Further Assessment of Air Quality in Whirlies AQMA

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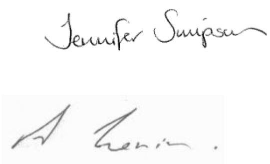
Author	Jennifer Simpson/ Andrew Lewin		Senior Consultant/ Consultant	22/06/10
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1 INTRODUCTION

BMT Cordah Limited has been commissioned by South Lanarkshire Council to conduct a Further Assessment of air quality within its Air Quality Management Area (AQMA) at Whirlies roundabout (Whirlies) in East Kilbride.

1.1 LAQM review and assessment framework

The Environment Act 1995 and subsequent regulations require local authorities to assess compliance of air quality in their area with the standards and objectives set out in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007 (NAQS). For local authorities within Scotland further regulations are set out in the Air Quality (Scotland) Regulations 2000 and Air Quality (Scotland) Amendment Regulations 2002.

The LAQM framework requires that local authorities carry out regular reviews of air quality. The first round of Review and Assessment commenced in 1998 and comprised a four stage approach to the assessment of air quality.

The Review and Assessment process was revised in 2009 and comprises a phased approach. The first phase of the Review and Assessment is an Updating and Screening Assessment (U&SA). The U&SA considers any changes that have occurred in pollutant emissions and sources since the last round of Review and Assessment that may affect air quality. The second phase is the completion of a Progress report which is required to be completed annually, apart from the years when an U&SA is being completed

The LAQM guidance requires that where the U&SA or Progress Report has identified a risk of exceedence of an air quality objective at a location with relevant public exposure is identified then a Detailed Assessment is undertaken. A Detailed Assessment will consider any risk of exceedence of an objective in greater depth in order to determine whether it is necessary to declare an Air Quality Management Area (AQMA).

When a new AQMA has been declared, local authorities are required to complete a Further Assessment within 12 months of designating the AQMA. The Further Assessment is intended to supplement the information provided in the Detailed Assessment. It should aim to confirm the exceedence of the objectives; define what improvement in air quality, and corresponding reduction in emissions is required to attain the objectives; and provide information on source contributions. The information on source contributions can be used to help develop an Air Quality Action Plan, and assist in the targeting of appropriate measures.

1.2 Air quality standards and objectives

The air quality standards and objectives which local authorities are required to meet are outlined in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland. The air quality objectives for NO_2 and PM_{10} which are applicable in Scotland are presented in Table 1.

Table 1 Scottish Air Quality Objectives

Pollutant	Air Quality Objective			Date to be achieved by
	Concentration	Measured as	Equivalent percentile	
Nitrogen dioxide (NO_2)	200 µg/m^3 not to be exceeded more than 18 times per year	1-hour mean	99.79th percentile of 1-hour mean concentrations	31/12/2005
	40 µg/m^3	annual mean	-	31/12/2005
Fine particulates (PM_{10})	50 µg/m^3 not to be exceeded more than 7 times per year	24-hour mean	98th percentile of 24-hour mean concentrations	31/12/2010
	18 µg/m^3	annual mean	-	31/12/2010

1.3 Previous assessments

Several assessments have been conducted over recent years to investigate air quality within the South Lanarkshire Council area. A full description of the previous review and assessment work to date is included in the 2009 Updating and Screening Assessment (U&SA)[1]. The following provides a brief summary of the review and assessment work completed to date for the area around Whirlies AQMA.

The 2003 U&SA concluded that potential exceedences of the 2010 PM_{10} objective may occur at the Whirlies roundabout in East Kilbride. A Detailed Assessment of PM_{10} concentration at Whirlies roundabout was subsequently undertaken in 2005; the assessment concluded that neither the annual average objective nor the 24-hour objectives was likely to be exceeded around the Whirlies roundabout in 2010. The predicted concentrations close to the roundabout were however close to the objective.

The 2007 U&SA concluded that the measured annual average PM_{10} concentrations at the Whirlies roundabout were in excess of the 2010 PM_{10} annual mean objective. A Detailed Assessment completed in 2007 concluded that the 2010 PM_{10} annual average objective was likely to be exceeded in the area around the Whirlies roundabout. It was recommended that air quality at this location was kept under review by South Lanarkshire Council and that the declaration of an AQMA be considered. Based on the conclusions of the Detailed Assessment, South Lanarkshire Council declared an AQMA for PM_{10} at Whirlies roundabout effective from the 28th November 2008. A map showing the location of the AQMA is presented in Figure 1.

[1] BMT Cordah (2009) Updating and Screening Assessment 2009; South Lanarkshire Council; Report no: G.SLC.004; August 2009

2 METHOD OF ASSESSMENT

The Further Assessment is a detailed review and assessment of air quality within the AQMA to verify that the decision to declare the AQMA and the extent of the AQMA remain valid. The Further Assessment also includes an analysis of the emission sources contributing to the exceedence of the NAQS objective to provide supporting evidence to advise the Air Quality Action Plan.

The Further Assessment comprises of:

- A review of local monitoring data obtained since the 2007 Detailed Assessment was conducted. The data was reviewed in comparison with historic monitored data to determine any trends in the data and compared with the dispersion modelling predictions undertaken as part of the Detailed Assessment to verify that the AQMA is still required.
- A baseline emissions inventory for the Whirlies AQMA was compiled. Emissions inventory is the generic term used to describe the process of estimating emissions from sources. The data held in the emissions inventory was be utilised in a detailed dispersion modelling study of Whirlies. Results from the modelling study were used to confirm the requirements for the AQMA and its boundaries.
- The baseline inventory has been updated for future years. Predictions of pollutant concentrations in future years has also been undertaken to determine future compliance with the objective without including any Action Plan measures. The emissions inventory and modelling studies were undertaken such that the relative contribution of various sources to air quality levels can be determined.

3 LOCAL MONITORING DATA

3.1 Automatic monitoring

South Lanarkshire Council have operated an automatic continuous monitoring site at Whirlies roundabout since 6th February 2008. Both NO_X and PM_{10} concentrations are measured at the site. As the data capture at this site in 2008 was below 90% this meant that the average of the measured results was not considered representative of the annual mean PM_{10} concentrations at the site. A PM_{10} concentration adjusted from the measurement period mean to the annual mean was however derived for the 2009 U&SA. Sufficient measurement data was captured in 2009 with which to derive the annual mean concentrations. Measured data for the site can also be accessed at the Scottish Air Quality website[2]. A summary of the PM_{10} and NO_2 measurements over 2008 and 2009 are presented in Table 2.

