix 1 and are summarised in Table 5.14

Table 5.14 Predicted concentrations of NO_2 at various locations at Bridge Street/ Norfolk Street (2005)

Receptor name	X(m)	Y(m)	Predicted Annual mean [NO_2] ($\mu g\ m^{-3}$)
Max [NO_2]			41.67
Bridge St./ Norfolk St. DT	258702	664480	39.43
Oxford Street DT	258731	664590	34.79
Coburg Street DT	258760	664473	37.23
Location 1	258727	664478	39.52
Location 2	258735	664572	37.25

DT: Diffusion Tube

The results from air-dispersion modelling at Bridge Street/ Norfolk Street 2005, predicted a maximum annual mean NO_2 concentration of 41.67 $\mu g\ m^{-3}$ on the road at the junction of Bridge

Street/ Norfolk Street. Modelled annual mean concentrations of NO_2 at locations relevant for human exposure within the vicinity of Bridge Street/ Norfolk Street are predicted to range from 37.01 to 40.51μg m^{-3}. Thus, the modelled results indicate a potential exceedence of the NAQS annual mean objective for NO_2 at Bridge Street/ Norfolk Street.

The maximum 99.79th percentile of hourly means predicted for Bridge Street/ Norfolk Street (2005) was 122.13 μg m^{-3}, suggesting that there is unlikely to be an exceedence of the 1-hour mean objective for NO_2 in the area.

Glasgow 1/ North Street

Glasgow 1 (the Groundhog) and North Street represent air quality monitoring locations on the western edge of the City Centre, next to the M8 motorway, just outside the current AQMA for NO_2. The decision to model these locations was prompted by their proximity to the M8 and the monitoring results from North Street (2002) which indicated that the area was potentially failing the NAQS annual mean objective for NO_2. Results from the air-dispersion modelling conducted for Glasgow 1/ North Street 2005 are presented within Appendix 1 and are summarised in Table 5.15

Table 5.15 Predicted concentrations of NO_2 at various locations at Glasgow 1/ North Street

Receptor name	X(m)	Y(m)	Predicted Annual mean [NO_2] (μg m^{-3})
Max [NO_2]			63.98
Glasgow 1	257943	665504	39.93
North Street DT	257971	665654	47.91
Location 1	257975	665521	43.22

DT: Diffusion Tube

The results from air-dispersion modelling at Glasgow 1/ North Street 2005, predicted a maximum annual mean NO_2 concentration of 63.98 μg m^{-3} on the M8 motorway, adjacent to the Glasgow 1 and North Street monitoring locations. There are relatively few locations relevant for human exposure (annual mean) within the modelled area. However, the residential property located at 257975, 665521 was predicted to have an annual mean NO_2 concentration of 43.22 μg m^{-3}, above the annual mean NAQS objective.

The maximum 99.79th percentile of hourly means predicted for Glasgow 1/ North Street (2005) was 147.20 μg m^{-3}, suggesting that there is unlikely to be an exceedence of the 1-hour mean objective for NO_2 in the area.

Dumbarton Road at Partick

Dumbarton Road is a busy road located to the west of Glasgow City Centre, outside the current AQMA for NO_2 and has junctions with Byres Road, Hyndland Street and Crow Road. Results from the air-dispersion modelling conducted for Dumbarton Road 2005 are presented in the separate Appendices of modelled map outputs and summarised in Table 5.16

Table 5.16 Predicted concentrations of NO_2 at various locations at Dumbarton Road (2005)

Receptor name	X(m)	Y(m)	Predicted Annual mean [NO_2] ($\mu g\ m^{-3}$)
Max [NO_2]			46.36
Location 1	256184	666561	36.25
Location 2	255662	666581	36.71
Location 3	255598	666581	39.94
Location 4	255202	666606	34.89

The results from air-dispersion modelling at Dumbarton Road 2005, predicted a maximum annual mean NO_2 concentration of 43.89 to 46.36 $\mu g\ m^{-3}$ at various busy junctions on the road. The main locations where elevated concentrations of NO_2 were predicted by the model were the junctions of Dumbarton Road with Byres Road, Hyndland Street and Crow Road.

Examination of the contour plots reveals that the highest concentrations of NO_2 are predicted to occur on the road at the junctions. In general, predicted annual mean concentrations of NO_2 at relevant locations along Dumbarton Road were found to decline with distance from the junctions. Annual mean concentrations at locations relevant to human exposure in close proximity to the junctions are predicted to range from 34.03 to 43.89 $\mu g\ m^{-3}$, whilst concentrations at locations further away from busy junctions were predicted to range 34.03 to 38.96 $\mu g\ m^{-3}$.

The maximum 99.79th percentile of hourly means predicted for Dumbarton Road (2005) was 118.59 $\mu g\ m^{-3}$. This result indicates that there is unlikely to be an exceedence of the 1-hour mean objective for NO_2 at Dumbarton Road (2005).

Parkhead Cross

Parkhead Cross is a busy junction representing the point of convergence of Gallowgate, Westmuir Street, Tollcross Road, Springfield Road and Duke Street. It is located to the south west of Glasgow City Centre, outside the current AQMA for NO_2. Results from the air-dispersion modelling conducted for Parkhead Cross 2005 are presented in the separate Appendices of modelled map outputs and summarised in Table 5.17

Table 5.17 Predicted concentrations of NO_2 at various locations at Parkhead Cross (2005)

Receptor name	X(m)	Y(m)	Predicted Annual mean [NO_2] ($\mu g\ m^{-3}$)
Max [NO_2]			46.65
Westmuir St. DT	262559	664181	39.87
Location 1	262530	664177	41.78
Location 2	262611	664208	38.59

DT: Diffusion Tube

The results from air-dispersion modelling at Parkhead Cross 2005, predicted a maximum annual mean NO_2 concentration of 46.65 $\mu g\ m^{-3}$ in the middle of the junction. Annual mean NO_2 concentrations at locations relevant to human exposure in close proximity to the junction are predicted to range from 37.27 to 42.90 $\mu g\ m^{-3}$. Thus, from the model results it is predicted that the NAQS annual mean objective is likely to be exceeded at Parkhead Cross.

The maximum 99.79th percentile of hourly means predicted for Parkhead Cross (2005) was 124.41 $\mu g\ m^{-3}$, thus indicating that there is unlikely to be an exceedence of the 1-hour mean objective for NO_2 at this location (2005).

Calder Street/ Aikenhead Road

Calder Street/ Aikenhead Road is a busy junction located to the south east of Glasgow City Centre, outside the current AQMA for NO_2. Results from the air-dispersion modelling conducted for Calder Street/ Aikenhead Road 2005 are presented in the separate Appendices of modelled map outputs and summarised in Table 5.18

Table 5.18 Predicted concentrations of NO_2 at various locations at Calder Street/ Aikenhead Road (2005)

Receptor name	X(m)	Y(m)	Predicted Annual mean [NO_2] ($\mu g\ m^{-3}$)
Max [NO_2]			42.53
Location 1	259224	662579	36.91
Location 2	259201	662543	35.27
Location 3	259239	662540	38.43

The results from air-dispersion modelling at Calder Street/ Aikenhead Road 2005, predicted a maximum annual mean NO_2 concentration of 42.53 $\mu g\ m^{-3}$ in the middle of the junction. Annual mean NO_2 concentrations at locations relevant to human exposure in close proximity to the junction are predicted to range from 34.79 to 38.66 $\mu g\ m^{-3}$. Thus, from the model results it is predicted that the NAQS annual mean objective is unlikely to be exceeded at the junction of Calder Street with Aikenhead Road.

The maximum 99.79th percentile of hourly means predicted for Calder Street/ Aikenhead Road (2005) was 122.38 $\mu g\ m^{-3}$, thus indicating that there is unlikely to be an exceedence of the 1-hour mean objective for NO_2 at this location (2005).

5.3 NO_2 Modelling Summary

In summary, the results from the air-dispersion modelling of NO_2 at busy roads and junctions outwith Glasgow City Centre predicted that the NAQS annual mean objective for NO_2 is likely to be exceeded at several locations in 2005. Exceedences of the annual mean objective at locations relevant to human exposure are predicted at Royston Road, Byres Road, Bridge Street/ Norfolk Street, North Street/ Glasgow 1, Dumbarton Road and Parkhead Cross. All other locations modelled for NO_2 are predicted to meet the NAQS annual mean objective for 2005.
No exceedences of the 1 hour objective for NO_2 were predicted at any of the locations modelled for 2005.

5.4 New/ Proposed Roads

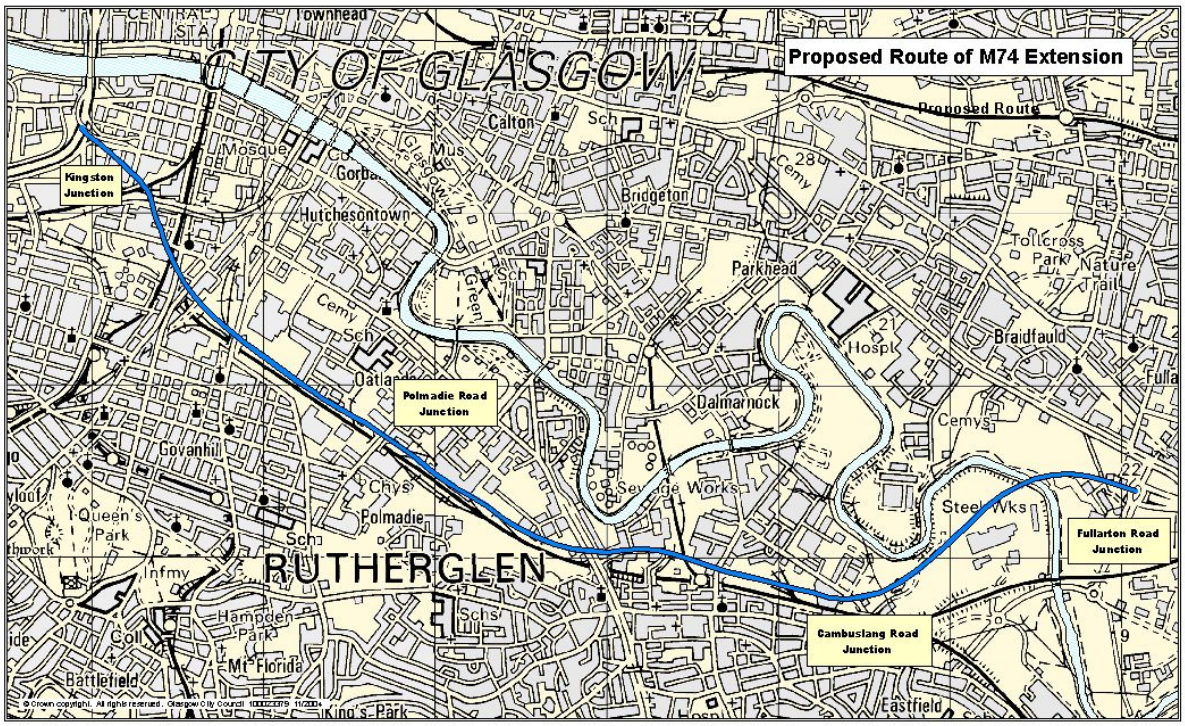
Glasgow City Council's Updating and Screening Assessment 2003 outlined the need to assess the impact of new or proposed roads on local air quality. In relation to this it was concluded that a detailed assessment was required regarding the proposed M74 extension.

