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REPORT

Further Assessment of Air Quality including Detailed Dispersion Modelling and Source Apportionment in relation to Air Quality Management within Chesterfield

Prepared for

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Chesterfield
BOROUGH COUNCIL

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EXECUTIVE SUMMARY

Chesterfield Borough Council intended to declare an Air Quality Management Area (AQMA) because previous air quality assessments had indicated that concentrations of Nitrogen Dioxide (NO_2) were predicted to exceed the air quality objectives. These exceedances of the air quality objectives for NO_2 were predicted at locations along the most heavily trafficked routes, but recent measurements, using diffusion tubes also appeared to indicate additional hot spots. A further detailed assessment was therefore commissioned with the aim of defining the extent of the problem and to provide information to assist in any future measures to improve air quality within the Borough and so ensure compliance with the air quality objectives.

This report details the finding of this further assessment of air quality within Chesterfield and is based on detailed dispersion modelling together with a detailed review of all recent monitoring data within the Borough. In addition to the assessment of air quality, this study also included a source apportionment assessment to determine the key sources of pollution and to inform the action plan or any subsequent measures to improve air quality in the area. The main findings and recommendations from this assessment are as follows.

Data from the two air quality stations operated by the Council (which form part of the national Automatic Urban and Rural Network) were examined and found to be largely consistent with data from other neighbouring stations. This was true both for NO_2 and fine particulate matter (PM_{10}'s and $PM_{2.5}$'s); it therefore appears that at least at the monitoring locations, a large proportion of the pollution is regional rather than local. It was also found that none of the data (for NO_2 or particulate matter) obtained from the continuous analysers exceeded any of the air quality objectives.

A total of 38 diffusion tubes are also used within Chesterfield to monitor NO_2 concentrations. Data from these tubes were therefore examined and checked against data from the continuous analysers. As is the accepted practice, diffusion tubes co-located with each analyser were used to calculate bias factors for the diffusion tube data. For the roadside analyser using the data for 2009, a bias factor of 0.7 was derived, whereas for the background analyser, the bias factor was 0.9. This latter bias factor (0.9) is the same as that contained in the national data base of diffusion tube bias factors for similar tubes deployed elsewhere in the UK and this was the factor that had been used to adjust the diffusion tube data in Chesterfield.

The bias factor of 0.7 is, however, the most appropriate factor to be used because most of the tubes are located close to the roads, and because it was determined from the continuous analyser which forms part of the national monitoring network. In addition, any attempt to use bias factors similar to that contained in the national database would lead to diffusion tube data which would be

inconsistent with the continuous monitoring data and by implication, inconsistent with that from neighbouring AURN stations also.

The correctly adjusted diffusion tube data indicate that there were no exceedances of the air quality objectives for NO_2 in 2009, but there were a few locations where elevated levels of NO_2 concentrations were obtained.

Dispersion modelling was conducted using the ADMS Roads model. The model included all of the major roads and heavily trafficked areas and was more detailed than any of the previous modelling studies conducted in Chesterfield, but used traffic data that were consistent with those used in previous studies. Modelling was conducted in accordance with the recommendations set out in the technical guidance for Local Air Quality Management (TG09). As such, the model was verified by comparing the modelled data for 2009 with the monitoring data for the same period. Reasonably good agreement was obtained between the modelled results and those obtained from the monitoring with a root mean square error of 2.23 $\mu g/m^3$ in the modelled concentrations, suggesting that the model could be used with confidence for this assessment.

NO_2 concentrations predicted by the model did not exceed the air quality objectives at any location where the objectives apply. Elevated levels of NO_2 concentrations were found at roundabouts, busy intersections and at areas of traffic congestion, but the highest concentrations were on the roads themselves where the objectives do not apply.

This finding differs from the earlier modelling studies, despite similar traffic and input data being used. This is due, at least in part, to the previous studies using background levels of NO_X and NO_2 concentrations which were higher than those believed to be valid for 2009. In the present study the most recent data for background concentrations were used and these were found to be consistent with the background data obtained from the background analyser. The findings of this study, based both on monitoring data, and dispersion modelling, is therefore that the air quality objectives are not being exceeded. Further, given current projections in traffic growth and vehicle emissions, it is unlikely that air quality objectives will be exceeded in future.

A source apportionment study was also conducted, and it was found that within Chesterfield as a whole, road transport accounted for some 35% of all NO_X emissions. Other significant sources of NO_X emissions within the Borough were Industrial Combustion (25%), Other Transport (22%) and Commercial, Institutional and Residential Combustion (17%). It was also found that within Chesterfield, not surprisingly, the areas where road transport produced the highest concentrations were within the City Centre and along the major roads and heavily trafficked routes. Further, these were also the areas where the highest NO_2 concentrations were obtained.

There were two locations outside the City Centre where high NO_2 concentrations were obtained; there were both on hills and in one case close to a roundabout and in the other, close to a junction. The source apportionment assessment indicated that, at these two locations HGV's were responsible for more than 50% of emissions even though HGV traffic was less than 5% of the total traffic flow. Improvements at these locations can therefore be made by reducing HGV traffic and / or by improving traffic flow.

The contribution of HGV's to NO_X emissions at hot spots within the City Centre was still relatively high, but several other factors contributed to the elevated concentrations; these included the volume of traffic and congestion. The most practical method of improving air quality at these locations therefore appears to be to reduce congestion and increase traffic flow.

No other pollutants, including fine particulate matter, were found to be in danger of exceeding their air quality objectives.

It is recommended that a thorough review should be conducted of each monitoring location to ensure that any local factors that are likely to affect or influence the measurements be noted. If possible additional monitoring should also be conducted at the hot spots identified.

It is also recommended that traffic flow assessments be conducted at the hot spots to supplement the source apportionment study and that this information be used to develop possible mitigation measures to ensure that air quality within the Borough is well managed.

1. INTRODUCTION

1.1 Chesterfield Borough Council (CBC) is contemplating the declaration of an Air Quality Management Area (AQMA). The area, shown in Figure 1.1, was derived from dispersion modelling studies conducted during the detailed assessment which formed part of the Local Air Quality Management (LAQM) Assessment and Review process. That assessment [1], conducted in 2007, found that concentrations of nitrogen dioxide (NO_2) were exceeding air quality objectives at the time and that they would continue to exceed the objectives in 2010.