Table 2: Whirlies Roundabout summary of monitoring data 2009 and 2009

Pollutant	Air Quality Objective	2008		2009	
		Conc. (µg m^{-3})	Data capture	Conc. (µg m^{-3})	Data capture
Nitrogen dioxide (NO_2)	Annual mean	38.8*	88.8%	34	99.5%
	No. of 1-hour mean concentrations greater than 200 µg m^{-3}	9	88.8%	1	99.5%
Fine particulates (PM_{10})	Annual mean	23	88.8%	15.8	98.6%
	No of 24-hour mean concentrations greater than 50 µg m^{-3}	11	88.8%	4	98.6%
* Adjusted from measurement period mean to annual mean					

The measured PM_{10} annual mean has reduced significantly in 2009 when compared to the 2008 concentration whereas the NO_2 annual mean has reduced slightly. This may be due to the 2008 PM_{10} annual mean being an adjusted value based on limited monitoring data or may reflect a reduction in PM_{10} emissions from road traffic sources in 2009.

The economic recession which has occurred over the last eighteen months has led to a reduction in both commuter and commercial vehicle use. Diesel fuelled commercial and heavy goods vehicles are particularly significant sources of particulate matter, therefore a reduction in ambient PM_{10} concentrations may therefore reflect a reduction in commercial vehicle use at this location.

In 2008, landscaping works were undertaken at Whirlies, which may have led to an elevation in the measured PM_{10} concentration. As the 2008 measured concentration may have been elevated, and if it is assumed that the 2009 concentration is temporarily reduced due to recessionary effects on traffic flows, then it may be more appropriate to consider a

2 www.scottishairquality.co.uk

two year average concentration. The two year average measured annual mean PM_{10} concentration is 19.4µg/m^3. Similarly, the two year average measured annual mean NO_2 concentration is 36.4µg/m^3.

3.2 NO_2 diffusion tube monitoring

Diffusion tube measurements of NO_2 are conducted at one location within the Whirlies roundabout AQMA. The diffusion tube is located at a roadside location close to the Kingsway A725 southbound carriageway. A summary of the NO_2 measurements from 2006 to 2008 are presented in Table 3. Diffusion tube results from 2009 are not currently available.

Table 3: Kingsway, East Kilbride NO_2 diffusion tube measurements 2006 - 2008

Location	Annual mean NO_2 concentration adjusted for bias (µg m^{-3})		
	2006	2007*	2008
Kingsway, East Kilbride 5N	38	**51**	**46**

*Estimated concentrations based on 9 months monitoring data

The measured annual mean at Kingsway, East Kilbride 5N in 2007 and 2008 was in excess of the 40 µg m^{-3} NAQS objective, it should however be considered that this is a roadside site and is not representative of long-term public exposure. Measured NO_2 concentrations were at a maximum in 2007.

4 ATMOSPHERIC EMISSIONS INVENTORY

The inventories were compiled using the atmospheric emissions database package EMIT[3] which aggregates emissions into 1km by 1km grid squares. The inventory includes emissions from the following sources:

- road traffic;
- commercial and domestic combustion;
- industrial combustion;
- industrial processes;
- large industrial sources;
- other transport;
- waste treatment and disposal;
- solvent use
- Agriculture and
- nature

Road traffic data were obtained from the Council and Transport Scotland, while data from all other sources were obtained from the National Atmospheric Emissions Inventory (NAEI). The NAEI is a national atmospheric emissions database which holds data on emissions from a variety of sources in 1km by 1km grid squares. Emissions are reported in tonnes per year. The NAEI data can be downloaded from the NAEI website[4] for individual local authorities, so the emissions are directly attributed to each authority. While the South Lanarkshire emissions inventory is based on 2008 emissions, the most recent NAEI data available are for 2007. The study assumed that 2007 emissions from the NAEI remain unchanged in 2008 and 2010.

4.1 NAEI road traffic data

Road traffic related emission data were also obtained from the NAEI. The data from the NAEI included emissions from exhausts, cold starts and brake and tyre wear. Emissions in the NAEI are aggregated over the 1km^2 grid squares. To prevent double counting the total emissions from the roads being specifically modelled were subtracted from the NAEI emission data. Full details of the specifically modelled roads data can be found in section 6.5 below.

[3] EMIT Atmospheric Emissions Inventory Toolkit, version 2.2, Cambridge Environment Research Consultants, February 2006
[4] www.naei.org.uk/datawarehouse

4.2 NAEI Commercial and domestic combustion

The NAEI contains data on emissions from commercial and domestic combustion, a group which includes stationary combustion sources in agriculture, domestic combustion, small scale industrial combustion, commercial combustion and public sector combustion. Commercial and domestic combustion is often highest in urban areas with a high concentration of public sector, commercial and domestic buildings. Like road traffic data, emissions are aggregated over the 1km^2 grid squares

4.3 NAEI Industrial combustion and Industrial processes

The NAEI holds data on the emission of pollutants from large industrial combustion sources. The sources in this group include combustion associated with ammonia production, cement production, iron and steel production, and lime production. Emissions data from sources in this group is often obtained using data submitted to SEPA or the Environment Agency through IPPC (Integrated Pollution Prevention and Control) process. Emissions are aggregated over the 1km^2 grid squares.

A second group within the NAEI contains emissions data for industrial production processes. The sources in this group include nitric acid use in the chemical industry, primary aluminium production and solid smokeless fuel production. Emissions are aggregated over the 1km^2 grid squares.

4.4 NAEI Other transport

The “other transport” group covers emissions from air, rail and marine transport. It also includes emissions from off road vehicles. Rail transport includes emissions from freight, intercity and regional. All regional rail transport is electrified within South Lanarkshire therefore any emissions from rail transport will be from both freight and intercity rail movements. Air transport includes total aircraft emissions occurring below 1000m from ground during takeoff and landing and from airport support vehicles. These emissions are then aggregated into the 1km^2 grid squares.

This emissions category also includes the emissions from off-road vehicles used on commercial or industrial sites.

4.5 NAEI Waste treatment and disposal

The NAEI contains a group with emission data from waste treatment and disposal activities. Sources included in this group are crematoria, incineration of animal carcasses, chemical waste and clinical waste, offshore oil and gas flaring and small-scale waste burning. Emissions from these sources are aggregated into the 1km^2 grid squares.

4.6 NAEI Solvents use

The NAEI also contains a group with emission data from solvent use associated with paints, glues, detergents and industrial processes. This data is often obtained from SEPA or Local Authorities in England and Wales who regulate processes involving solvents. As for other pollutant sources, solvent emissions are aggregated into the $1km^2$ grid squares.

The principal source of emissions related to solvent use was determined by NAEI to be from the Rolls Royce industrial site.

4.7 NAEI Agriculture

The NAEI also contains a group with emission data from all agricultural livestock, poultry and agricultural off road machinery. Emissions from these sources are aggregated into the $1km^2$ grid squares.

4.8 NAEI Nature

The NAEI also contains a group with emission data from naturally occurring emissions from woodlands, mines, quarries and opencast mines. Emissions from these sources are aggregated into the $1km^2$ grid squares.