The existing M74 terminates at Fullarton Road in the south east of Glasgow, with a 'missing link' between here and the Kingston Bridge. Work is currently still in development, however, it is planned to complete the 5 mile link from the Fullarton Road Junction to the M8 just west of the Kingston Bridge, and have this section of road open to traffic by 2008. Obviously, such a major road may have implications for local air quality. The proposed line of the route is shown in Figure 5.1.

The proposals require an environmental impact assessment (EIA) under the provisions of Section 20A of the Roads (Scotland) Act 1984 as amended by Part III of the Environmental Impact Assessment (Scotland) Regulations 1999.

Environmental Resources Management Ltd (ERM) have conducted an environmental impact assessment and prepared an Environmental Statement (ES) on behalf of Glasgow City Council to inform the public, the Scottish Ministers and organizations with statutory and non-statutory interests in the environment of the likely environmental effects of the works. The findings of the assessment, including the measures that will be taken to avoid, reduce or remedy adverse impacts are reported in the ES.

Figure 5.1 Proposed Route of M74 Extension



In terms of the predicted impact on NO_2 concentrations in Glasgow, the ES concluded that although a long term overall improvement in air quality is predicted with some 96 % of residential properties in the wider study area expected to experience a reduction in NO_2 concentrations; detailed modelling identified some increases in NO_2 concentrations close to the road corridor which could potentially result in exceedences of the air quality objectives.

Subsequent discussions between the appointed agents Environmental Resources Management and the Scottish Executive resulted in the recommendation that additional information on air quality in the vicinity of the proposed route prior to, during, and after construction of the 27 scheme would be of benefit. This would allow an assessment of the impact of the road on background air quality.

Following further discussions between the appointed agents with representatives of Glasgow City Council (Land Services Design), the report *M74 Completion: Air Quality Proposed Monitoring Study (2002)* was prepared, and recommended the pollutants and locations to be monitored together with appropriate methodology. The study recommended monitoring of PM_{10} particulate matter twice every year (2 weeks during both summer and winter periods) by Glasgow City Council Environmental Protection Services at relevant sites near to the proposed M74 extension. In addition, Land Services are undertaking diffusion tube monitoring of NO_2 at 56 sites and benzene at 4 sites along the proposed route. Once the construction of the road is complete and it is open to traffic, monitoring results can be analysed to determine the impact of the road on local air quality.

5.5 NO_2 Conclusions

The results from the current study of air quality monitoring and air-dispersion modelling of NO_2 in Glasgow, indicate that numerous locations outwith the present AQMA are likely to fail the annual mean objective in 2005. Results from air dispersion modelling at busy roads/ junctions indicate that exceedences of the annual mean objective are likely to occur at Royston Road, Byres Road, Bridge Street/ Norfolk Street, North Street/ Glasgow 1, Dumbarton Road and Parkhead Cross.

In comparison, the results from NO_2 diffusion tubes located at Royston Road (2004) reported annual mean concentrations ranging from 39-45 μg m^{-3}, supporting the findings of the model at this location. Similarly, results from NO_2 diffusion tubes located at Byres Road (42 μg m^{-3}), North Street (43 μg m^{-3}) and Westmuir Street (Parkhead Cross) (50 μg m^{-3}) also support the findings of the model in that these locations are likely to fail the annual mean objective for NO_2 in 2005. In contrast, the results from the NO_2 diffusion tube located at Bridge Street/ Norfolk Street from 2004 do not agree with the results of the model. In 2004, the diffusion tube located at Bridge Street/ Norfolk Street recorded an annual mean concentration of 36 μg m^{-3}. As this site represents a kerbside location, this result indicates that the NAQS annual mean objective for NO_2 is unlikely to be exceeded at Bridge Street/ Norfolk Street in 2005.

In addition, monitoring results from the NO_2 diffusion tube located at Napiershall Street in 2004 recorded an annual mean concentration of 54 μg m^{-3}. This tube was only introduced at the end of 2003 and indicates that this location is likely to fail the annual mean objective for NO_2 in 2005 and thus requires further assessment.

Furthermore, this study has recognised that there are gaps in Glasgow City Council's diffusion tube network including areas around Paisley Road and Great Western Road, whilst a high number of tubes are located at Kerbside and Roadside locations and are thus not representative of human exposure. Consequently, it is recommended that where possible, Glasgow's current NO_2 diffusion tube network is extended to those areas where gaps have been identified and that some reassessment of diffusion tube locations is conducted.

In relation to potential exceedences of the NAQS objectives from the proposed M74 extension and industrial sites within Glasgow, it is concluded that further monitoring and assessment is required in the vicinity of these sites before conclusions can be drawn.

6.0 PM_{10}

Glasgow City Council's Updating and Screening Assessment (2003) identified that potential exceedences of the National Air Quality Strategy Objectives for PM_{10} (2010) were likely to occur at numerous busy roads and junctions across the city. Thus, the report concluded that concentrations of PM_{10} should be assessed at the busy roads/ junctions listed in Table 5.1 and at monitoring locations where elevated concentrations of PM_{10} had been recorded.

A list of the locations where detailed assessments of PM_{10} were required is presented in Table 5.1 together with the predicted background concentrations of PM_{10} for each site for 2005 and 2010.

Table 6.1 Glasgow locations assessed for exceedences of the NAQS Objectives for PM_{10} together with predicted background concentrations for 2005 and 2010

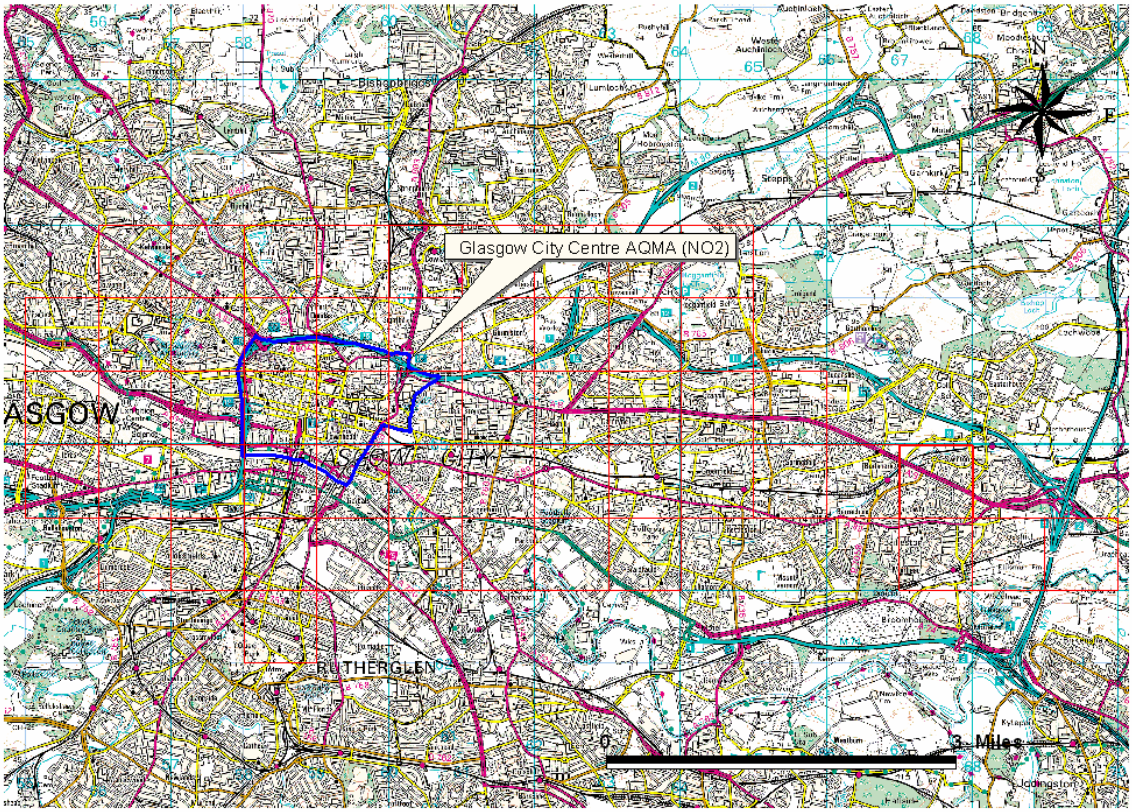
Category	Location	Background [PM_{10}] ($\mu g\ m^{-3}$)	
		2005	2010
Monitoring locations	Glasgow Kerbside (Hope Street)	19.5	17.9
	Glasgow Centre (St Enoch Sq.)	19.5	17.9
	Glasgow 1 (Anderston)	19.5	17.9
	Glasgow 2 (Byres Road)	18.8	17.3
Busy Roads/ Junctions	Paisley Road	18.1	16.7
	Calder Street/ Aikenhead Road	18.4	17.1
	Bridgeton Cross	19.1	17.7
	Battlefield	17.7	16.5
	Victoria Infirmary	17.7	16.5
	Pollokshaws Road/ Minard Road	18.2	16.8
	Crow Road	17.4	16.1
	Victoria Park Drive South at Whiteinch	17.8	16.5
	Dumbarton Road at Partick	18.4	16.9
	Shieldhall Rd at Cardonald	17.4	16.2
	Maryhill Road at Kelvindale	17.5	16.2
	Union St	19.5	17.9
	Cathedral Street	19.6	18.0
	M8 Charing Cross	19.2	17.9
	Argyle Street	19.8	18.2
	Renfield Street	19.5	17.9
	M8 at Scotland Street	18.5	17.1
	Balshagray Avenue	17.4	16.1
	Parkhead Cross	18.2	16.9

Furthermore, Glasgow City Council's Updating and Screening Assessment (2003) recommended that further assessments of PM_{10} concentrations in relation to the proposed M74 extension and existing industrial sources in Glasgow are conducted in future assessments.