1.2 In addition to recommending the declaration of an AQMA, the study also recommended continued monitoring and that a further detailed assessment be conducted. Since that study was performed, monitoring of NO_2 by diffusion tubes have continued and these measurements have, at least in part, supported the findings of the original detailed assessment. In addition, the most recent diffusion tube measurements have indicated a possible hot spot at a location not currently included within the proposed AQMA boundary. This was in Compton Street, close to the junction with Saltergate.

1.3 CBC therefore commissioned this further detailed assessment, aimed at assessing air quality within and around the originally proposed AQMA as well as the other areas (such as the Compton Street area) identified as possible hot spots from recent diffusion tube measurements. The work commissioned also include an examination of the contributions form the various sources (a source apportionment study) in order to inform the action plan or any subsequent measures to improve air quality in the area.

1.4 The study is based on detailed dispersion modelling together with an examination of recent air quality monitoring data. Further, since it has been demonstrated by previous assessments that the prime source of concern is NO_2, resulting from vehicular traffic, this study focuses on NO_2, but particulate matter (PM_{10}) has also been examined as it is understood this was identified in early assessments, as another pollutant of concern in Chesterfield. This assessment therefore focuses on all areas within Chesterfield where recent studies or measurements have indicated the possibility of elevated levels of air pollution due to traffic.

1.5 The assessment starts with a review of current air quality in Chesterfield and draws on the available monitoring data. It then introduces results from detailed modelling to present a comprehensive assessment of the current and likely future air quality in Chesterfield. A source apportionment investigation is then undertaken to show the contribution of the various source categories.

2. BACKGROUND

2.1 Legislative Aspects

2.1.1 Part IV of the Environment Act 1995 requires Local Authorities to periodically review and assess air quality in their area. The review and assessment must consider both the current state of air quality and that likely in future, with the overall aim being to ensure that national air quality objectives will be met. If the review process shows that the air quality objectives are not likely to be met, either at present or in future, at any location where members of the public are likely to be present, then the Local Authority must declare the location as an Air Quality Management Area (AQMA). An action plan for the location must then be prepared, and it should provide a clear statement and procedures for improving air quality and hence achieving the air quality objectives. This is in effect, part of the process of Local Air Quality Management (LAQM) introduced by the 1995 Environment Act.

2.1.2 The air quality objectives are set out in the National Air Quality Strategy as contained initially in the Air Quality Regulations in 2000 [2], but which have since been amended, first in 2002 [3], then in 2007 [4]. The latter, the Air Quality Standards Regulation 2007, will be revoked by the 2010 Regulations [5] which will soon come into force. Table 2.1 below shows air quality objectives as set out in the 2007 Regulations, and Table 2.2 shows the latest limit values as applicable to England as published in the 2010 Regulations. The 2010 Regulations also include target values for other pollutants and long term objectives for ozone.

2.1.3 With regards to the two pollutants of interest in Chesterfield, i.e., those for which concerns have been expressed in the past, namely NO_2 and PM_{10}, the air quality standards as set out in the 2010 Regulations are the same as they were in 2007. The new Regulations do not therefore impact directly on air quality within Chesterfield.

Table 2.1 The Air Quality Objectives as contained in the 2007 Regulations.

UK Air Quality Objectives for protection of human health, July 2007			
Pollutant	**Air Quality Objective**		**To be achieved by**
	Concentration	**Measured as**	
Benzene			
All authorities	16.25 µg m^{-3}	Running annual mean	31 December 2003
England and Wales Only	5.00 µg m^{-3}	Annual mean	31 December 2010
1,3-Butadiene	2.25 µg m^{-3}	Running annual mean	31 December 2003
Carbon Monoxide			
England, Wales and N. Ireland	10.0 mg m^{-3}	Maximum daily running 8-hour mean	31 December 2003
Lead	0.5 mg m^{-3}	Annual mean	31 December 2004

	0.25 mg m^{-3}	Annual mean	31 December 2008
Nitrogen Dioxide	200 µg m^{-3} not to be exceeded more than 18 times a year	1-hour mean	31 December 2005
	40 µg m^{-3}	Annual mean	31 December 2005
Particles (PM10) (gravimetric)	50 µg m^{-3}, not to be exceeded more than 35 times a year	24-hour mean	31 December 2004
	40 µg m^{-3}	Annual mean	31 December 2004
PM10 *	20 µg m^{-3}	Annual mean	31 December 2010
Particles (PM2.5) (gravimetric) *	25 µg m^{-3} (target)	Annual mean	2020
All authorities	15% cut in urban background exposure	Annual mean	2010 - 2020
Sulphur dioxide	350 µg m^{-3}, not to be exceeded more than 24 times a year	1-hour mean	31 December 2004
	125 µg m^{-3}, not to be exceeded more than 3 times a year	24-hour mean	31 December 2004
	266 µg m^{-3}, not to be exceeded more than 35 times a year	15-minute mean	31 December 2005
PAH *	0.25 ng m^{-3}	Annual mean	31 December 2010
Ozone *	100 µg m^{-3} not to be exceeded more than 10 times a year	Daily maximum of running 8-hour mean	31 December 2005

Table 2.1 continued

UK Air Quality Objectives for protection of vegetation and ecosystems, July 2007 objectives highlighted in shading			
Pollutant	**Air Quality Objective**		**To be achieved by**
	Concentration	**Measured as**	
Nitrogen dioxide (for protection of vegetation & ecosystems) *	30 µg m^{-3}	Annual mean	31 December 2000
Sulphur dioxide (for protection of vegetation & ecosystems) *	30 µg m^{-3} 30 µg m^{-3}	Annual mean Winter Average (Oct - Mar)	31 December 2000
Ozone *	18 µg m^{-3}	$AOT40^{+}$, calculated from 1h values May-July. Mean of 5 years, starting 2010	01 January 2010

*** not included in regulations at present**

$^{+}$ AOT 40 is the sum of the differences between hourly concentrations greater than 80 µg m^{-3} (=40ppb) and 80 µg m^{-3}, over a given period using only the 1-hour averages measured between 0800 and 2000.