5 EMISSIONS TOTALS

The total atmospheric emissions from the 1km grid squares covering the Whirlies AQMA in 2008 are presented in Table 4, with the totals broken down by source in Charts 1 and 2.

Chart 1 indicates that the most significant source of PM_{10} in the AQMA is road transport emissions with 45% of PM_{10} emissions attributed to this source. Solvent emissions are estimated to be 18% of total PM_{10} emissions, waste treatment emissions are estimated to account for 13% of total NO_x emissions. Other transport emissions and emissions from Nature contributing 7% each of total PM_{10} emissions. The remaining 10% of PM_{10} emissions attributed from industrial combustion and processes and commercial, institutional and residential combustion emissions.

Chart 2 indicates that the most significant source of NO_x in the AQMA is road transport emissions accounting for 57% of total NO_x emissions. Commercial, institutional and residential emissions are estimated to be 24% of total NO_x emissions. NO_x emissions from industrial combustion accounts for 14% of total NO_x emissions. The remaining 5% NO_x emissions are attributed from other transport.

Table 4: Whirlies emissions

Source	NO_x emitted (tonnes)	PM_{10} emitted (tonnes)
Agriculture	0.00	0.00
Commercial, Institutional and Residential Combustion	0.16	17.32
Energy Production	0.00	0.00
Fossil Fuel	0.00	0.00
Industrial Combustion	0.17	10.27
Industrial Processes	0.21	0.00
Nature	0.39	0.05
Other Transport	0.35	4.00
Road Transport	2.38	41.20
Solvent use	0.96	0.00
Waste Treatment	0.66	0.06
Total	5.28	72.89

Chart 1: PM_{10} emissions

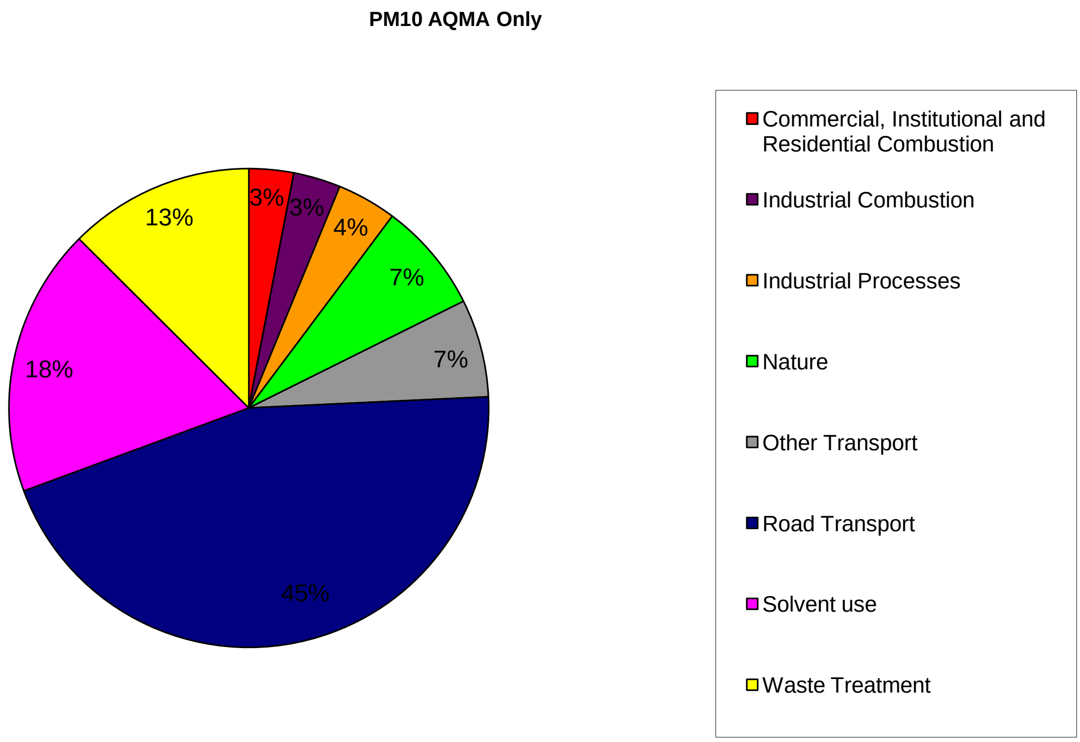
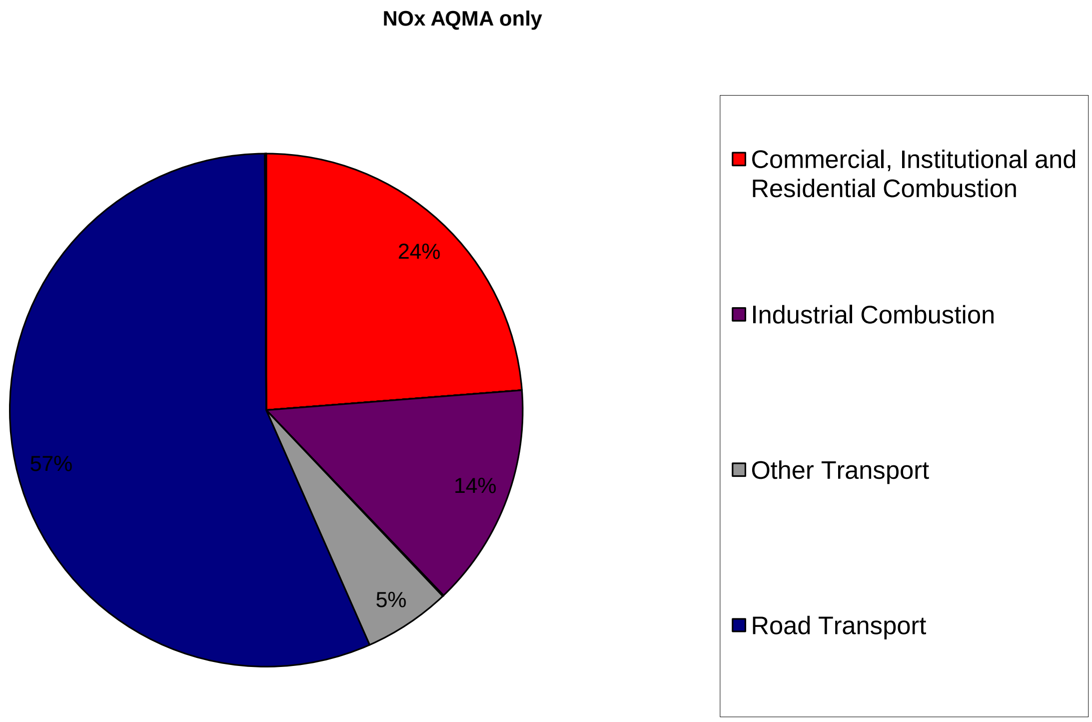


Chart 2: NO_x emissions



6 ATMOSPHERIC DISPERSION MODELLING

To predict the ambient NO_2 and PM_{10} concentrations at the Whirlies Roundabout AQMA, an atmospheric dispersion modelling study of road traffic emissions was undertaken. The atmospheric dispersion model predicts pollutant concentrations based upon the traffic volume, street geometry, traffic composition, traffic speed, background sources and meteorological and topographical conditions of the area.