In 2005 new NAQS objectives for PM_{10} came into force in Scotland. These new objectives saw the annual mean objective reduced from 40 μg m^{-3} to 18 g $μm^{-3}$, and a reduction in the number of permitted exceedences of the 24-hour mean objective (50 μg m^{-3}) from 35 to 7.

As demonstrated in Figure 6.1, examination of the predicted background concentrations of PM_{10} across Glasgow for 2005, suggests that most of the city is currently failing the NAQS annual mean objective.

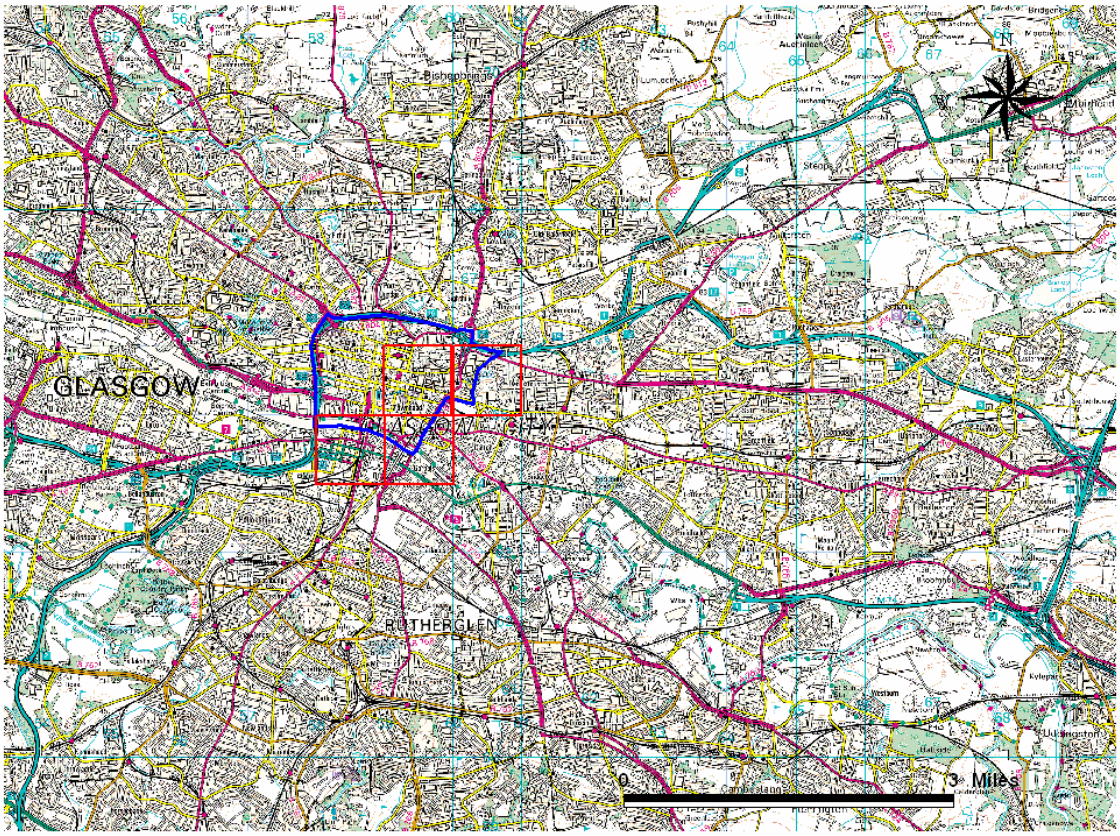
Figure 6.1. Areas of Glasgow (2005) where the annual mean background concentration of PM_{10} is predicted to exceed 18 μg m^{-3}.



□ - 1 km grid square where annual mean concentration of PM_{10} is predicted to be ≥ 18 μg m^{-3}

By 2010 background concentrations of PM_{10} are predicted to decline to the extent that a much smaller area of Glasgow is predicted to fail the basis of background concentrations. Areas of Glasgow where the background concentration of PM_{10} is predicted to exceed the NAQS annual mean objective of 18 μg m^{-3} are presented in Figure 6.2. However, in addition to the areas where background annual mean concentrations of PM_{10} are predicted to be ≥ 18 μg m^{-3}, background concentrations in many other areas of the City are predicted to be only slightly under 18 μg m^{-3}.

Figure 6.2. Areas of Glasgow (2010) where the annual mean background concentration of PM_{10} is predicted to exceed 18 μg m^{-3}.



□ - 1 km grid square where annual mean concentration of PM_{10} is predicted to be ≥ 18 μg m^{-3}

6.1 PM_{10} Monitoring Data

At present data from monitoring of ambient concentrations of PM_{10} in Glasgow are available from two sites, (1) Glasgow Kerbside and (2) Glasgow Centre which constitute part of the Automatic Urban and Rural Network. Both of these sites are discussed in section 3.2.1 and results from PM_{10} monitoring in recent years presented in Tables 6.2 and 6.3. Projected annual mean concentrations of PM_{10} for Glasgow Kerbside and Glasgow Centre for 2010 are presented in Table 6.4.

Table 6.2 Results of monitoring for PM_{10} at Glasgow Kerbside

Year	Data capture (%)	Annual mean PM_{10} ($\mu g/m^3$)	Maximum 24-hour mean ($\mu g/m^3$)	No. of days >50$\mu g/m^3$
1997	72	40	125	80
1998	97	35	147	68
1999	97	27	105	44
2000	97	27	75	23
2001	98	31	147	36
2002	96	30	132	42
2003	93	32	146	53
2004	95	27	71	35

All values of [PM_{10}] are presented as gravimetric equivalent concentrations
Values presented in red indicate exceedences of NAQS objectives

Table 6.3 Results of monitoring for PM_{10} at Glasgow Centre (Gravimetric concentrations)

Year	Data capture (%)	Annual mean PM_{10} ($\mu g/m^3$)	Maximum 24-hour mean ($\mu g/m^3$)	No. of days >50$\mu g/m^3$
1997	95	27	113	19
1998	98	26	70	11
1999	98	23	87	9
2000	97	28	111	27
2001	99	22	130	12
2002	97	20	114	8
2003	96	21	68	13
2004	67	19	50	0

All values of [PM_{10}] are presented as gravimetric equivalent concentrations
Values presented in red indicate exceedences of NAQS objectives

Table 6.4 Estimated PM_{10} Annual Mean Concentrations (Gravimetric concentrations)

Location	Estimated 2010 PM_{10} annual mean concentration ($\mu g/m^3$)				
	Base year 2000	Base year 2001	Base year 2002	Base year 2003	Base year 2004
Glasgow Centre	25	20	19	20	18
Glasgow Kerbside	24	27	27	28	25

All values of [PM_{10}] are presented as gravimetric equivalent concentrations
Values presented in red indicate exceedences of NAQS objectives

6.1.1 PM_{10} Monitoring Summary

In summary, the results from the air quality monitoring of PM_{10} in Glasgow indicated that the NAQS annual mean objective for PM_{10} was exceeded at both Glasgow Kerbside and Glasgow Centre in 2004 and is also likely to be exceeded at both in 2010. In addition, the monitoring results from 2004 indicated that the 24-hour mean objective for PM_{10} was also exceeded at Glasgow Kerbside, with daily mean concentrations in excess of 50 μg m^{-3} being recorded on 35 occasions.

6.2 Air Dispersion Modelling – Road Traffic Emissions

Glasgow City Council's Updating and Screening Assessment (2003) identified numerous monitoring locations and busy streets/ junctions within Glasgow where there was a potential for exceedence of the NAQS objectives for PM_{10}. Due to the very high background concentrations of PM_{10} predicted at Argyle Street, Union Street, Renfield Street, Glasgow Centre, Glasgow Kerbside and Charing Cross for 2005 and 2010, dispersion modelling was not conducted at these locations, as it was assumed that these locations will fail the objective. Annual and 24-hour mean concentrations of PM_{10} at all other locations listed in Table 6.1 were predicted for 2005 and 2010 using the air-dispersion modelling tools and data outlined in Section 4.2.

The following sections outline the results of these modelling studies and summarise the predicted maximum annual mean concentrations identified at each site and annual mean concentrations predicted at locations relevant for human exposure for 2010. In addition, the maximum 98.08th percentile of 24-hour mean PM_{10} concentration predicted at each location for 2010 is also compared with the objective.

Byres Road

Byres Road is a busy thoroughfare in the west end of the City, and connects Dumbarton Road with Great Western Road. Results from the air-dispersion modelling conducted for Byres Road 2005 and 2010 are presented within Appendixes 2 and 3 respectively. Table 6.2 summarises the predicted maximum annual mean PM_{10} concentrations identified at Byres Road and annual mean concentrations predicted at locations relevant for human exposure for 2010.

Table 6.2 Predicted concentrations of PM_{10} at various locations at Byres Road (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] (μg m^{-3})
Max [PM_{10}]			18.17
Location 1	256532	666940	17.59
Location 2	256511	666953	17.64
Location 3	256373	666757	17.56

Results from the PM_{10} modelling study of Byres Road 2005, predict that the entire area surrounding Byres Road will fail to meet the new annual mean objective, which is to be achieved by 2010. Annual mean concentrations of PM_{10} in the vicinity of the road are predicted to range from 18.75 to 20.03 μg m^{-3}.

In comparison, the results from the modelling of PM_{10} concentrations at Byres Road for 2010, predicted lower annual mean concentrations, with elevated concentrations (17.92–18.17 μg m^{-3}) largely restricted to the junctions of Byres Road with Dumbarton Road, University Avenue and Great Western Road. Annual mean concentrations at locations along Byres Road relevant to human exposure are predicted to be lower, ranging from 17.42–17.92 μg m^{-3}.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at Byres Road for 2010 was 37.08 μg m^{-3}, indicating that it is unlikely that the 24-hour objective for PM_{10} will be exceeded at Byres Road in 2010.

Glasgow 1 (St Patrick's Primary School)

Glasgow 1 ('the Groundhog') is one of Glasgow City Council's automatic air quality monitoring units. It is located in the grounds of St Patrick's Primary School on the western edge of the City Centre, next to the M8 motorway and just outside the current AQMA for NO_2. The decision to model this location was prompted by the monitoring results from 2001 which indicated that the area was potentially failing the NAQS annual mean objective for PM_{10}. Results from the air-dispersion modelling of PM_{10} conducted for Glasgow 1are presented in the separate Appendices of modelled map outputs and are summarised in Table 6.3.