Table 2.2 The Air Quality Standards (based on the 2010 Regulations)

Pollutant	Averaging Period	Limit Value	Margin of Tolerance	Date by which is to be met
Sulphur Dioxide (SO_2)	1 hour	350 μg/m^3 not to be exceeded more than 24 times a calendar year	150 μg/m^3 (43%)	Current
	One day	150 μg/m^3 not to be exceeded more than 3 times a calendar year		Current
Nitrogen Dioxide (NO_2)	1 hour	200 μg/m^3 not to be exceeded more than 18 times a calendar year		Current
	Calendar Year	40 μg/m^3		Current
Benzene	Calendar Year	5 μg/m^3		Current
Carbon Monoxide	Maximum daily 8 hour running mean	10 mg/m^3		Current
Lead	Calendar Year	0.5 μg/m^3	100%	Current
PM_{10}	One day	50 μg/m^3 not to be exceeded more than 35 times a calendar year	50%	Current
	Calendar Year	40 μg/m^3	20%	Current
$PM_{2.5}$	Calendar Year	25 μg/m^3	20%[1]	1 January 2015

1. 20% on 11 June 2008 decreasing on the next 1 January and every 12 months thereafter by equal annual percentages to reach 0% by 1 January 2015

2.2 Historical Perspective

2.2.1 In common with Local Authorities throughout the country, CBC conducted their first, second and third round of reviews and assessments. The first round of reviews, conducted in 2003 [6], concluded that NO_2 and PM_{10}, were at risk of exceeding their air quality objectives at the time; a detailed assessment was therefore recommended. This was conducted in 2004 [7] and concluded that the two pollutants in question should be kept under close review and that monitoring be continued, but no further immediate action be taken. The subsequent Progress Report in 2005 [8] reported new monitoring data and pointed to additional possible hotspots in the Borough.

2.2.2 The 2006 Updating and Screening assessment [9] included a full review of all pollutants and all data available at that time. The conclusion from that assessment was that a detailed assessment should be conducted because NO_2 concentrations were exceeding the objectives at three locations within the Borough. It was believed that the elevated levels of NO_2 were due to high levels of traffic coupled with congestion, particularly at rush hour. None of the other pollutants were found to be at risk of exceeding their objectives, but at Whittington Moor, elevated levels of PM_{10} were also measured. These PM_{10} levels did in fact, exceed the provisional objectives applicable at that time.

2.2.3 The detailed assessment [1], conducted by Bureau Veritas, focussed on the three areas identified during the 2006 Updating and Screening Assessment; these were the A61 Derby Road and expressway, the A619 Chesterfield Road, and the A619

Chatsworth – Markham Road. These areas are shown in Figure 2.1 taken from Bureau Veritas' report on the detailed assessment. The study predicted that NO_2 concentrations would be exceeded at several locations in the Borough, mainly, along the most heavily trafficked routes as modelled. As a result, it was recommended that an Air Quality Management Area (AQMA) be declared and the proposed area was that shown in Figure 1.1. It was also recommended that monitoring of NO_2 be continued and that a further assessment be conducted at a later stage.

2.2.4 Since the detailed assessment in 2007, progress reports and updating and screening assessments have been conducted; the latest of which is the USA conducted in April 2009 [10]. That assessment confirmed that up to 2008, there were still areas where, based on the diffusion tube data, air quality objectives were being exceeded. In fact, exceedances were obtained at three locations, two of which were within the previously proposed AQMA, but a third location was also found to experience levels of NO_2 which exceeded the air quality standards. This was in Compton Street, close to the junction with Saltergate. A further site at Whittington Hill was identified in the USA [10] as being within 10% of the annual objective for NO_2 hence has been included in this detailed assessment.

2.2.5 In summary therefore, the last few round of Reviews and Assessments has pointed to the exceedance of the air quality objectives for NO_2 in a number of areas within the Borough; initially, along the most trafficked routes of the A61 and A619, but in 2008, the possibility of an additional area exceeding the NO_2 objectives also came to light. None of the other pollutants were exceeded, though historically, a close watch has been kept on PM_{10}. The following section examines the current state of air quality in the Borough.

3. AIR QUALITY MONITORING IN CHESTERFIELD

3.1 Continuous Monitoring

3.1.1 Chesterfield Borough Council (CBC) operates two automatic monitoring stations. These stations are in fact part of the Automatic Urban and Rural Network (AURN) and as a result, the stations are maintained and operated in strict accordance with the required data collection and quality assurance procedures that applies to all national monitoring stations. This includes a routine maintenance service every six months as well as a six-month audit by AEA Energy and Environment in addition to the fortnightly visit by the Local Site Operator (LSO). The LSO is an Environmental Health Officer from CBC, who has been fully trained to conduct the LSO duties such as performing calibrations and routine checks and maintenance such as filter replacements.

3.1.2 Results are submitted to AEA for verification after each calibration. The data is also downloaded on a daily basis by AEA Energy and Environment, who then validate and ratify the raw data and provide ratified data reports to Chesterfield Borough Council on a monthly basis. Since both stations received AURN status in 2008, Bureau Veritas also now download the data on a daily basis and check for any faults with the analysers. The data is also available on the national ar quality website at www.airquality.co.uk.

3.1.3 One of these stations is an Urban Background station, located adjacent to the Pavilion at Queens Park Annexe sport Ground in Chesterfield (OS coordinates 437909E, 370545N). The other is a Roadside station located adjacent to number 461 of the A619 Chatsworth Road (OS coordinates, 436349E, 370657N). Figure 3.1 shows the Roadside station, located some 5m from the kerb.

3.1.4 The Roadside station monitors NO, NO_x and NO_2 as well as PM_{10}, $PM_{2.5}$ and Benzene, and the background station monitors NO, NO_x, NO_2, PM_{10} and $PM_{2.5}$. Continuous monitoring of most of these pollutants has been conducted in Chesterfield for a number of years but the analysers were moved to their current locations on 13 March 2008.

3.1.5 Continuous monitoring is supplemented by a series of diffusion tube measurements of NO_2. Currently, thirty eight (38) tubes (including the two sets of triple co-located tubes at each monitoring station) are deployed throughout the borough. The tubes (50% TEA in Acetone) are supplied and analysed by South Yorkshire Laboratories, who are accredited for such analysis. Diffusion tube monitoring of NO_2 in Chesterfield has been conducted for a number of years.

3.1.6 As mentioned above, the analysers used for continuous monitoring (which from part of the AURN) were moved to their present location in March 2008. The following therefore summarises and discusses data from April 2008 to the end of 2009. These data are summarised below in Tables 3.1 and 3.2 for the background and roadside analysers in 2008 respectively; data for 2009 are summarised in Tables 3.3 and 3.4.