Road traffic emissions have been modelled for 2008 as a baseline scenario with which to verify the results when compared with pollutant concentrations measured in 2008. Future years have also been modelled to provide an indication of the reduction in road traffic emissions required to attain the air quality objective within the designated AQMA at Whirlies Roundabout with various traffic flow reduction scenarios.

6.1 Atmospheric dispersion model

The atmospheric model used in the assessment was ADMS-Roads version 2.3. ADMS-Roads is a new generation dispersion model which has been validated and verified in numerous studies which are summarised in the user guide, and has been declared fit for the purpose of local air quality assessment by DEFRA and the devolved administrations.

6.2 Area of assessment and Receptors

Modelling predictions were undertaken over a modelled domain consisting of a 1.8km by 2.9km Cartesian grid pattern which encompasses the Whirlies Roundabout and surrounding area in East Kilbride. The number of calculation points was set at 100 by 100 which provides predicted concentrations at an approximate minimum resolution of 30m. The option of “intelligent gridding” was selected whereby the model predicts pollutant concentrations at a higher spatial density (finer resolution) close to the emission sources and at a lower spatial density at background locations.

The model can also predict pollutant concentrations at specific locations where relevant public exposure may occur. Nine locations within the assessment area, at points representative of relevant public exposure, were specified as receptors. The receptor locations are presented in Table 5 and annotated on Figure 2.

Table 5: Location of specific receptors

Receptor	Category	Location (NGR)	
		Easting	Northing
Wilson Place	Residential	264360	655730
Whin Place	Residential	264670	655960
Whin Hill	Residential	264590	655740
Auto monitor	Air quality monitoring location	264370	655670
Gullion Park Flats	Residential	264376	655654
Burns Park	Residential	264388	655317

Receptor	Category	Location (NGR)	
Whitemoss Grove	Residential	264234	654720
Calderwood Road	Residential	264689	655538
Geddes Hill	Residential	264642	655643
East mains road	Residential	264214	655613
Kingsway diff tube	Air quality monitoring location	264373	655354

6.3 Meteorological data

The model requires a minimum input of six meteorological parameters for hourly sequential or statistical data. The six parameters included in the meteorological data are surface temperature (in ºC), wind speed (in m/s), wind direction (as degrees from north), relative humidity (as a %), cloud cover (in oktas) and precipitation (in mm). The closest meteorological stations to East Kilbride recording the full suite of meteorological parameters required by the model is at Glasgow Airport (Bishopton).

The Bishopton station is situated at NGR 2418E 6711N, Latitude: 55.91 degrees; Longitude: -4.53 degrees; altitude: 59 metres above sea level, approximately 20 kilometres NW of East Kilbride. Although East Kilbride is at a higher elevation than Bishopton and may therefore experience higher wind speeds, the meteorological conditions measured at Bishopton are considered the best available data with which to represent those experienced at East Kilbride.

A windrose for the 2008 Bishopton meteorological data sets is shown on Figure 3. Examination of the wind rose shows that the winds measured at Bishopton are predominantly from the west and south-west with regular winds from the north-west and east. This is characteristic of the conditions experienced generally in the west of Scotland.

6.4 Surface roughness

The interaction of wind flow with the earth's surface generates turbulence, influencing pollutant dispersion. The strength of this turbulence is dependent on the land use, with built-up areas generating more turbulence than open countryside. The ADMS-Roads user guide indicates that a surface roughness length of 0.5m is suitable for parkland and open suburbia. The area surrounding the Whirlies roundabout mainly comprises of residential properties with gardens, open parkland and wooded areas; a surface roughness of 0.5m was therefore considered appropriate for the dispersion site. A surface roughness factor of 0.2m was used to represent the agricultural land around the meteorological site at Bishopton.

6.5 Pollutant emissions

6.5.1 Road traffic emissions

The ADMS Roads atmospheric dispersion model uses the annual average hourly (AAHT) traffic flow, vehicle split and traffic speed to determine the pollutant emission rates for each section of road modelled.

Traffic count data for the roads which intersect at the Whirlies roundabout were provided by the South Lanarkshire Council Road Traffic Department. 4-hour manual traffic counts conducted during a week day in 2005 were provided for East Mains Road, the A749 Kingsway and Calderwood Road. The 4-hour counts were converted to 24-hr AADT using factors supplied by the Council road traffic department and projected forward to 2008 using the National Road Traffic Forecast (NRTF) central growth factor[5] for urban roads. Automatic traffic count data measured over 2008 was provided for the A725 and an average AADT calculated. AAHT values for each road were calculated from the AADT values.

Vehicle split data for the A749 Kingsway and Calderwood road was calculated from the manual traffic count data. For all other roads where split data was not available, published UK fleet composition data from the NRTF were used.

The road sources modelled in the assessment and the traffic flow data are presented in Table 6. The locations and extent of the roads modelled are presented on Figure 4.

Table 6: Modelled road sources data 2008

Road	Road width (m)	AAHT LGV's	LGV speed (kph)	AAHT HGV's	HGV speed (kph)	% HGV's
Calderwood Rd Eastbound	4	371	50	23	50	5.9%
Calderwood Rd westbound	4	223	50	20	50	8.1%
Eastmains Rd eastbound	4	472	65	21	65	4.2%
Eastmains Rd westbound	4	371	65	16	65	4.2%
Hamilton Rd eastbound	7	592	80	26	80	4.2%
Hamilton Rd westbound	7	596	80	26	80	4.2%
Hamilton – Calderwood connect	4	223	25	20	25	4.2%
Kingsway A725 northbound	7	517	80	23	80	4.2%
Kingsway A725 southbound	7	541	80	24	80	4.2%
Kingsway A749 northbound	7	310	80	13	80	3.9%
Kingsway A749 southbound	7	388	80	20	80	5.0%
Roundabout	12	599	30	26	30	4.2%

[5] DETR (1997) National Road Traffic Forecasts (Great Britain) 1997

6.5.1.1 Reduced speed road sections

Road links of approximately 50m length were included to account for reduced vehicle speeds when traffic is approaching the roundabout. The road also widens to three lanes as the traffic approaches the roundabout. Traffic flow around the roundabout was assumed as the maximum of the road counts coming on to the roundabout travelling at a reduced speed of 30 km/hr. The roundabout has 3 lanes of traffic.

Details of the road widths and reduced vehicle speeds are presented in Table 7.