Table 6.3 Predicted concentrations of PM_{10} at various locations at Glasgow 1(2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] (μg m^{-3})
Max [PM_{10}]			21.11
Glasgow 1	257943	665504	18.06
Location 1	257975	665521	18.59

Results from the PM_{10} modelling study of Glasgow 1 (2005), predict that the area around St Patrick's primary school will fail to meet the new annual mean objective, which is to be achieved by 2010.

In comparison, the results from the modelling of PM_{10} concentrations at Glasgow 1 for 2010, predicted maximum annual mean concentrations of PM_{10} in the range 19.73–21.11 μg m^{-3}, which were largely restricted to the area covered by the M8 motorway. Annual mean PM_{10} concentrations at commercial, educational and residential locations within the area were predicted to fall within the range 17.90–19.28 μg m^{-3}. There are relatively few locations within the area which are relevant to the annual mean objective for PM_{10}. However, relevant locations such the site at 257975 665521 are likely to fail the objective.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at Glasgow 1for 2010 was 44.58 μg m^{-3}, indicating that the 24-hour objective for PM_{10} is unlikely to be exceeded at this location.

Crow Road

Crow Road is a busy road located in the west of the City, and connects with Dumbarton Road and Balshagray Avenue. Results from the air-dispersion modelling conducted for Crow Road in 2005 and 2010 are presented in the separate Appendices of modelled map outputs. Table 6.4

summarises the predicted maximum annual mean PM_{10} concentrations identified at Crow Road and annual mean concentrations predicted at locations relevant for human exposure in 2010.

Table 6.4 Predicted concentrations of PM_{10} at various locations at Crow Road (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] ($\mu g\ m^{-3}$)
Max [PM_{10}]			18.43
Location 1	255395	666623	17.03
Location 2	255357	666757	16.48
Location 3	255063	667122	16.64
Location 4	254836	667339	16.48

The results from the modelling of PM_{10} concentrations at Crow Road for 2005 predicted that numerous properties in close proximity to Crow Road are likely to fail new annual mean objective, which is to be achieved by 2010. Annual mean concentrations for 2005 are predicted to range from 17.77 to 18.60 $\mu g\ m^{-3}$ at most properties close to the road. Higher concentrations are predicted to occur at busy junctions such as the junction with Dumbarton Road.

In comparison, the results from the modelling of PM_{10} concentrations at Crow Road 2010, predict that elevated annual mean concentrations of PM_{10} close to the annual mean objective (17.43-18.43 $\mu g\ m^{-3}$) will be largely restricted to the junctions of Crow Road with Dumbarton Road and Thornwood Avenue. Consequently, a limited number of properties in close proximity to these junctions are predicted to exceed the annual mean objective for PM_{10} in 2010. Annual mean PM_{10} concentrations at all other properties along Crow road are predicted to be equal or lower than 17.43 $\mu g\ m^{-3}$, thus achieving the annual mean objective.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at Crow Road for 2010 was 37.61 $\mu g\ m^{-3}$, indicating that it is unlikely that the 24-hour objective for PM_{10} will be exceeded at this location.

Balshagray Avenue

Balshagray Avenue is a busy road located in the west of the Glasgow, and connects with Crow Road and Victoria Park Drive South. Results from the air-dispersion modelling conducted for Balshagray Avenue in 2005 and 2010 are presented in the separate Appendices of modelled map outputs. Table 6.5 summarises the predicted maximum annual mean PM_{10} concentrations identified at Balshagray Avenue and annual mean concentrations predicted at locations relevant for human exposure in 2010.

Table 6.5 Predicted concentrations of PM_{10} at various locations at Balshagray Avenue (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] ($\mu g\ m^{-3}$)
Max [PM_{10}]			17.76
Location 1	254570	667667	16.68
Location 2	254537	667499	16.51
Location 3	254529	667442	16.72

The results from the modelling of PM_{10} concentrations at Balshagray Avenue for 2005 are presented within Appendix 2. These predicted that in 2005, most properties in close proximity to

the road are likely to fail the new annual mean objective of 18 μg m^{-3} (to be achieved by 2010), with concentrations ranging from 17.77 to 18.87 μg m^{-3}.

In contrast, the results from the modelling of PM_{10} concentrations at Balshagray Avenue 2010, predict a maximum annual mean PM_{10} concentration of 17.76 μg m^{-3} to occur on the road itself. Annual mean PM_{10} concentrations at residential properties in the vicinity are predicted to range from 16.43–17.43 μg m^{-3}, thus achieving the annual mean objective.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at Balshagray Avenue for 2010 was 36.84 μg m^{-3}, indicating that the 24-hour objective for PM_{10} is unlikely to be exceeded at this location.

Maryhill Road

Maryhill Road is a busy road located to the north west of the Glasgow City Centre, outside Glasgow's current AQMA for NO_2. Results from the air-dispersion modelling of PM_{10} conducted for Maryhill Road in 2005 and 2010 are presented in the separate Appendices of modelled map outputs. Table 6.6 summarises the predicted maximum annual mean PM_{10} concentrations identified in the modelled area and annual mean concentrations predicted at locations relevant for human exposure in 2010.

Table 6.6 Predicted concentrations of PM_{10} at various locations at Maryhill Road (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] (μg m^{-3})
Max [PM_{10}]			17.14
Location 1	256960	668679	16.46
Location 2	257077	668499	16.51
Location 3	257240	668260	16.38
Location 4	257442	668065	16.79

The results from the modelling of PM_{10} concentrations at Maryhill Road for 2005 are presented within Appendix 2. These indicated that in 2005, numerous properties in close proximity to Maryhill Road are likely to fail the new annual mean objective of 18 μg m^{-3} (to be achieved by 2010), with concentrations ranging from 17.70 to 18.48 μg m^{-3}.

However, the results from the modelling of PM_{10} concentrations at Maryhill Road 2010, predict a maximum annual mean PM_{10} concentration of 17.14 μg m^{-3} to occur on the road itself, with the highest concentrations occurring in close proximity to junctions. Annual mean PM_{10} concentrations at locations relevant to human exposure in the vicinity are predicted to range from 16.33–16.87 μg m^{-3}, thus achieving the annual mean objective.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at Maryhill Road for 2010 was 35.52 μg m^{-3}, indicating that it is unlikely that the 24-hour objective for PM_{10} will be exceeded at this location.

Battlefield

The Battlefield area is located to the south of Glasgow City Centre and incorporates numerous busy roads including Langside Avenue and Battlefield Road. This site is of particular interest as

the Victoria Infirmary is located within the area being modelled. Results from the air-dispersion modelling conducted for Battlefield in 2005 and 2010 are presented in the separate Appendices of modelled map outputs. Table 6.7 summarises the predicted maximum annual mean PM_{10} concentrations identified in the modelled area and annual mean concentrations predicted at locations relevant for human exposure in 2010.

Table 6.7 Predicted concentrations of PM_{10} at various locations at Battlefield (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] ($\mu g\ m^{-3}$)
Max [PM_{10}]			17.20
Location 1	257715	661784	16.65
Location 2	257963	661709	16.64
Location 3	258118	661624	16.77
Location 4	258170	661585	16.82

The results from modelling PM_{10} concentrations at Battlefield in 2005 are presented within Appendix 2. These results predicted that in 2005, numerous properties in close proximity to the roundabout at Langside Avenue/ Battlefield road and the junction of Battlefield with Grange Road and Prospecthill Road are likely fail the annual mean objective, which is to be achieved by 2010.

However, the results from the modelling of PM_{10} concentrations at Battlefield in 2010, predicted a maximum annual mean PM_{10} concentration of $17.20\ \mu g\ m^{-3}$ to occur on the Langside Avenue/ Battlefield road roundabout. Annual mean PM_{10} concentrations at locations relevant to human exposure in the vicinity are predicted to range from 16.60-16.90 $\mu g\ m^{-3}$, thus achieving the annual mean objective. Annual mean PM_{10} concentrations for the Victoria Infirmary (2010) are predicted to range from 16.60-16.80 $\mu g\ m^{-3}$ in 2010.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at Battlefield for 2010 was 35.01 $\mu g\ m^{-3}$, indicating that the 24-hour objective for PM_{10} is unlikely to be exceeded at this location.

Victoria Park Drive South

Victoria Park Drive South is a busy road which is located to the north west of the Glasgow City Centre. Results from the air-dispersion modelling conducted for Victoria Park Drive South in 2005 and 2010 are presented in the separate Appendices of modelled map outputs. Table 6.8 summarises the predicted maximum annual mean PM_{10} concentrations identified in the modelled area and annual mean concentrations predicted at locations relevant for human exposure in 2010.

Table 6.8 Predicted concentrations of PM_{10} at various locations at Victoria Park Drive South (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] ($\mu g\ m^{-3}$)
Max [PM_{10}]			16.96
Location 1	253647	667280	16.61
Location 2	253773	667215	16.58
Location 3	254149	667036	16.59
Location 4	254293	666984	16.54

Results from the modelling of PM_{10} concentrations at Victoria Park Drive South in 2005, suggested that a few properties in Victoria Park Drive South, close to the junction with Victoria Park Drive North are likely to fail annual mean objective for PM_{10} in this year.

However, by 2010, the year by which the objective is to be achieved, the results from the modelling of PM_{10} concentrations at Victoria Park Drive South, predict maximum annual mean concentrations ranging from 16.90-16.96 $\mu g\ m^{-3}$ to occur on the road itself. Concentrations at locations relevant to human exposure were predicted to range from 16.57-16.76 $\mu g\ m^{-3}$. Thus, from the modelling results, it is considered unlikely that the annual mean objective for PM_{10} will be exceeded at Victoria Park Drive South in 2010.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at Victoria Park Drive South for 2010 is 34.29 $\mu g\ m^{-3}$, indicating that it is unlikely that the 24-hour objective for PM_{10} will be exceeded at this location.

Pollokshaws Road/ Minard Road

Pollokshaws Road/ Minard Road is a busy junction located to the south of Glasgow City Centre. Results from the air-dispersion modelling conducted for the Pollokshaws Road/ Minard Road junction in 2005 and 2010 are presented in the separate Appendices of modelled map outputs. Table 6.9 summarises the predicted maximum annual mean PM_{10} concentrations identified in the modelled area and annual mean concentrations predicted at locations relevant for human exposure in 2010.