3.1.7 Because of the relocation of the analysers in March 2008, the data capture for 2008 was only 74% for NO_2 and is therefore less than that recommended for assessing annual average NO_x concentrations with confidence. However, the data capture for 2009 was in excess of 95% for NO_x and in excess of 90% for PM_{10}. The 2009 data can therefore be used with confidence.

3.1.8 It is also worth noting that $PM_{2.5}$ monitoring began in December 2008 for the background analyser and in July 2009 for the roadside analyser. At this time the volatile and non-volatile fractions of PM_{10} and $PM_{2.5}$ were also available. These data are discussed in subsequent sections, suffice to say that none of the air quality standards for NO_2 or PM_{10} were exceeded at the two locations at which continuous monitoring data were available.

Table 3.1 Data for the Background analyser for 2008

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All Year
Percentage data capture (NO_X)	ND	ND	ND	95.4	95.6	95.3	67.6	73.1	99.4	99.6	99.6	99.2	73.7
Percentage data capture (PM_{10})	ND	ND	ND	99.2	99.7	99.4	97.4	98.9	98.9	99.5	81.8	83.9	76.7
Average NO	ND	ND	ND	4.0	3.1	2.4	2.3	2.9	6.2	4.7	7.0	11.8	5.1
Average NO_2	ND	ND	ND	16.9	22.9	12.5	10.8	10.2	20.1	16.6	21.5	25.6	17.8
Average NO_X	ND	ND	ND	22.8	27.6	16.1	14.2	14.5	29.4	23.7	32.0	43.5	25.5
Hourly Average PM_{10}	ND	ND	ND	21.4	29.5	18.5	18.8	15.6	20.2	15.7	17.3	20.3	19.6
Maximum NO_2	ND	ND	ND	59.0	74.0	55.0	46.0	44.0	73.0	69.0	67.0	82.0	82.0
Maximum NO_X	ND	ND	ND	197.0	128.0	96.0	96.0	97.0	199.0	195.0	285.0	418.0	418.0
Maximum hourly PM_{10}	ND	ND	ND	73.0	101.0	48.0	73.0	52.0	65.0	59.0	118.0	70.0	118.0
Maximum 24 Hour PM_{10}	ND	ND	ND	42.3	49.4	27.8	40.5	31.8	34.4	26.1	33.8	49.7	49.7
99.79 percentile NO_2	ND	ND	ND	---	---	---	---	---	---	---	---	---	69.0
Standard deviation NO_2	ND	ND	ND	12.2	13.2	10.0	9.2	8.7	13.1	14.4	15.1	17.9	14.1
Standard deviation NO_X	ND	ND	ND	20.8	17.8	13.7	13.6	12.8	26.4	26.0	35.2	54.4	29.6
Non Volatile PM_{10}	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	19.2	19.2
Non Volatile $PM_{2.5}$	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	13.6	13.6
$PM_{2.5}$	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	17.4	17.4
Volatile PM_{10}	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.6	3.6
Volatile $PM_{2.5}$	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.7	3.7

Table 3.2 Data for the Roadside analyser for 2008

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All Year
Percentage data capture (NO_X)	ND	ND	ND	95.0	90.6	87.5	98.8	69.0	94.7	99.1	98.2	99.2	72.6
Percentage data capture (PM_{10})	ND	ND	ND	92.4	83.1	98.8	98.7	99.1	99.4	96.8	98.1	99.3	76.8
Average NO	ND	ND	ND	18.1	14.7	13.5	15.1	15.1	19.6	18.6	16.0	26.5	17.5
Average NO_2	ND	ND	ND	21.8	22.7	14.4	18.8	16.1	25.3	21.9	23.0	32.4	21.9
Average NO_X	ND	ND	ND	49.1	45.0	34.8	41.6	38.9	54.9	50.1	47.2	72.8	48.4
Hourly Average PM_{10}	ND	ND	ND	25.1	34.9	25.3	28.8	23.8	27.9	24.2	24.7	27.6	26.7
Maximum NO_2	ND	ND	ND	78.0	86.0	57.0	69.0	65.0	74.0	82.0	96.0	117.0	117.0
Maximum NO_X	ND	ND	ND	279.0	216.0	157.0	187.0	227.0	248.0	336.0	365.0	399.0	424.0
Maximum hourly PM_{10}	ND	ND	ND	124.0	99.0	88.0	131.0	62.0	70.0	91.0	133.0	88.0	133.0
Maximum 24 Hour PM_{10}	ND	ND	ND	47.2	56.0[1]	33.3	49.0	40.2	41.8	33.9	42.1	49.7	56.0
99.79 percentile NO_2	ND	ND	ND	---	---	---	---	---	---	---	---	---	88.0
Standard deviation NO_2	ND	ND	ND	14.5	14.5	10.2	12.3	10.5	15.0	16.7	18.3	21.9	16.2
Standard deviation NO_X	ND	ND	ND	42.5	31.2	27.7	30.7	30.4	42.8	47.5	53.4	67.5	45.3

[1] Daily PM_{10} exceeded 50 $\mu g/m^3$ 3 times during the month.