Table 7: Reduced speed road links modelled

Road	Road width (m)	AAHT LGV's	LGV speed (kph)	AAHT HGV's	HGV speed (kph)	% HGV's
Calderwood Rd westbound approach	12	223	25	20	25	8.1%
Eastmains Rd eastbound approach	12	472	25	21	25	4.2%
Hamilton Rd westbound approach	12	596	25	26	25	4.2%
Hamilton – Calderwood connect	4	223	25	20	25	4.2%
Kingsway A725 northbound approach	12	517	25	23	25	4.2%
Kingsway A749 southbound approach	12	388	25	20	25	5.0%
Roundabout	12	599	30	26	30	4.2%

6.5.1.2 Queuing traffic

Traffic is known to become congested when approaching the Whirlies roundabout during peak commuting hours in the morning and early evening. A method of modelling queuing traffic using ADMS-Roads proposed by model developers CERC has been used to represent the periodic congestion at the junction. The method assumes that during congested periods a representative traffic flow rate must be estimated.

Assuming that the vehicles are travelling at the lowest speed that can be modelled using ADMS-Roads (5 km/hr (5000m/hr)), with an average vehicle length of 4m, and are positioned close to each other during congested periods. The annual average hourly traffic (AAHT) flow is calculated by dividing the speed of the vehicles by the average vehicle length, which gives a representative AAHT of 1250 vehicles per hour during congested periods.

Queuing traffic road sections of 50m length were included for all roads approaching the junction being modelled. A time varying profile was applied to each queue section to account for the twice-daily congestion periods during weekdays. The congested periods were assumed to occur from 07:00-09:00 and from 16:00-18:00. No queues were included during weekend traffic flows.

The queue road section modelled in the assessment and the traffic flow data are presented in Table 8.

Table 8: Modelled queue road sections data

Road	Road width (m)	AAHT LGV's	LGV speed (kph)	AAHT HGV's	HGV speed (kph)	% HGV's
Calderwood Rd westbound queue	12	223	5	20	5	8.1%
Eastmains Rd eastbound queue	12	472	5	21	5	4.2%
Hamilton Rd westbound queue	12	596	5	26	5	4.2%
Kingsway A725 northbound queue	12	517	5	23	5	4.2%

6.5.2 Other local sources

Sources from the emissions inventory, described in Section 4 above, were included in the model to represent the local non-road background sources of NO_2 and PM_{10}. The local background sources were modelled as volume sources. Emissions in a volume source are expressed in $g/m^3/s$. The area of the volume source was chosen to match the size of the emission inventory grid squares. The depth of the volume source was chosen to be 10 m as it was considered that the vast majority of pollutants emitted from the other sources (commercial and domestic, industrial processes, etc) would be emitted within 10 m from the ground. Emissions from six 1km x 1km grid squares covering the Whirlies AQMA were included in the study.

6.5.3 Chemistry scheme and background concentrations

ADMS-Roads has the facility to model the photochemical reactions that occur between oxides of nitrogen (NO_x), ozone and hydrocarbons. It is important to include chemical reactions since NO_2 emissions generally account for only around 10-20% of total NO_x emissions from motor vehicles. While there are numerous reactions which occur between these compounds, the facility in ADMS-Roads, the Chemical Reaction Scheme, simplifies this to eight reactions known as the Generic Reaction Set. ADMS roads uses a default 10% of total NO_x to NO_2 relationship from motor vehicles however this is now know to be approximately 15% depending on the area, therefore, NO_2 emission rates from motor vehicles were specified within ADMS-Roads.

The chemistry module of ADMS-Roads requires hourly averaged background concentrations of NO, NO_2, O_3, PM_{10} and SO_2. Since all local emission sources have been included in the modelling through the explicitly modelled roads and the emission inventory volume source emissions, the only remaining contribution to ambient pollutant concentrations will come from sources outside the study area. Accordingly, measured pollutant concentrations from a rural monitoring site to the east of Whirlies (Walkmillglen) were used to represent background concentrations.

The ADMS-Roads user guide states that a background monitoring site should be used or a rural background when volume sources are also included in the model. Rural background concentrations of NO_x, NO_2, O_3 and PM_{10} were taken from the rural background monitoring site, as this site does not monitor SO_2, background concentrations of SO_2 were taken from the urban background automatic monitoring site at Glasgow Centre. The annual mean background concentrations measured in 2008 are presented in Table 9.

Table 9: 2008 measured annual mean background pollutant concentrations

Year	NO_X(µg/m^3)	NO_2 (µg/m^3)	Ozone (µg/m^3)	PM_{10} (µg/m^3)	SO_2 (µg/m^3)
2008	21.7	12.1	56.1	14.2	2

6.6 Model results

6.6.1 Model Verification

To verify the performance of the modelling assessment, predictions of pollutant concentrations were compared against measured pollutant concentrations. The model verification methodology followed the technical guidance TG (09). The verification will be discussed in the following sections.

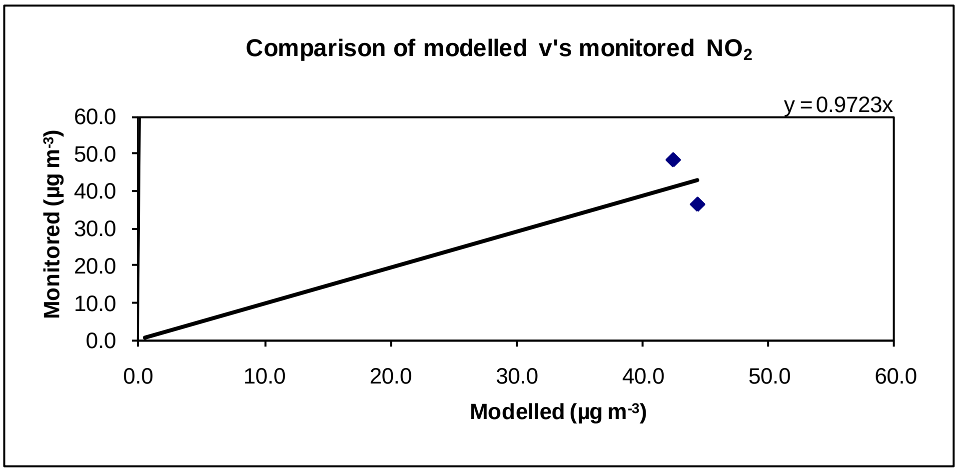
6.6.1.1 NO_2

Modelled predictions of annual mean NO_2 concentrations in 2008 were compared with the available local monitoring data to examine the correlation between the modelled and measured concentrations for NO_2. As discussed in Section 3.1 above, the 2008 and 2009 automatic monitoring data was averaged over 2008 and 2009 to account for factors which may have affected the measured NO2 and PM10 concentrations at the study area. All monitoring data have been fully ratified and bias correction factors, where required, have been applied. The results of the comparison are presented in Table 10 and Chart 3.