Table 6.9 Predicted concentrations of PM_{10} at various locations at Pollokshaws Road/ Minard Road (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] ($\mu g\ m^{-3}$)
Max [PM_{10}]			17.51
Location 1	257367	662182	17.28
Location 2	257332	662181	17.07
Location 3	257339	662130	17.02

The results from the modelling of PM_{10} concentrations at the junction of Pollokshaws Road/ Minard Road in 2005 are presented within Appendix 2. These results suggested that that the area surrounding the junction is unlikely to meet the new annual mean objective for PM_{10} in 2005. However, the new objectives for PM_{10} target attainment by 2010. The results from the modelling of PM_{10} concentrations at the junction of Pollokshaws Road with Minard Road for 2010 are summarised in Table 6.9 and the paragraph below.

In contrast to the model findings for 2005, the results from the modelling of PM_{10} concentrations at the junction of Pollokshaws Road with Minard Road in 2010, predicted a maximum annual mean PM_{10} concentration of 17.51 $\mu g\ m^{-3}$ to occur at the centre of the junction. Concentrations at locations relevant to human exposure are predicted to range from 16.90–17.31 $\mu g\ m^{-3}$. Thus, the modelling results suggested that the annual mean objective for PM_{10} is unlikely be exceeded at the Pollokshaws Road/ Minard Road junction in 2010.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at Pollokshaws Road/ Minard Road junction for 2010 is 35.61 $\mu g\ m^{-3}$, indicating that it is unlikely that the 24-hour objective for PM_{10} will be exceeded at this location.

Bridgeton Cross

Bridgeton Cross is a busy junction located to the south east of Glasgow City Centre and incorporates sections of London Road, Dalmarnock Road, Main Street and James Street. The outputs from the air-dispersion modelling conducted for this junction in 2005 and 2010 are presented in the separate Appendices of modelled map outputs respectively. Table 6.10 summarises the predicted maximum annual mean PM_{10} concentrations identified in the modelled area and annual mean concentrations predicted at locations relevant for human exposure in 2010.

Table 6.10 Predicted concentrations of PM_{10} at various locations at Bridgeton Cross (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] ($\mu g\ m^{-3}$)
Max [PM_{10}]			18.25
Location 1	260665	664025	17.95
Location 2	260661	663958	18.03
Location 3	260720	663954	18.11

The results from the modelling of PM_{10} concentrations at the Bridgeton Cross junction in 2005 are presented within Appendix 2. The findings of the modelling study suggested that due to high background concentrations the area surrounding the junction is unlikely to meet the new annual mean objective in 2005. However, the new objectives for PM_{10} target attainment by 2010. The results from the modelling of PM_{10} concentrations at the Bridgeton Cross junction for 2010 are summarised in Table 6.10 and in the following paragraph.

The results of modelling the PM_{10} concentrations at Bridgeton Cross for 2010 indicated that although background concentrations of PM_{10} are likely to be significantly lower than in 2005, the annual mean objective is likely to be exceeded at numerous relevant locations around the junction. The maximum annual mean PM_{10} concentration predicted to occur at Bridgeton Cross in 2010 is 18.25$\mu g\ m^{-3}$, with concentrations in relevant locations predicted to range from 17.79-18.17 $\mu g\ m^{-3}$. Thus, the modelling results suggest that the annual mean objective for PM_{10} is likely to be exceeded at Bridgeton Cross in 2010.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at Bridgeton Cross in 2010 is 36.93 $\mu g\ m^{-3}$, indicating that it is unlikely that the 24-hour objective for PM_{10} will be exceeded at this location.

Calder Street/ Aikenhead Road

Calder Street/ Aikenhead Road is a busy junction located to the south east of Glasgow City Centre. Results from the air-dispersion modelling conducted for the Calder Street/ Aikenhead Road junction in 2005 and 2010 are presented in the separate Appendices of modelled map outputs. Table 6.11 summarises the predicted maximum annual mean PM_{10} concentrations identified in the modelled area and annual mean concentrations predicted at locations relevant for human exposure in 2010.

Table 6.11 Predicted concentrations of PM_{10} at various locations at Calder Street/ Aikenhead Road (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] ($\mu g\ m^{-3}$)
Max [PM_{10}]			17.84
Location 1	259230	662584	17.37
Location 2	259238	662541	17.42
Location 3	259197	662552	17.23

The results from the modelling of annual mean concentrations of PM_{10} at the junction of Calder Street with Aikenhead Road for 2005 are presented within Appendix 2. These results predicted that due to the relatively high background concentrations of PM_{10} expected to prevail in 2005, the area surrounding the junction of Calder Street with Aikenhead Road is unlikely to meet the new annual mean objective. However, the new objectives for PM_{10} target attainment by 2010. The results from the modelling of PM_{10} concentrations at the junction of Calder Street with Aikenhead Road for 2010 are summarised in Table 6.11 and the following paragraph.

The results from the modelling of PM_{10} concentrations at the Pollokshaws Road/ Minard Road junction in 2010 predicted a maximum annual mean PM_{10} concentration of 17.84 $\mu g\ m^{-3}$ to occur at the centre of the junction. Concentrations at locations relevant to human exposure are predicted to range from 17.21-17.63 $\mu g\ m^{-3}$. Thus, the modelling results indicates that the annual mean objective for PM_{10} is unlikely be exceeded at this junction in 2010.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at the Calder Street/ Aikenhead Road junction for 2010 is 36.32 $\mu g\ m^{-3}$, indicating that it is unlikely that the 24-hour objective for PM_{10} will be exceeded at this location.

Parkhead Cross

Parkhead Cross is a busy junction located to the east of Glasgow City Centre and incorporates sections of Gallowgate, Westmuir Street, Duke Street, Springfield Road and Tollcross Road. The outputs from the air-dispersion modelling conducted for this junction in 2005 and 2010 are presented in the separate Appendices of modelled map outputs. Table 6.12 summarises the predicted maximum annual mean PM_{10} concentrations identified in the modelled area and annual mean concentrations predicted at locations relevant for human exposure in 2010.

Table 6.12 Predicted concentrations of PM_{10} at various locations at Parkhead Cross (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] ($\mu g\ m^{-3}$)
Max [PM_{10}]			18.06
Location 1	262529	664178	17.62
Location 2	262576	664182	17.28
Location 3	262501	664219	17.32

The results from the modelling of annual mean concentrations of PM_{10} at Parkhead Cross for 2005 are presented within Appendix 2. Due to the relatively high background concentrations of PM_{10} expected to prevail in 2005, these results from modelling predicted that the area surrounding Parkhead Cross is unlikely to meet the new annual mean objective. However, the new objectives for PM_{10} target attainment by 2010 and results for that year are summarised in Table 6.12 and the following paragraph.

Modelling of PM_{10} annual mean concentrations at Parkhead Cross for 2010, predicted a maximum annual mean PM_{10} concentration of 18.06 $\mu g\ m^{-3}$ at the centre of the junction. Concentrations at locations relevant to human exposure around the Parkhead Cross are predicted to range from 17.07–17.73 $\mu g\ m^{-3}$, suggesting that the annual mean objective for PM_{10} is unlikely be exceeded at this location in 2010.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at Parkhead Cross in 2010 is 36.32 $\mu g\ m^{-3}$. This result indicates that it is unlikely that the 24-hour objective for PM_{10} will be exceeded at this location in 2010.

Scotland Street/ M8 Motorway

The outputs from the air-dispersion modelling conducted for the M8 at Scotland Street in 2005 and 2010 are presented in the separate Appendices of modelled map outputs. Table 6.13 summarises the predicted maximum annual mean PM_{10} concentrations identified in the modelled area and annual mean concentrations predicted at locations relevant for human exposure in 2010.

Table 6.13 Predicted concentrations of PM_{10} at various locations at Scotland Street/ M8 Motorway (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] ($\mu g\ m^{-3}$)
Max [PM_{10}]			19.02
Location 1 (Station)	257639	664202	18.02
Location 2	257558	664166	17.48

The results from the modelling of PM_{10} concentrations at the M8/ Scotland Street for 2005 are presented within Appendix 2. Due to the relatively high background concentrations of PM_{10} expected to prevail in 2005, the modelling results predicted that the area surrounding Scotland Street/ M8 motorway is unlikely to meet the new annual mean objective. However, the new objectives for PM_{10} target attainment by 2010 and results for that year are summarised in Table 6.13 and the following paragraph.

The results from the modelling of PM_{10} concentrations around the M8 at Scotland Street for 2010, predicted a maximum annual mean PM_{10} concentration of 19.02 $\mu g\ m^{-3}$ on the motorway,

with concentrations at locations relevant to human exposure (annual mean) predicted to be lower than 17.65 μg m^{-3}. These results suggest that the annual mean objective for PM_{10} is unlikely be exceeded at this location in 2010.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at Parkhead Cross in 2010 is 39.30 μg m^{-3}, indicating that it is unlikely that the 24-hour objective for PM_{10} will be exceeded at this location in 2010.

Shieldhall Road

Shieldhall Road is a busy road located to the south west of Glasgow City Centre. The outputs from the air-dispersion modelling conducted at this location for 2005 and 2010 are presented in the separate Appendices of modelled map outputs. Table 6.14 summarises the predicted maximum annual mean PM_{10} concentrations identified in the modelled area and annual mean concentrations predicted at locations relevant for human exposure in 2010.

Table 6.14 Predicted concentrations of PM_{10} at various locations at Shieldhall Road (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] (μg m^{-3})
Max [PM_{10}]			16.76
Location 1	254721	664793	16.45
Location 2	254666	664774	16.33
Location 3	254211	664923	16.44

Results from the PM_{10} modelling study of Shieldhall Road for 2005, indicate that that the area surrounding the road is likely to meet the new annual mean objective set for 2010. The maximum annual mean PM_{10} concentration predicted for this location in 2005 is 18.31μg m^{-3} at the Shieldhall Road/ Helen Street roundabout, whilst concentrations at locations relevant to human exposure in are predicted to range from 17.53-17.92 μg m^{-3}.

Similarly, modelling of PM_{10} concentrations at Shieldhall Road in 2010, predicted a maximum annual mean concentration of 16.76 μg m^{-3} at the Shieldhall Road/ Helen Street roundabout. Annual mean concentrations of PM_{10} at locations relevant to human exposure along Shieldhall Road are predicted to range from 16.28-16.52 μg m^{-3}. These results suggest that the annual mean objective for PM_{10} is unlikely be exceeded at this location in 2010.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at Shieldhall Road in 2010 is 33.91 μg m^{-3}, thus indicating that it is unlikely that the 24-hour objective for PM_{10} will be exceeded at this location.

Dumbarton Road at Partick

Dumbarton Road is a busy road located to the west of Glasgow City Centre, outside the current AQMA for NO_2 which has junctions with Byres Road, Hyndland Street and Crow Road. Results from the air-dispersion modelling conducted for Dumbarton Road 2005 and 2010 are presented in the separate Appendices of modelled map outputs and summarised in Table 6.15.