Table 3.3 Data for the Background Analyser for 2009

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All Year
Percentage data capture (NO_X)	99.3	99.3	97.2	95.4	99.9	98.5	98.9	78.0	89.9	93.8	94.9	99.2	95.3
Percentage data capture (PM_{10})	96.0	100.0	99.3	99.0	99.9	99.2	92.3	98.4	98.6	52.4	67.1	99.9	91.8
Average NO	9.0	10.7	6.5	4.5	2.9	4.4	3.3	6.7	6.5	14.3	8.1	17.3	7.9
Average NO_2	30.2	29.5	17.1	22.6	11.9	14.2	12.0	10.8	12.8	20.5	17.7	27.5	19.0
Average NO_X	43.9	45.8	26.9	29.4	16.1	20.8	16.9	20.8	22.4	42.2	29.9	53.7	30.9
Hourly Average PM_{10}	23.7	20.3	22.1	28.4	13.4	15.9	10.0	11.1	12.9	16.6	17.7	18.6	17.6
Maximum NO_2	92.0	97.0	80.0	76.0	55.0	59.0	55.0	34.0	48.0	65.0	73.0	97.0	97.0
Maximum NO_X	344.0	275.0	363.0	136.0	74.0	147.0	139.0	80.0	143.0	386.0	374.0	590.0	590.0
Maximum hourly PM_{10}	80.0	96.0	183.0	148.0	47.0	53.0	35.0	50.0	53.0	40.0	132.0	79.0	183.0
Maximum 24 Hour PM_{10}	63.3	49.0	64.8	60.1	27.2	30.5	22.8	16.2	26.1	29.2	46.3	39.8	64.8
No. Of times Daily PM10 > 50 $\mu g/m^3$	1	0	3	2	0	0	0	0	0	0	0	0	6
99.79 percentile NO_2	---	---	---	---	---	---	---	---	---	---	---	---	82.0
Standard deviation NO_2	17.8	19.1	16.4	13.0	8.6	8.7	8.3	5.3	7.1	12.5	14.8	20.2	15.3
Standard deviation NO_X	41.3	43.6	38.2	19.7	11.2	13.7	15.5	10.7	14.0	41.8	38.9	69.5	37.1
Non Volatile PM_{10}	18.8	16.0	17.7	22.1	11.0	13.2	7.9	9.2	10.9	13.3	14.0	14.6	14.1
Non Volatile $PM_{2.5}$	13.7	12.0	11.8	17.4	7.5	8.5	5.1	6.1	6.5	10.2	10.4	10.0	10.1
$PM_{2.5}$	18.3	16.2	16.2	25.0	10.1	11.6	7.5	8.4	8.4	13.1	13.8	13.2	13.6
Volatile PM_{10}	4.9	4.2	4.3	6.1	2.4	2.7	2.1	1.9	1.9	3.3	3.7	4.0	3.4
Volatile $PM_{2.5}$	4.5	4.3	4.4	7.5	2.5	3.1	2.4	2.3	1.9	2.9	3.4	3.1	3.6

Table 3.4 Data for the Roadside Analyser for 2009

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	All Year
Percentage data capture (NO_X)	99.3	98.7	99.5	97.8	90.7	96.5	95.8	96.9	95.3	99.5	98.9	94.1	96.9
Percentage data capture (PM_{10})	99.5	98.8	99.5	95.6	78.9	66.0	81.3	96.5	88.8	99.1	97.4	99.3	91.7
Average NO	24.8	22.4	19.8	19.4	12.7	13.9	14.2	13.9	14.8	25.1	22.0	29.3	19.4
Average NO_2	33.8	27.7	16.4	19.3	14.2	17.2	12.7	13.7	14.8	23.5	21.7	32.3	20.6
Average NO_X	71.4	61.6	46.4	48.8	33.3	38.2	34.2	34.7	37.2	61.6	55.0	76.9	50.1
Hourly Average PM_{10}	23.3	21.6	25.8	25.0	10.0	11.5	8.5	10.0	10.5	15.5	12.6	13.9	16.0
Maximum NO_2	113.0	84.0	65.0	65.0	53.0	61.0	48.0	46.0	57.0	80.0	76.0	84.0	113.0
Maximum NO_X	487.0	327.0	386.0	231.0	143.0	155.0	178.0	189.0	178.0	393.0	456.0	443.0	487.0
Maximum hourly PM_{10}	105.0	146.0	157.0	73.0	36.0	37.0	32.0	27.0	52.0	44.0	163.0	70.0	163.0
Maximum 24 Hour PM_{10}	43.8	37.9	51.5[2]	49.8	24.0	18.0	16.4	16.0	22.1	30.7	35.5	29.9	51.5
99.79 percentile NO_2	---	---	---	---	---	---	---	---	---	---	---	---	84.0
Standard deviation NO_2	21.8	17.7	12.6	10.8	10.1	11.4	8.7	8.0	10.2	15.8	16.2	20.3	16.0
Standard deviation NO_X	62.0	53.5	45.1	36.1	24.1	27.3	26.5	25.3	28.9	53.3	54.6	72.1	47.6
Non Volatile PM_{10}	ND	ND	ND	10.7	9.8	11.0	7.7	9.5	10.3	14.0	11.5	12.4	10.9
Non Volatile $PM_{2.5}$	ND	ND	ND	ND	ND	ND	5.3	5.7	6.2	9.9	9.0	9.2	7.6
$PM_{2.5}$	ND	ND	ND	ND	ND	ND	7.0	7.2	7.9	12.8	11.8	12.1	9.8
Volatile PM_{10}	ND	ND	ND	2.4	0.1	0.5	0.7	0.5	0.2	1.5	1.1	1.6	0.8
Volatile $PM_{2.5}$	ND	ND	ND	ND	ND	ND	1.7	1.4	1.7	3.0	2.8	2.8	2.2

[2] Daily PM_{10} exceeded 50 $\mu g/m^3$ once only during the month

3.2 Nitrogen Dioxide

3.2.1 Nitrogen dioxide concentrations from the continuous analyser are summarised below in Table 3.5. It is clear from these data that at these locations, neither the annual mean nor the short term (hourly) air quality standards for nitrogen dioxide (NO_2) were exceeded at the locations measured. In fact, with regards to NO_2, surprisingly, both the roadside and the background analyser had similar results. This is readily apparent in Figure 3.2 where the monthly average NO_2 concentrations at the background and roadside analysers from April 2008 to December 2009 are compared. Evidently, both sites showed the same trends over time and although the roadside analyser generally produced higher NO_2 concentrations, there were a few months when this was not the case.

3.2.2 In contrast, Figure 3.3 shows that the NO_x levels at the roadside station were notably higher than those at the background station. The similarity in NO_2 concentrations at the two sites despite the difference in NOx concentrations suggests that the conversion of NO_x to NO_2 at the roadside and background sites were quite different. This point will be discussed further later in the report.

Table 3.5 Summary of data from the continuous analysers for oxides of nitrogen

	Percentage data Capture	Annual Average NO_X	Maximum 1-Hr NO_X	Annual Average NO_2	Maximum 1-Hr NO_2	99.79th Percentile of NO_2
Background (2008)	73.7	25.5	418	17.8	82	69
Roadside (2008)	72.6	48.4	424	21.9	117	88
Background (2009)	95.3	30.9	590	19	97	82
Roadside (2009)	96.9	50.1	487	20.6	113	84

3.2.2 Finally, the data obtained in Chesterfield from the continuous analysers were compared to those from other stations within the national monitoring network, that were within 50 km of Chesterfield and which had data for 2009. Four stations were identified; the type of station and their distance from Chesterfield are as summarised below in Table 3.6. Monthly averaged NO_2 data from these stations are compared with those obtained from the background and roadside stations in Chesterfield in Figure 3.4.