Table 10 Comparison of modelled v's monitored NO_2 concentrations (µg m^{-3})

Receptor Name	Monitor type	Site type	Background NO_2	Monitored total NO_2	Modelled total NO_2	% difference
Whirlies Automatic	CM	R	12.1	36.4	44.4	22%
Kingsway	PDT	R	12.1	48.3	42.5	-12%

Chart 3: Comparison of Monitored NO_2 vs. Modelled NO_2



The comparison indicates that, on average, the model is under-predicting annual mean NO_2 concentrations by approximately 2.8%. This may be due to a number of reasons, for example:

- estimated background concentrations may be incorrect;
- meteorological data may not accurately represent local conditions;
- uncertainties may exist in source activity data, such as traffic flows and emission factors;
- inherent uncertainties or limitations in model input parameters, such as surface roughness length, and
- uncertainties associated with the monitoring data.

Whilst it is considered that the model input data used for the study is the best available data with which to conduct the study, assumptions have been made when compiling the traffic flow data. A review of the model input data was therefore undertaken. Following review, the verified model data was considered to be the best available data with which to represent the local environment.

TG (09) specifies that model predictions should ideally be within 10% of the monitored results. In this case a 2.8% under-prediction is not considered significant; therefore no model adjustment for predicted NO_2 concentrations is required. Although no adjustment of the results is required, the predicted NO_2 concentrations across the study area should be considered in context with the 2.8% over-prediction.

6.6.1.2 PM_{10}

The predicted annual mean PM_{10} concentrations in 2008 were also compared with the 2008/2009 averaged local monitoring data to examine the correlation between the modelled and measured concentrations. The results of this comparison are presented in Table 10.

Table 11 Comparison of modelled and monitored PM_{10} concentrations (μg/m³)

Receptor Name	Monitor type	Site type	Monitored total PM_{10} (μg/m³)	Modelled PM_{10} (μg/m³)	% difference
Whirlies Automatic	CM	Roadside	19.4	20.7	7%

The comparison of modelled annual mean PM_{10} concentrations with monitored PM_{10} indicates an over prediction of 7% which is within the 10% threshold specified in TG(09) as acceptable, with no model adjustment required. The predicted concentrations are however still considered an overestimation. The predicted annual mean PM_{10} concentrations across the modelled study area should be considered in context with the 7% over-prediction.

The review of model input data conducted for the NO_2 verification process concluded that the verified model input data was considered to be the best available data with which to represent the local environment. The 7% over-prediction of PM_{10} concentrations is however greater than the modelled 3% over-prediction of NO_2 concentrations. This may be due to the modelled assumptions made with respect to contributory sources of particulate emissions such as re-suspension of particulate matter, the effects of which are difficult to predict.

6.6.2 Baseline scenario modelling results

Contour plots showing predicted annual mean NO_2 concentrations are presented on Figure 5. The predicted 99.79th percentile of 1-hour mean concentrations is presented on Figure 6. Contour plots showing the predicted annual mean PM_{10} concentrations in 2010 are presented on Figure 7. The predicted annual mean PM_{10} concentrations in 2010 and NO_2 concentrations in 2009 at the specified receptors are presented in Table 12.

Table 12: Baseline scenario-Predicted pollutant concentrations at specified receptors

Receptor	Annual mean NO_2 concentration 2008 (μg m^{-3})	Annual mean PM_{10} concentration 2010 (μg m^{-3})
Wilson Place	41.7	19.3
Whin Place	37.0	18.0
Whin Hill	39.2	18.5
Auto monitor	44.4	20.4
Gullion Park Flats	42.7	20.0

Receptor	Annual mean NO_2 concentration 2008 (µg m^{-3})	Annual mean PM_{10} concentration 2010 (µg m^{-3})
Burns Park	39.3	18.6
Whitemoss Grove	39.9	19.3
Calderwood Road	39.3	18.6
Geddes Hill	38.2	18.1
East mains road	39.2	18.8
Kingsway diff tube	42.5	20.2

7 VALIDATION OF AQMA BOUNDARY

The modelled predictions of annual mean PM_{10} concentrations in 2010 will be used to validate the existing PM_{10} AQMA boundary. Model verification has identified that the model has performed reasonably well when compared to automatic monitoring data and no model adjustment was required. It should however be emphasised that an over-prediction of 7% of the annual mean PM_{10} concentrations across study area occurred, and that the results should be considered in this context.

Examination of Figure 7 indicates that annual mean PM_{10} concentrations are predicted to exceed the 2010 objective of 18 µg m^{-3} at locations within approximately 40 to 45m from the roads modelled, and at up to 70m from the Whirlies roundabout. As several residential properties are present close to the roads modelled, this represents many locations of relevant human exposure which are close to the roads assessed.

The areas at which an exceedence of the 2010 PM_{10} objective is predicted extends further than the existing boundary of the AQMA at many locations. The decision to declare the AQMA therefore remains valid. If the area of exceedence is considered within the context of the 7% over-estimation of annual mean PM_{10} concentrations the area of exceedence reduces to within the current AQMA boundary. Based on the uncertainties in the monitoring data and model verification process, it is not considered appropriate to extend the AQMA at this stage.

Model verification of the predicted annual mean NO_2 concentrations identified that the model is over-predicting by approximately 3%. Although this is not significant enough to require adjustment of the results, the predicted NO_2 concentrations across the study area should be considered with this over-estimation in mind. The predicted annual mean NO_2 concentrations are below the NAQS annual mean objective of 40 µg m^{-3} at all of the specified receptors with the exception of Wilson Place; this is however a commercial property where the long-term NO_2 objective is not applicable. Examination of the contour plot , Figure 5, showing the spatial variation in predicted annual mean NO_2 concentrations does not identify any locations of relevant exposure where concentrations are in excess of the 40 µg m^{-3} objective. As confirmed by modelling future traffic emission scenarios, NO_2

emissions are expected to decrease over time; therefore, based on the modelling study conducted, the NO_2 annual mean objective is not expected to be exceeded in the coming years.

8 FUTURE SCENARIOS

Future road traffic scenarios have been modelled to investigate the effect of expected increases in traffic flows and reductions in vehicle emissions over the next five years. Traffic volumes are predicted to grow by 1.48% per year from 2011- 2015. Emissions factors for NO_2 and PM_{10} from vehicles are expected to reduce annually due to technological advances in vehicle and engine design combined with older, more polluting vehicles being removed from the UK vehicle fleet. This represents a “do-nothing” scenario with respect to managing road traffic emissions.

As it is extremely difficult to quantify the reduction in pollutant concentrations for individual action plan and traffic reduction measures, a holistic approach to assessing future scenarios was considered as the best approach. Traffic volume reduction scenarios have been modelled for 2010 and 2012 to represent the potential changes that may occur if traffic management and action plan measures are implemented successfully i.e. a ”do-something” scenario.