Table 6.15 Predicted concentrations of PM_{10} at various locations at Dumbarton Road at Partick (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] ($\mu g\ m^{-3}$)
Max [PM_{10}]			18.21
Location 1	256184	666561	17.38
Location 2	255938	666595	17.49
Location 3	255482	666580	17.74

The results from the PM_{10} modelling study at Dumbarton Road 2005 are presented within Appendix 2. Due to the relatively high background concentrations of PM_{10} expected to prevail in 2005, the modelling results predicted that the area surrounding Dumbarton Road is unlikely to meet the new annual mean objective. However, the new objectives for PM_{10} target attainment by 2010 and results for that year are summarised in Table 6.15 and the following paragraph.

In comparison, the results from the modelling of PM_{10} concentrations at Dumbarton Road 2010, predict that the annual mean objective is likely to be exceeded at properties close to the junctions with Byres Road, Hyndland Street and Crow Road. The model predicted a maximum annual mean PM_{10} concentration on the road (2010) of 18.21$\mu g\ m^{-3}$, with concentrations at locations relevant to human exposure predicted to range from 17.09-18.03 $\mu g\ m^{-3}$.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted on Dumbarton Road for 2010 is 37.01 $\mu g\ m^{-3}$, indicating that it is unlikely that the 24-hour objective for PM_{10} will be exceeded at this location.

Paisley Road

Paisley road is a busy road located on the south-west edge of Glasgow City Centre, south of the river Clyde and just outside the current AQMA for NO_2. The road passes directly under the M8 at its eastern edge and is strongly influenced by vehicles coming off the motorway. Results from the air-dispersion modelling conducted for Paisley Road 2005 are presented in the separate Appendices of modelled map outputs and summarised in Table 6.16.

Table 6.16 Predicted concentrations of PM_{10} at various locations at Paisley Road (2010)

Receptor name	X(m)	Y(m)	Predicted Annual mean [PM_{10}] ($\mu g\ m^{-3}$)
Max [PM_{10}]			17.38
Location 1	258095	664683	16.95
Location 2	257745	664629	16.82
Location 3	257353	664622	16.96

The results from the PM_{10} modelling study at Paisley Road 2005 are presented within Appendix 2. Due to the relatively high background concentrations of PM_{10} expected to prevail in 2005, the modelling results predicted that the area surrounding Paisley Road is unlikely to meet the new annual mean objective. However, the new objectives for PM_{10}, target attainment by 2010 and results for that year are summarised in Table 6.16 and the following paragraph.

In contrast, the results from the modelling of PM_{10} concentrations at Paisley Road 2010, suggest that the annual mean objective is unlikely to be exceeded at locations relevant to human exposure. The maximum annual mean PM_{10} concentration predicted for Paisley Road in 2010 is 17.38 $\mu g\ m^{-3}$ close to the Kingston Bridge. Predicted concentrations at locations relevant to human exposure (annual mean) range from 16.78–17.28 $\mu g\ m^{-3}$.

The maximum 98.08th percentile of the 24-hour mean PM_{10} concentrations predicted at Paisley for 2010 is 35.26 $\mu g\ m^{-3}$, indicating that it is unlikely that the 24-hour objective for PM_{10} will be exceeded at this location.

6.3 PM_{10} Modelling Summary

In summary, the results from the air-dispersion modelling of PM_{10} at busy roads and junctions in Glasgow predict that the NAQS annual mean objective is likely to be exceeded at several locations in 2010. Due to high background PM_{10} concentrations, areas of the City Centre including Hope Street, Renfield Street, Union Street, Cathedral Street and Charing Cross are considered highly likely to fail the annual mean objective. Furthermore, detailed modelling of road traffic emissions has indicated potential exceedences of the annual mean objective at Dumbarton Road, Bridgeton Cross, Crow Road and at Glasgow 1 (Air Quality monitoring Unit).

All other locations assessed in this study are predicted to meet the NAQS annual mean objective for 2010.

However, due to the limited availability of PM_{10} data and the consequent inability to ratify the model output, it is recommended that these findings are treated with caution until a verification exercise can be conducted. As a result it is recommended that modelled data of PM_{10} concentrations is verified against monitoring results as soon as these become available, and that a monitoring programme is introduced to assess ambient concentrations at locations predicted to fail the annual mean objective.

6.4 New/ Proposed Roads

Glasgow City Council's Updating and Screening Assessment 2003 outlined the need to assess the impact of new or proposed roads on local air quality. In relation to this it was concluded that a detailed assessment was required regarding the proposed M74 extension.

The existing M74 terminates at Fullarton Road in the south east of Glasgow, with a 'missing link' between here and the Kingston Bridge. Work is currently still in development, however, it is planned to complete the 5 mile link from the Fullarton Road Junction to the M8 just west of the Kingston Bridge, and have this section of road open to traffic by 2008. Obviously, such a major road may have implications for local air quality. The proposed line of the route is shown in Figure 4.1. The proposals require an environmental impact assessment (EIA) under the provisions of Section 20A of the Roads (Scotland) Act 1984 as amended by Part III of the Environmental Impact Assessment (Scotland) Regulations 1999.

Environmental Resources Management Ltd (ERM) have conducted an environmental impact assessment and prepared an Environmental Statement (ES) on behalf of Glasgow City Council to inform the public, the Scottish Ministers and organizations with statutory and non-statutory interests in the environment of the likely environmental effects of the works. The findings of the

assessment, including the measures that will be taken to avoid, reduce or remedy adverse impacts are reported in the ES.

In terms of the predicted impact on PM_{10} concentrations in Glasgow, the ES concluded that although a long term overall improvement in air quality is predicted with some 56 % of residential properties in the wider study area expected to experience a reduction in particulate matter (PM_{10}) whilst 1% will experience no change; detailed modelling identified some increases in PM_{10} concentrations close to the road corridor which could potentially result in exceedences of the air quality objectives.

Subsequent discussions between the appointed agents Environmental Resources Management and the Scottish Executive resulted in the recommendation that additional information on air quality in the vicinity of the proposed route prior to, during, and after construction of the 27 scheme would be of benefit. This would allow an assessment of the impact of the road on background air quality. Following further discussions between the appointed agents with representatives of Glasgow City Council (Land Services Design), the report *M74 Completion: Air Quality Proposed Monitoring Study (2002)* was prepared, and recommended the pollutants and locations to be monitored together with appropriate methodology. The study recommended monitoring of PM10 particulate matter twice every year (2 weeks during both summer and winter periods) by Glasgow City Council Environmental Protection Services at relevant sites near to the proposed M74 extension. In addition, Land Services are undertaking diffusion tube monitoring of NO_2 at 56 sites and benzene at 4 sites along the proposed route. Once the construction of the road is complete and it is open to traffic, monitoring results can be analysed to determine the impact of the road on local air quality.

6.5 Industrial emissions

The Scottish Environment Protection Agency (SEPA) has responsibility over prescribed processes in Scotland. SEPA authorise Part A and B processes and set conditions that limit emissions from them and places them under an obligation to use 'the best available techniques' to prevent or minimise pollution.

In relation to industrial emissions of PM_{10}, Glasgow City Council's Updating and Screening Assessment (2003) concluded that as there were no new or existing industrial sources with significantly increased emissions of PM_{10} a detailed assessment was not required. However, due to the more stringent objectives introduced for PM_{10} in relation to 2010, the report also recommended that emissions from existing industrial sources in Glasgow be reassessed against the new objectives.

In response to this recommendation, Glasgow City Council proposes to introduce a monitoring programme to assess ambient concentrations of PM_{10} at relevant locations in the vicinity of A. Cohen and Co. and United Distillers. The result from this monitoring programme and air-dispersion modelling from each location will be presented in future review and assessment documents.

6.6 PM_{10} – Conclusions

The results from air quality monitoring and air-dispersion modelling of PM_{10} in Glasgow indicate that sections of the City Centre including Hope Street, Renfield Street, Union Street, Cathedral

Street and Charing Cross are considered highly likely to fail the annual mean objective set for 2010, whilst further exceedences of the objective are predicted outwith the City Centre at Dumbarton Road, Bridgeton Cross, Crow Road and at Glasgow 1 (Air Quality monitoring Unit).

It must be stated however, that the modelling results for PM_{10} have not been verified, due to the limited availability of suitable monitoring data. As such, the findings of the modelling studies and the preliminary declaration of Air Quality Management Areas must be treated with cautions until further monitoring and verification can be conducted.

In relation to emissions of PM_{10} and potential exceedences of the NAQS objectives from the proposed M74 extension and industrial sites within Glasgow, it is concluded that further monitoring and assessment is required at these locations in future years.

7.0 SO_2

Glasgow City Council's Updating and Screening Assessment (2003) identified potential exceedences of the 15-min mean NAQS objective for SO_2 at the 8-port bubblers monitoring SO_2 at Baillieston, Springburn, Kelvinhall and Cardonald. Results from the continued monitoring for SO_2 at Glasgow Centre (automatic analyser) and SO_2 bubblers located across Glasgow (Figure 3.3) are presented below in Figures 7.1-7.7 and Table 7.1