Table 3.6 Continuous monitoring stations within 50km of Chesterfield

Station	**Type**	**Distance from Chesterfield Roadside station (km)**
Sheffield Centre	Urban Centre	16.3
Ladybower	Rural	27.4
Barnsley Gawber	Urban Background	37.0
Nottingham Centre	Urban Centre	37.2

3.2.3 Not surprisingly, Ladybower, the rural site, reported the lowest concentrations, whereas Sheffield centre and Nottingham Centre experienced the highest concentrations. Barnsley Gawber, an urban background site, reported concentrations similar to those in Chesterfield. Further, the sites all tended to show a similar variation in average concentration over time. In fact, examination of the time histories of NO_2 concentrations in Chesterfield with those from Barnsley Gawber, show a remarkably similar variation; this is clearly demonstrated in Figure 3.5 where the time histories for January are compared. These comparisons tend to confirm that the authenticity of the data obtained from the continuous analysers in Chesterfield, and provide added confidence in their use.

3.2.4 As mentioned above, Chesterfield Borough Council (CBC) also monitor NO_2 using a number of diffusion tubes and as is the common practice, three tubes are co-located with each analyser so that bias factors can be obtained for the diffusion tubes. The data from the co-located tubes were therefore used to determine the bias factors for the tubes. Figures 3.6 and 3.7 show the data obtained from the diffusion tubes co-located with the roadside analyser, for the period April 2008 to December 2009; figures 3.6 shows results for each tube whereas figure 3.7 shows the average of the three tubes.

3.2.5 The bias factor is simply the ratio of the concentration obtained from the continuous analyser to that obtained from the co-located diffusion tubes with all data averaged over the calendar year. For the 2009 data, this gives a bias factor of 0.7, but there is insufficient data to calculate a bias factor with confidence from the 2008 data. Nonetheless, a similar procedure would yield a bias factor of 0.82 for the 2008 data (based on using data from April to December 2008).

3.2.6 It should be noted that the National Air Quality Website (www.airquality.co.uk) has a tool for calculating the bias factors together with the precision and accuracy of the data used. Table 3.7 presents the results of this spreadsheet tool for the 2009 data. This confirms that the bias factor for 2009 is indeed 0.7 for the roadside analyser and that the data can be used with confidence. A similar process reveals that the bias factor for the tubes co-located with the background analyser for 2009 is 0.9. The roadside bias factor is however used as this is more appropriate for the rest of the tubes deployed in Chesterfield.

3.2.7 It should be noted that in cases where the confidence in the data is poor or where there is insufficient data, it is recommended to use the database of national bias factors. For tubes of the types used here (50% TEA in Acetone analysed by South Yorkshire Labs), the bias factor from the national database is 0.9. Whilst this is consistent with the Chesterfield data for the background analyser, use of such a bias factor for the roadside analyser would be inappropriate, as this would result in excessively high concentrations being produced by the co-located tubes, especially for 2009. This can be seen in figure 3.8 where the bias corrected diffusion tube data have been compared with those from the roadside analyser, with the derived bias factors being used (the blue line) and that assuming a bias factor of 0.9 for both 2008 and 2009. The derived bias factor of 0.7 was therefore used for the 2009 data, and for 2008, a bias factor of 0.82 was used.

Table 3.7 Calculation of Bias factor for the 2009 data from the roadside analyser

Checking Precision and Accuracy of Triplicate Tubes

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From the AEA group

Diffusion Tubes Measurements									
Period	Start Date dd/mm/yyyy	End Date dd/mm/yyyy	Tube 1 µgm $^{-3}$	Tube 2 µgm $^{-3}$	Tube 3 µgm $^{-3}$	Triplicate Mean	Standard Deviation	Coefficient of Variation (CV)	95% CI of mean
1			37	34	39	37	2.5	7	6.3
2			34	35	36	35	1.0	3	2.5
3			28	30	30	29	1.2	4	2.9
4			25	33	34	31	4.9	16	12.3
5			24	25	23	24	1.0	4	2.5
6			25	23	24	24	1.0	4	2.5
7			24	24	25	24	0.6	2	1.4
8			20	20	19	20	0.6	3	1.4
9			27	25	26	26	1.0	4	2.5
10			33	33	31	32	1.2	4	2.9
11			35	34	36	35	1.0	3	2.5
12			36	39	35	37	2.1	6	5.2
13									

It is necessary to have results for at least two tubes in order to calculate the precision of the measurements

Automatic Method		Data Quality Check	
Period Mean	Data Capture (% DC)	Tubes Precision Check	Automatic Monitor Data
33.81	99.33	Good	Good
27.74	98.66	Good	Good
16.38	99.46	Good	Good
19.29	97.78	Good	Good
14.16	90.73	Good	Good
17.15	96.53	Good	Good
12.73	95.83	Good	Good
13.65	96.91	Good	Good
14.80	95.28	Good	Good
23.46	99.46	Good	Good
21.66	98.89	Good	Good
32.28	94.09	Good	Good
Overall survey -->		Good precision	Good Overall DC

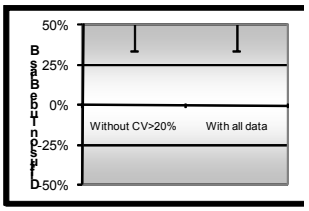
(Check average CV & DC from Accuracy calculations)

Site Name/ ID:	

Precision: 12 out of 12 periods have a CV smaller than 20%

Accuracy (with 95% confidence interval) without periods with CV larger than 20%	
Bias calculated using 12 periods of data	
Bias factor A	0.7 (0.63 - 0.79)
Bias B	43% (26% - 60%)
Diffusion Tubes Mean:	29 µgm^{-3}
Mean CV (Precision):	5
Automatic Mean:	21 µgm^{-3}
Data Capture for periods used:	97%
Adjusted Tubes Mean:	21 (19 - 23) µgm^{-3}

Accuracy (with 95% confidence interval) WITH ALL DATA	
Bias calculated using 12 periods of data	
Bias factor A	0.7 (0.63 - 0.79)
Bias B	43% (26% - 60%)
Diffusion Tubes Mean:	29 µgm^{-3}
Mean CV (Precision):	5
Automatic Mean:	21 µgm^{-3}
Data Capture for periods used:	97%
Adjusted Tubes Mean:	21 (19 - 23) µgm^{-3}



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3.2.8 Based on the derived bias factor of 0.7 therefore, the current state of air quality in Chesterfield as obtained from diffusion tube data in 2009 is as summarised below in table 3.7. Although the air quality standard was not exceeded at any of the locations monitored, there were a few locations where elevated levels of NO_2 concentrations were obtained. These include locations 2, 6 and 7 all of which were within 90% of the air quality standard of 40µg/m^3. Of these three locations, the highest concentration (39µg/m^3) was obtained at location 6, Chesterfield Road roundabout (Church Street Brimington), Location 2, at Markham Road also experienced elevated levels of NO_2 concentration, as did location 7 in Staveley.