8.1 2011 – 2015 predictions – expected traffic growth scenario

Traffic flows for 2011 to 2015 were extrapolated from 2008 using the NRTF projected growth factor of 1.48% per year. All other road model parameters were identical to those used in the baseline scenario.

The predicted annual mean NO_2 and PM_{10} concentrations at the specified receptors are presented in Table 13 and Table 14 respectively. A reduction in overall NO_2 and PM_{10} concentrations is predicted at all receptors, which reflects the expected reduction in vehicle emissions despite increased traffic flows. The reductions are, however, small and not sufficient to enable the NAQS objective for annual mean PM_{10} concentrations to be met. The predicted reductions in annual mean NO_2 concentrations are also insufficient to meet the annual mean NO_2 objective at all locations of relevant exposure.

Table 13: NO_2 annual mean predictions 2010 – 2015 (µg m^{-3})

Receptor	2010	2011	2012	2013	2014	2015	Reduction
Wilson Place	41.8	41.4	41.2	41.0	40.7	40.6	1.20
Whin Place	37.0	36.9	36.8	36.7	36.6	36.6	0.42
Whin Hill	39.7	39.5	39.3	39.4	39.1	39.0	0.70
Auto monitor	44.7	44.3	43.9	43.6	43.2	43.0	1.75
Gullion Park Flats	44.1	43.7	43.3	43.0	42.7	42.5	1.62
Burns Park	39.1	39.0	38.9	38.9	38.8	38.8	0.54
Whitemoss Grove	39.6	39.5	39.5	39.4	39.3	39.3	0.56
Calderwood Road	39.2	39.1	39.0	38.9	38.8	38.7	0.66
Geddes Hill	38.5	38.4	38.3	38.3	38.1	38.1	0.43
East mains road	39.0	38.8	38.7	38.6	38.5	38.4	0.75

Table 14: PM_{10} annual mean predictions 2010-2015 (µg m^{-3})

Receptor	2010	2011	2012	2013	2014	2015	Reduction
Wilson Place	19.3	19.2	19.2	19.2	19.1	19.1	0.51
Whin Place	18.0	18.0	18.0	18.0	18.0	18.0	0.31
Whin Hill	18.5	18.4	18.4	18.5	18.4	18.4	0.37
Auto monitor	20.4	20.2	20.2	20.2	20.0	20.1	0.61
Gullion Park Flats	20.0	19.8	19.8	19.8	19.7	19.7	0.31
Burns Park	18.6	18.6	18.6	18.6	18.6	18.6	0.02
Whitemoss Grove	19.3	19.3	19.3	19.3	19.3	19.3	0.03
Calderwood Road	18.6	18.6	18.6	18.6	18.6	18.6	0.07
Geddes Hill	18.1	18.1	18.1	18.1	18.1	18.1	0.06
East mains road	18.8	18.8	18.8	18.8	18.8	18.8	0.05

8.2 Effect of Action Plan measures

To examine the effect of the proposed Action Plan measures on improving air quality an attempt was made to quantify the improvements resulting from each measure. The likely improvement associated with each Action Plan measure was debated and discussed within the Action Plan working group and a qualitative descriptor applied. The findings of these evaluations are reported in the Action Plan report.

To quantify the improvement in air quality levels at receptors within the AQMA it was necessary however to determine a tangible reduction in activity levels of emissions sources, particularly from road traffic.

In discussion with the Council Roads Department it was determined that it was impossible to quantify the improvement associated with each individual measure. A pragmatic approach was, therefore, taken whereby various measures were bundled together and a combined improvement assumed. Five scenarios were determined, each based on changes to traffic flow levels based on the 2008 base flow. The scenarios were as follows:

- Restriction of traffic flow growth to 0.5%, 2008 - 2012;
- Maintaining traffic flows as 2008 base level, 2008 - 2012 i.e. 0% growth;
- Reductions of traffic flow of 0.5%, 2008-2012;
- Reduction of traffic flow of 1%, 2008 – 2012; and
- Reduction of traffic flow of 2%, 2008 – 2012.

Amendments to the traffic flow levels for each scenario were made and the emissions inventory recalculated accordingly. The emissions from each scenario were input to the dispersion model and the model re-run to evaluate the impact of each scenario on air quality levels in 2010 and 2012.

All other road model parameters were identical to those used in the baseline scenario.

The results of the dispersion modelling calculations are presented in Tables 15 and 16. It can be observed from the various scenarios in both 2010 and 2012 that traffic flow reductions of up to 2% will be insufficient to reduce annual mean PM_{10} concentrations sufficiently to comply with the 2010 objective of 18 µg m^{-3}.

Table 15: Traffic growth/reduction scenarios PM_{10} annual mean concentrations 2010

Receptor	0.5% growth (µg m^{-3})	Remains at 2008 level (0% growth) (µg m^{-3})	0.5% reduction (µg m^{-3})	1% reduction(µg m^{-3})	2% reduction (µg m^{-3})	Reduction in conc. (µg m^{-3})
Wilson Place	18.48	18.47	18.47	18.44	18.43	0.046
Whin Place	17.67	17.67	17.67	17.66	17.66	0.015
Whin Hill	18.03	18.03	18.02	17.99	17.98	0.052
Auto monitor	18.96	18.95	18.95	18.89	18.88	0.086
Gullion Park Flats	18.76	18.75	18.75	18.66	18.65	0.112
Burns Park	18.02	18.02	18.01	18.01	18.00	0.014
Whitemoss Grove	18.71	18.71	18.70	18.70	18.69	0.014
Calderwood Road	18.00	18.00	18.00	17.99	17.98	0.024
Geddes Hill	17.85	17.84	17.84	17.83	17.83	0.022
East mains road	17.98	17.97	17.97	17.96	17.96	0.021

Table 16: Traffic growth/reduction scenarios PM_{10} annual mean concentrations 2012

Receptor	0.5% growth (µg m^{-3})	Remains at 2008 level (0% growth) (µg m^{-3})	0.5% reduction (µg m^{-3})	1% reduction (µg m^{-3})	2% reduction (µg m^{-3})	Reduction in conc. (µg m^{-3})
Wilson Place	18.4	18.34	18.4	18.3	18.3	0.036
Whin Place	17.6	17.64	17.6	17.6	17.6	0.019
Whin Hill	18.0	17.94	18.0	17.9	17.9	0.045
Auto monitor	18.8	18.75	18.8	18.8	18.7	0.058
Gullion Park Flats	18.6	18.55	18.6	18.5	18.6	0.089
Burns Park	18.0	17.99	18.0	18.0	18.0	0.023
Whitemoss Grove	18.7	18.67	18.7	18.7	18.7	0.026
Calderwood Road	18.0	17.95	17.9	17.9	17.9	0.028
Geddes Hill	17.8	17.80	17.8	17.8	17.8	0.019
East mains road	17.9	17.92	17.9	17.9	17.9	0.051