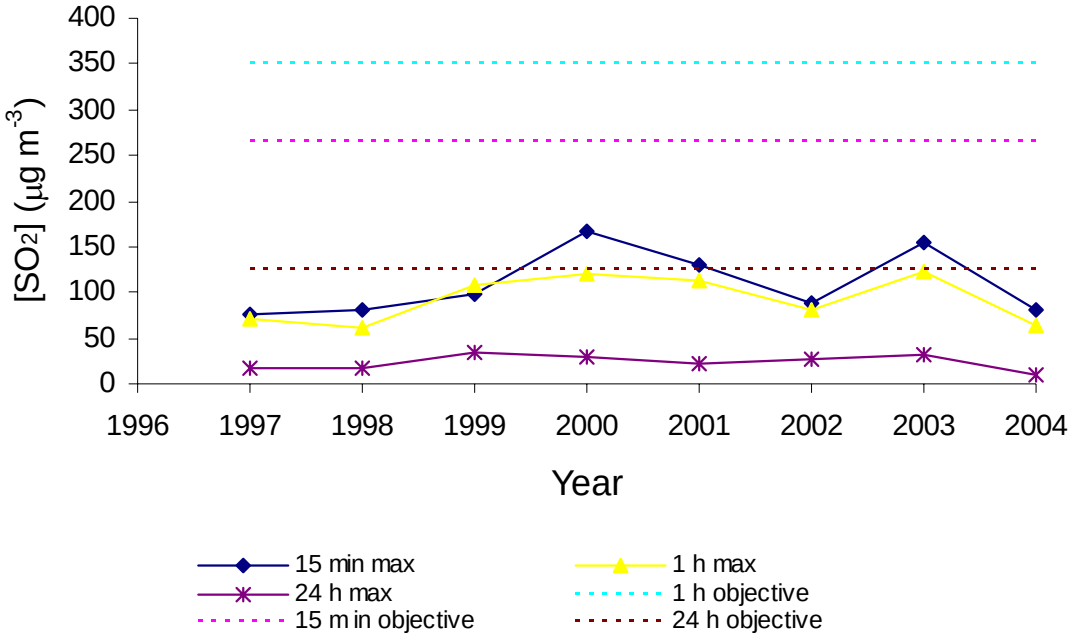
However it must be noted, that data of SO_2 concentration obtained from 8-port bubblers relates to a period of 24 h. As a result SO_2 bubblers do not provide a direct measurement of SO_2 concentration in relation to the 1 h mean or 15 min mean. Instead, 1 hour mean and 15 min mean concentrations for bubbler locations are estimated from the 24 h mean using guidance contained within LAQM.TG(03). In order to take account of the uncertainty in these procedures LAQM.TG(03) states that;

"…it may be assumed that the 15-minute mean objective is unlikely to be exceeded if the maximum daily mean concentration is less than 80 µg/m^3, and the 1-hour mean objective is unlikely to be exceeded if the maximum daily mean concentration is less than 200 µg/m^3."

7.1 Monitoring Results

7.1.1 Automatic Analyser

Figure 7.1 Glasgow Centre AURN maximum SO_2 Concentrations



7.1.2 8-port bubblers

Figure 7.2 Baillieston SO_2 Concentrations (8-port bubbler)

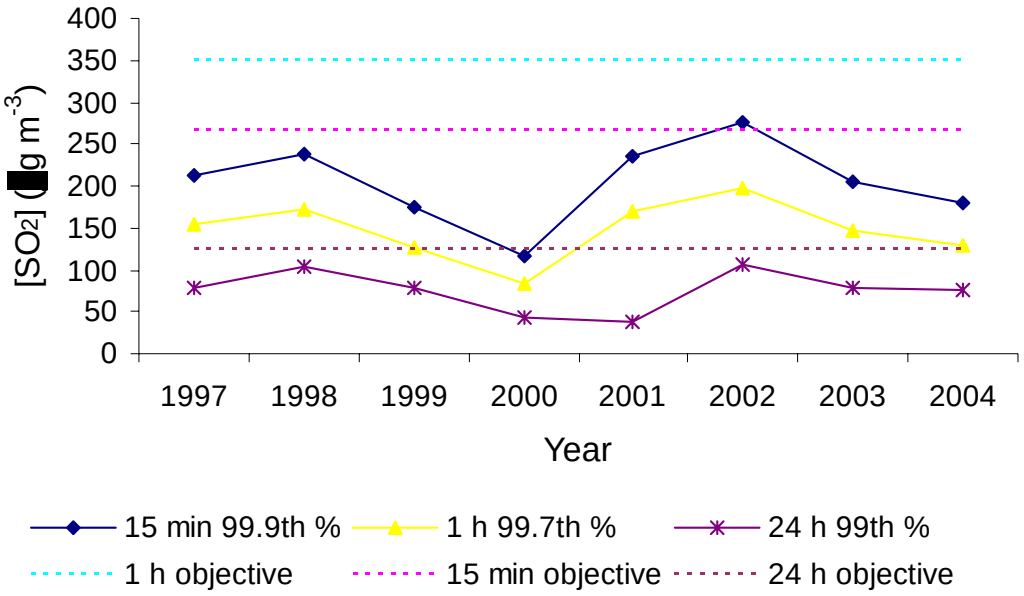


Figure 7.3 Dalmarnock SO_2 Concentrations (8-port bubbler)

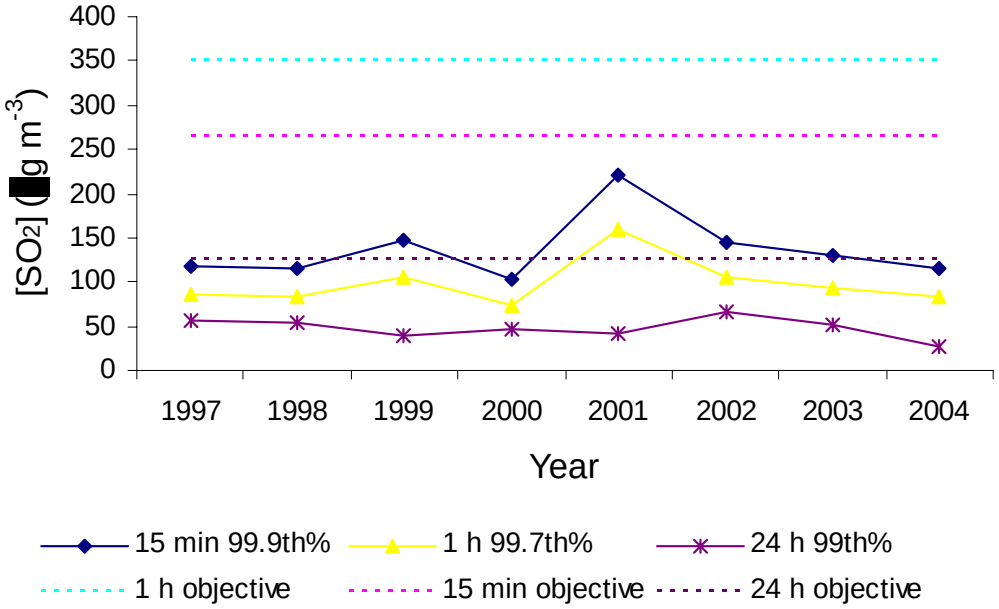


Figure 7.4 Springburn SO_2 Concentrations (8-port bubbler)

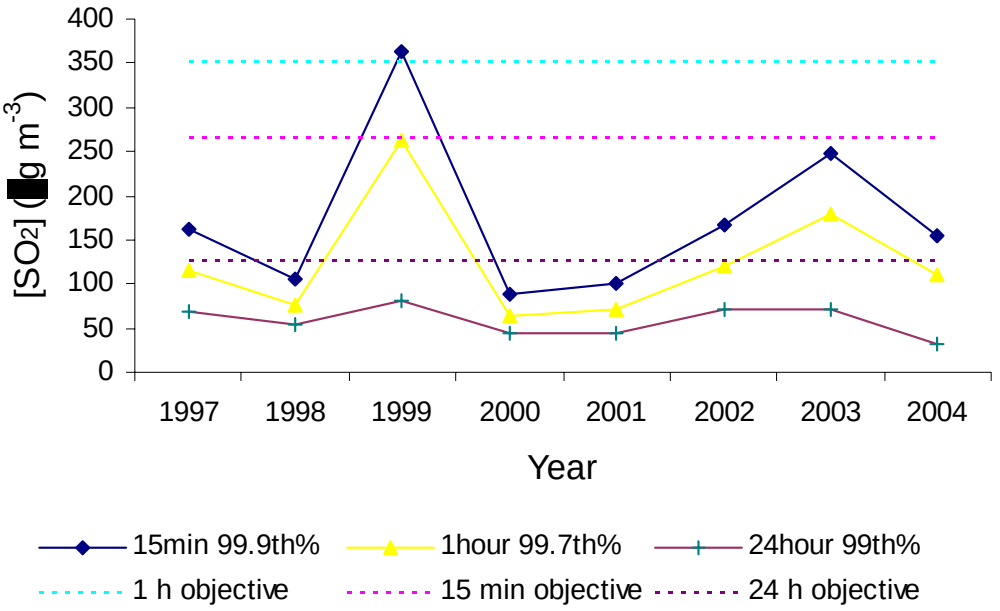


Figure 7.5 Montrose Street SO_2 Concentrations (8-port bubbler)

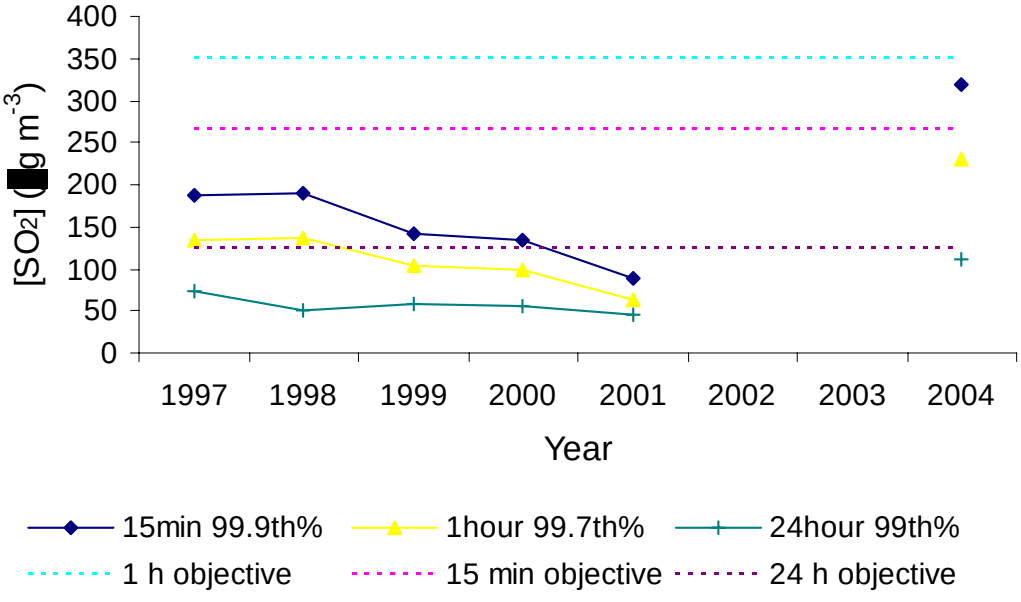


Figure 7.6 Cardonald SO_2 Concentrations (8-port bubbler)