3.2.9 The data obtained from these three tubes are presented in Figure 3.9 where they are compared with the average of those obtained from the tubes co-located with the continuous analysers. Tubes 2 and 7 experienced large monthly variations which were not consistent with the data obtained at the monitoring stations. Tube 6, on the other hand exhibited a monthly variation which was similar to that obtained from the continuous analysers. Although large monthly variations are possible, they might also point to possible problems with the location of these tubes and an assessment should be conducted to determine whether there are any spurious sources or factors which might affect the data at these locations.

Table 3.8 Summary of annually averaged diffusion tube data for NO_2 in Chesterfield during 2009.

Grid Reference	Site No.	Site Name	Bias Adjusted data (μg/m^3)
437224 370958	1	Bradbury Club, 150 Chatsworth Road, (A619)	25.7
438427 370832	2	Markham Road, (A619)	***36.4***
438306 369739	3	3, St Augustines Road	19.5
438517 370229	4	Derby Road Development (A61)	19.9
438293 370870	5	17 South Place	26.7
440445 373514	6	Chest Rd Rndbt	***39.0***
443457 374807	7	Dukes Street, Staveley	***36.2***
438395 369776	8	St Augustines Church, 212 Derby Road	30.6
438385 369573	9	Lincoln Street, 287 Derby Road,	28.4
440149 373384	10	18, Chesterfield Road, Brimington	24.0
438307 374563	11	42, Whittington Hill (B6052)	33.3
438280 373334	12	460, Sheffield Road	27.8
442759 374270	13	99, Chesterfield Road, Staveley	27.9
438357 369411	14	348 Derby Road, Storforth Lane	31.7
436349 370657	15	Chatsworth Road (Roadside AQ Station)	20.3
436349 370657	16	Chatsworth Road (Roadside AQ Station)	20.7
436349 370657	17	Chatsworth Road (Roadside AQ Station)	20.9
437909 370545	18	Queens Park Annex (Background AQ station)	18.4
437909 370545	19	Queens Park Annex (Background AQ station)	18.2
437909 370545	20	Queens Park Annex (Background AQ station)	17.8
443417 374911	21	Staveley Stables	17.5
440689 373569	22	35, Ringwood Road, Brimington	27.3
438112 370980	23	1 Beetwell Street	23.2
437687 371433	24	10, Compton Street, near Saltergate	33.7
435988 370601	25	501, Chatsworth Road, near Vincent Crescent	17.7
437795 371368	26	114, Saltergate	25.4
443885 374907	27	Lowgates	29.5
438740 370946	28	45 Hollis Lane	27.7
438425 371346	29	Hollywell Cross Roundabout, Old Post	30.4
436704 370763	30	348, Chatsworth Road, Brampton Mile	26.6
438359 369978	31	24, Derby Road, Jawbones Hill	24.1
439244 370153	32	Hasland By-Pass (A617)	22.0
444702 372482	33	Oak Farm	23.0
436377 370663	34	451, Chatsworth Road, opp Chapel Lane West	24.1
435654 370538	35	632, Chatsworth Road, near Storrs Road	27.5
437935 370866	36	Queens Park	15.2
438921 372055	37	15, Muirfield Road	18.8
438517 373513	38	93 Eastside Road	25.6

3.2.10 Based on the 2009 data therefore, in contrast with the previous findings, it would appear that whilst elevated levels of NO_2 are indeed present at three of the thirty eight locations monitored in Chesterfield, the air quality objectives have not been exceeded. Nonetheless, the elevated levels, coupled with the history of possible exceedances in the past, justify a detailed assessment and continued monitoring.

3.3 Particulate Matter (PM_{10} and $PM_{2.5}$)

3.3.1 The available data on particulate matter (both PM_{10} and $PM_{2.5}$) are summarised below in Table 3.9. As seen in Tables 3.1 to 3.4 above, and as summarised below, there was no $PM_{2.5}$ data in 2008, and in 2009 the data capture of $PM_{2.5}$ at the roadside analyser was low, because data collection began in July 2009. Nonetheless, it is clear that none of the air quality objectives or targets (for $PM_{2.5}$) were exceeded at the two monitoring locations.

Table 3.9 Summary of data from the continuous analysers for PM_{10} and $PM_{2.5}$

Analyser	Percentage data Capture		Annual Average PM_{10}	Annual Average $PM_{2.5}$	Daily Maximum PM_{10}	Number of times daily PM10 exceeds 50 $\mu g/m^3$
	PM_{10}	$PM_{2.5}$				
Background (2008)	76.7	0	19.6	---	49.7	0
Roadside (2008)	76.8	0	26.7	---	56	3
Background (2009)	91.8	93.1	17.6	13.6	64.8	6
Roadside (2009)	91.7	49	16	9.8	51.5	1

3.3.3 It is interesting to note that Table 3.9 suggests that both PM_{10} and $PM_{2.5}$ concentrations stations were higher at the background site than at the roadside site in 2009. This appears to be odd given that the greater volume of traffic at the roadside site should have produced higher particulate concentrations. Examination of the time history of the daily (24 hour averaged) PM_{10} concentrations in 2008 and 2009, as in Figure 3.10, shows that while the 2009 background concentrations were in fact largely similar to those at the roadside analyser, in 2008 the roadside analyser definitely experienced higher concentrations.

3.3.4 No data exists for $PM_{2.5}$ in 2008, but in 2009, Table 3.9 also suggests that $PM_{2.5}$ concentrations at the background site were higher than those at the roadside site. However, the time history of the data (Figure 3.11) shows that the PM2.5 concentrations at the two sites were largely similar, but those at the background site had slightly higher peaks.