9 SOURCE APPORTIONMENT

A source apportionment study has been undertaken to investigate the fraction of total PM_{10} attributable to different sources at the Whirlies roundabout AQMA. This was conducted using the "Groups" feature of ADMS-Roads; separate groups are created to include different sources, the model then predicts pollutant concentrations as a result of emissions from each group. The groups which were included in the model were:

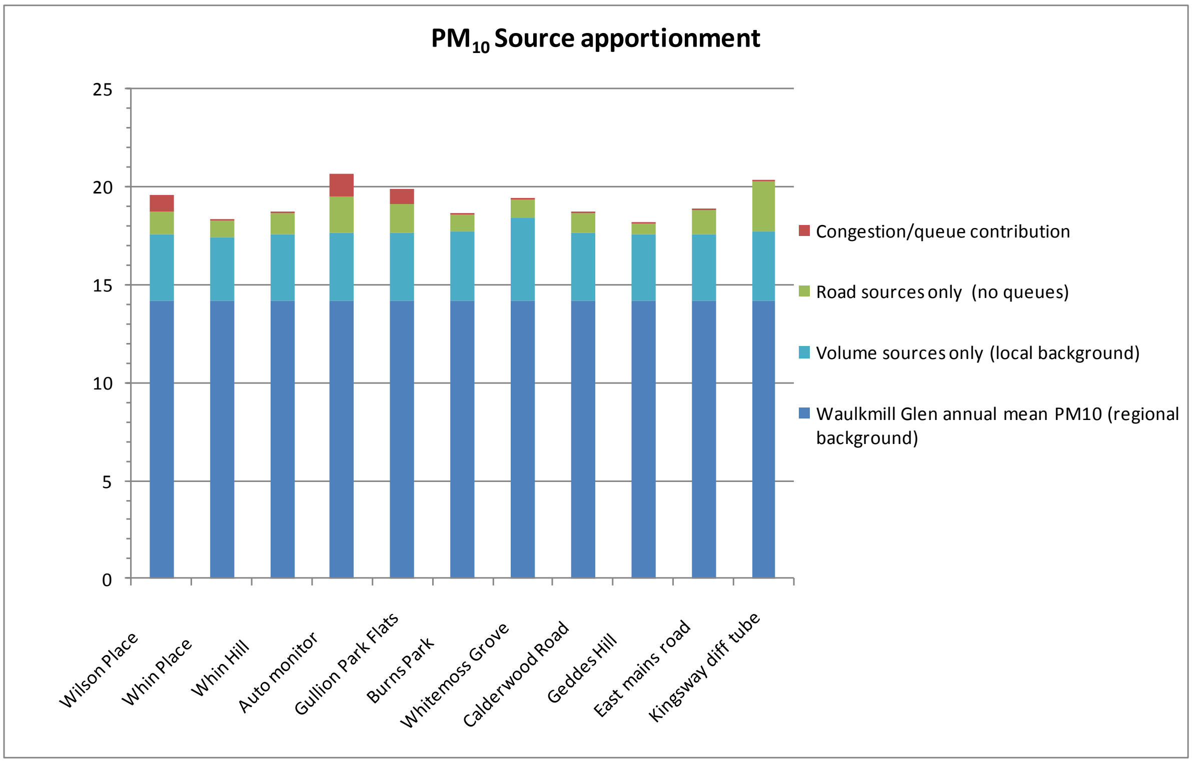
- All sources
- Volume sources only (local non road traffic emissions)
- Roads only (no queuing traffic)
- Roads only (with queues)

This allowed calculation of the fraction of the total predicted PM_{10} annual mean attributable to the following sources:

- Regional background
- Volume sources (i.e. local non-road traffic sources)
- Road sources only (with queuing traffic excluded); and
- Queuing traffic only

To demonstrate the contribution of each source to annual mean PM_{10} concentrations at the receptors specified in the study, PM_{10} concentrations attributable to each source are presented in the bar chart below. The chart indicates that road sources contribute only a small fraction of total PM_{10} concentrations at the specified receptor locations with the majority of PM_{10} attributable to regional background and local non-road sources. The combined regional and local background PM_{10} concentrations are close to the 2010 annual mean objective of 18 µg m^{-3} at all of the specified receptors.

The effect of queuing or congested traffic is greatest at the receptor locations closest to the roundabout and is negligible at locations away from the modelled queues.



The source apportionment study demonstrates that reduction of traffic emissions alone is unlikely to enable compliance with the 2010 PM_{10} annual mean objective. This supports the findings of the traffic reduction scenario modelling described in Section 8.1. Reduction of other local sources of PM_{10} is likely to be required to enable compliance with the objective.

10 CONCLUSIONS

Analysis of local monitoring data at Whirlies roundabout indicates an improvement in air quality in 2009, an improvement that is attributed to a reduction in traffic flows associated with the economic downturn. Whilst this improvement is welcomed it is anticipated that this may be a short-lived improvement and that it is expected that air quality will deteriorate again as traffic flows increase as the economy recovers.

Due to the assumed temporary improvement in air quality levels the study considered air quality over a two-year period, i.e. analysed the average annual mean concentrations for the period 2008-09. The two-year average measured mean PM_{10} concentrations was found to be above the 2010 objective level, however measured NO_2 concentrations were below objective levels.

To evaluate the validity of the approach to monitoring data, and to examine the spatial extent of any exceedence of NAQS objectives a dispersion modelling study of local emissions sources was undertaken. The dispersion modelling study utilised emissions data compiled in an inventory of local emissions sources.

The results of the dispersion modelling study have indicated that there are likely to be no predicted exceedences of the NO_2 objectives at a location of relevant public exposure, therefore there is no requirement to declare an AQMA for NO_2.

Modelling predictions of PM_{10} concentrations has confirmed that the declaration of the AQMA is valid and that the boundary that has been set should be maintained. Annual mean PM_{10} concentrations are predicted to exceed the 2010 objective of 18 µg m^{-3} at locations within approximately 40-45m from the roads modelled, and at up to 70m from the Whirlies roundabout. This represents many locations of relevant human exposure which are close to the roads assessed.

The source apportionment study has indicated that volume sources are the most significant source of PM_{10} concentrations. Road traffic is the dominant source of PM_{10} concentrations at roadside locations while at background locations, volume sources are a more significant source of both PM_{10} and NO_2 concentrations.

Analysis of the likely effect of Action Plan measures on traffic flows in and around the AQMA indicate that a modest reduction in traffic flows will occur. The reduction in traffic flows will result in a small improvement in PM_{10} concentrations within the AQMA, however the improvements will not be sufficient to allow the 2010 annual mean objective level to be met by 2012.