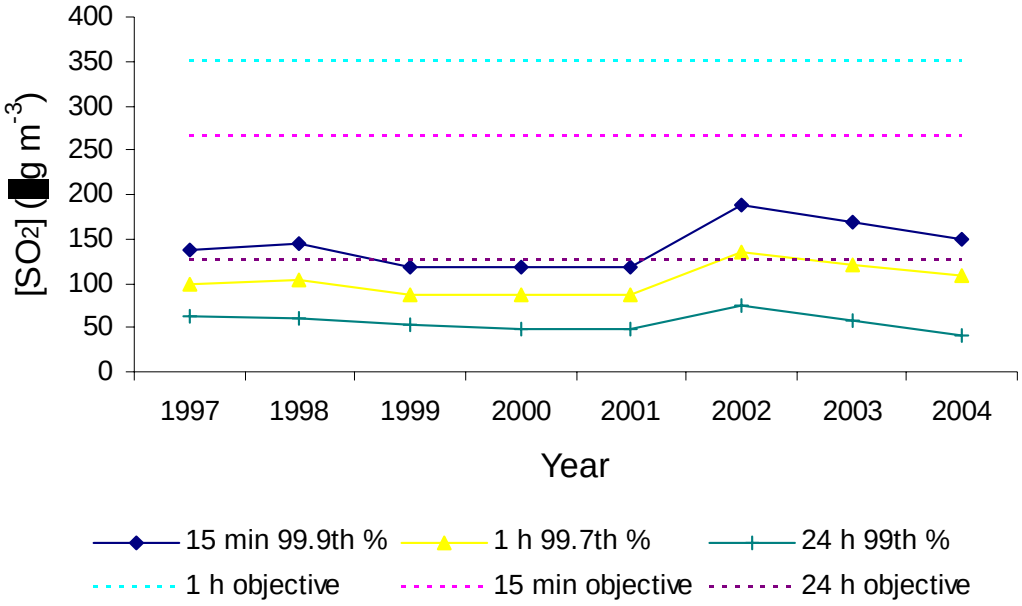


Figure 7.7 Carmyle SO_2 Concentrations (8-port bubbler)

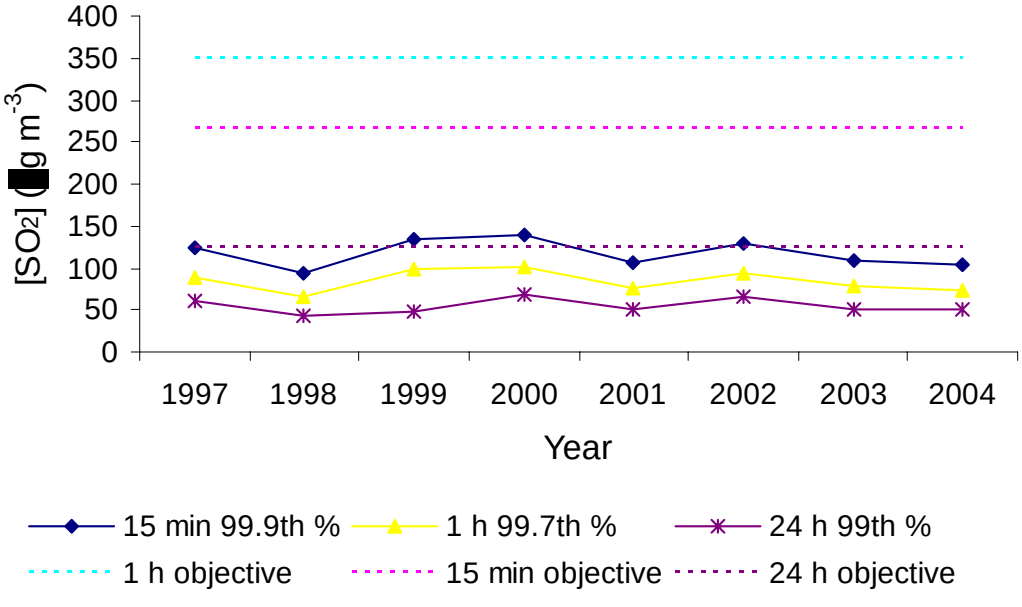


Table 7.1 Maximum daily mean SO_2 concentration (µg m^{-3}) determined by 8-port bubblers

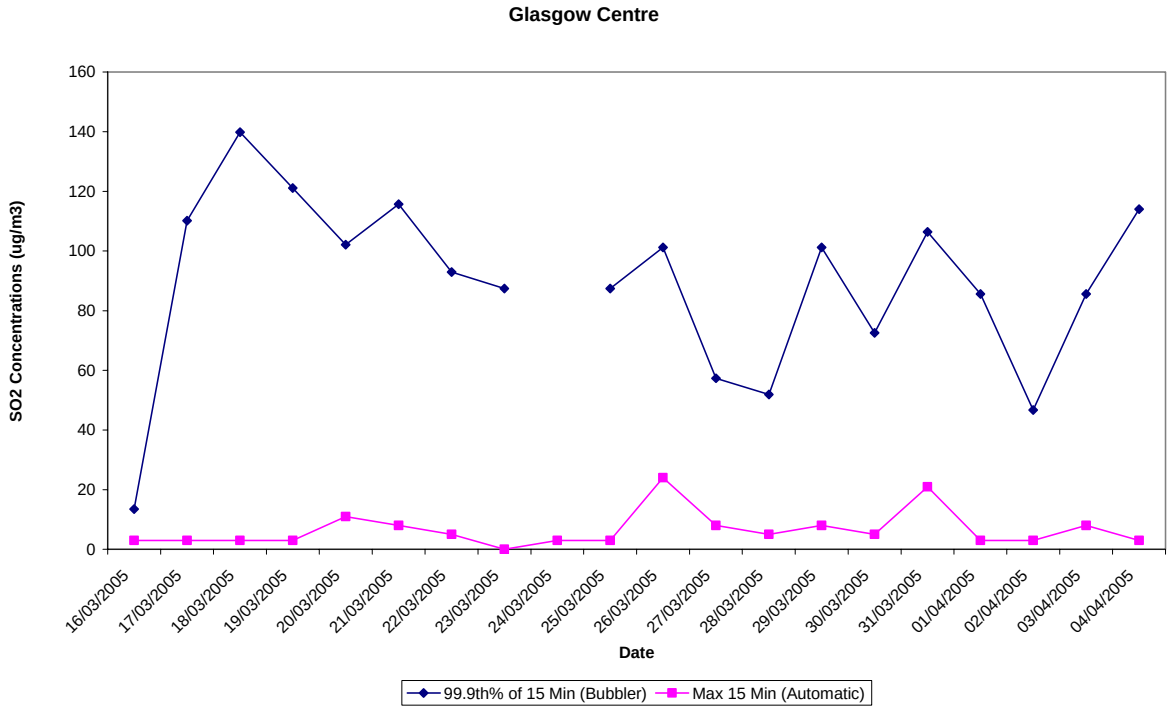
	Baillieston	Carmyle	Dalmarnock	Springburn	Montrose St.	Kelvinhall Art Galleries	Cardonald
Year							
1997	113	65	63	85	79	140	73
1998	125	49	61	56	80	80	76
1999	93	71	78	191	75	N.A.	63
2000	61	74	54	58	71	N.A.	63
2001	124	56	116	53	47	68	63
2002	145	68	76	88	-	126	99
2003	107	57	69	131	-	-	89
2004	95	54	61	81	169	-	79

7.2 SO_2 Monitoring Summary and Conclusions

The results from the monitoring of SO_2 indicated that no exceedences of the 24 h mean or 1 hour mean objective were observed at any of Glasgow's monitoring sites in 2003 or 2004. However, assessment of the maximum 24 h mean SO_2 concentrations reported at all 8-port bubbler locations (Table 7.1) demonstrated that daily means equal to or in excess of 80µgm^{-3} have been observed at Baillieston, Dalmarnock, Springburn, Montrose Street and Cardonald in recent years.

In light of these indicated exceedences of the 15 min objectives at multiple 8-port bubbler locations and the recognition that SO_2 bubblers do not provide a direct measurement of SO_2 concentration in relation to the 15 min mean the decision was taken to co-locate an 8-port bubbler with the automatic analyser at Glasgow Centre in order to assess bubbler performance. The results of this short term co-location study are presented in Figure 7.8.

Figure 7.8 Automatic analyser – 8-port bubbler comparison



The results demonstrated that the concentrations of SO_2 measured by the 8-port SO_2 bubbler and the more accurate automatic SO_2 analyser differed significantly over the study period. These results appear to indicate that 8-port SO_2 bubblers overestimate ambient concentrations of SO_2 and do not represent an accurate method of estimating 15 min maximum concentrations. However, in order to assess the validity of these findings, Glasgow City Council intends to continue this co-location experiment over a longer time period.

8.0 Conclusions

This document represents Glasgow City Council's LAQM Review and Assessment of Air Quality: Detailed Assessment and has assessed concentrations of NO_2, PM_{10} and SO_2 at locations where exceedences of the National Air Quality Strategy objectives were predicted in the Updating and Screening Assessment (2003).

The findings are summarised below:

NO_2

Assessment of NO_2 concentrations outwith the current City Centre AQMA indicates that exceedences of the annual mean objective are likely to occur at Royston Road, Byres Road, North Street/ Glasgow 1(Air Quality Monitoring Unit), Dumbarton Road and Parkhead Cross in 2005. Consequently, Glasgow City Council is required to declare Air Quality Management Areas at these locations.

Furthermore, results from air quality monitoring (2004) have indicated that the annual mean objective at Napiershall Street is likely to exceed the annual mean objective for NO_2 in 2005. As a result, it is concluded that further assessment of NO_2 is required at this location.

PM_{10}

The results from air quality monitoring and air-dispersion modelling of PM_{10} in Glasgow indicates that sections of the City Centre including Hope Street, Renfield Street, Union Street, Cathedral Street and Charing Cross are considered highly likely to fail the annual mean objective set for 2010. Through air-dispersion modelling, exceedences of the annual mean objective were also predicted outwith the City Centre at Dumbarton Road, Bridgeton Cross, Crow Road and at Glasgow 1 (Air Quality Monitoring Unit).

However, it was also concluded that as the modelling results for PM_{10} could not been verified, due to the limited availability of suitable monitoring data, the findings must be treated with caution and the declaration of Air Quality Management Areas delayed until further monitoring and verification can be conducted.

SO_2

Assessments of SO_2 concentrations using 8-port bubblers indicate that a number of sites in Glasgow are likely to exceed the 15 min mean objectives. However, results from the co-location of an 8-port SO_2 bubbler with an automatic analyser demonstrate that the bubblers are significantly overestimating the ambient SO_2 concentrations. Thus, these findings suggest that the SO_2 objectives are being met throughout the city.

Co-location of these analysers will continue at the Glasgow Centre site to establish a long term relationship between the two but on current evidence it is unlikely that Glasgow will be in breach of the SO_2 objectives.

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