3.3.5 The 2009 PM_{10} and $PM_{2.5}$ data for Chesterfield has also been compared with data from surrounding national monitoring sites within 50km of Chesterfield. Of the available sites, the only two with PM data are Sheffield Centre and Nottingham Centre. The daily averaged PM_{10} and $PM_{2.5}$ concentrations for these sites are therefore compared with the data for Chesterfield in Figures 3.12 and 3.13 respectively. It is clear that both PM_{10} and $PM_{2.5}$ at the four sites exhibited similar trends with time and experienced similar levels of concentrations. This would suggest that concentrations of fine particulate matter (PM_{10} and $PM_{2.5}$) are less influenced by local factors such as traffic, than by regional factors. Further, these comparisons confirm the validity of the particulate matter data collected. It is therefore clear that the air quality standards or targets for particulate matter were not exceeded in 2009 in Chesterfield.

3.4 Other Pollutants

None of the previous assessments have indicated that any of the pollutants were likely to exceed their air quality standards or objectives. No new sources of these pollutants were identified prior to this study and as a result, this assessment focuses on NO_2 and PM_{10} only.

4. MODELLED PREDICTIONS – DETAILED ASSESSMENT

4.1 Introduction

4.1.1 As mentioned in section 2, the previous air quality studies indicated that there were three areas within the Borough of Chesterfield where air quality appeared to be relatively poor. Two of these areas were within the previously proposed AQMA as shown in Figure 1.1, but a third location was also identified as having the potential to exceed current air quality standards. This was in Compton Street, close to the junction with Saltergate.

4.1.2 As part of this detailed assessment therefore, all of these areas have been modelled. The total area is relatively large and includes a number of major roads as well as other heavily trafficked or congested roads. In order to model the entire area as accurately as possible with all of the necessary road sources represented, for the purposes of modelling, the area was split into two distinct regions with a small overlap. Figure 4.1 shows the extent of the area modelled and the sources included. It is worth noting that the area shown in Figure 4.1 includes the entire area that was initially proposed as the AQMA. Further, the modelled area now includes many additional road sources compared to those included in the 2007 detailed assessment, as is evident from a comparison of Figure 4.1 with Figure 2.1.

4.1.3 Full details of the modelling methodology, the input data, and the verification are presented in Annexe 1. Suffice to say that throughout this study, version 2.3 of the ADMS Roads model has been used, and that as far as practical, modelling was conducted in accordance with the recommendations as contained in LAQM TG09 [11]. In addition to model verification therefore, statistical parameters relating to the uncertainty in the modelling were also evaluated and are presented in Annexe 1. Of these, it is worth noting that the fractional bias was just -0.02 and the root mean square error in the modelled concentrations was calculated to be 2.2 $\mu g/m^3$. The modelled concentrations can therefore be used with a fair degree of confidence to predict the likely concentrations in Chesterfield.

4.2 Model predictions

4.2.1 The predicted ground level NO_2 concentrations in Chesterfield City centre and in the Whittington Hill area are as shown in Figures 4.2 and 4.3 respectively; areas which exceed the objective of 40 $\mu g/m^3$ are shaded in red. These, results cover all areas within Chesterfield where traffic related pollution levels are expected to be the greatest. It is clears from these results that the air quality objectives are not exceeded in any areas where they apply, i.e where members of the public are likely to be regularly present.

4.2.2 The results presented in Figures 4.2 and 4.3 are for traffic and emissions for 2009, however, similar results would apply to 2010, as the change in traffic is less than 1%. This is derived from the Regional Traffic Growth Factors (RTF) as available

from the spreadsheet calculator tool [12] and adjusted for local conditions using the TEMPRO [13] factors. It should also be noted that this small increase in traffic is more than offset by the slight reductions in emissions and the change in the background concentrations that would result if data for 2010 were used. In fact, Box 2.1 of LAQM TG09 suggests that there is approximately 5% reduction in annual averaged mean NO_2 concentrations from 2009 to 2010 in areas outside London. Figures 4.2 and 4.3 are therefore accurate predictions of the current levels of NO_2 concentrations in Chesterfield and a conservative estimate of the concentrations in 2010. These results are, however, based on meteorological data for 2009 and the 2009 meteorological data might not be representative of the meteorological data in future years.

4.2.3 The sensitivity of the modelled predictions to the input meteorological data was therefore examined by re-running the model for two other years of meteorological data, but with the emissions and traffic data for 2009 being used. The results therefore, strictly speaking are for 2009, but as stated above, given that the difference in traffic between 2009 and 2010 is small and offset by emissions reduction in 2010, the results can be considered as being valid for 2010 also.

4.2.4 The results obtained using the 2008 meteorological data are presented in Figures 4.4 and 4.5 to show the annual averaged NO_2 concentrations in the City Centre and in the Whittington Hill area respectively. Similarly, Figures 4.6 and 4.7 show the results for 2007. The sensitivity of the model predictions to the input meteorological data are also summarised in Table 4.1 below where the results at selected receptors are compared.

Table 4.1 – Sensitivity of modelled annual averaged ground level concentrations (for 2009) to input meteorological data

Site No.	Site Name	Using 2009 Met' data	Using 2008 Met' data	Using 2007 Met' data
1	Bradbury Club, 150 Chatsworth Road, (A619)	24.7	22.3	22.8
2	Markham Road, (A619)	33.5	29.4	30.5
3	3, St Augustines Road	18.4	18.2	18.3
4	Derby Road Development (A61)	21.6	20.5	20.5
5	17 South Place	28.5	25.0	24.8
6	Chest Rd Rndbt	38.2	33.2	32.3
10	18, Chesterfield Road, Brimington	24.3	23.0	22.4
11	42, Whittington Hill (B6052)	30.4	28.5	28.1
12	460, Sheffield Road	26.1	25.1	25.1
15 - 17	Chatsworth Road (Roadside AQ Station)	24.5	22.4	21.9
18 - 20	Queens Park Annex (Background AQ station)	19.7	19.0	19.1
22	35, Ringwood Road, Brimington	26.7	24.3	23.9
23	1 Beetwell Street	25.8	23.1	23.5
24	10, Compton Street, near Saltergate	30.0	27.0	27.1

25	501, Chatsworth Road, near Vincent Crescent	22.0	20.6	20.3
26	114, Saltergate	25.1	22.8	23.3
28	45 Hollis Lane	30.8	26.2	26.2
29	Hollywell Cross Roundabout, Old Post Restaurant	33.2	27.6	28.0
30	348, Chatsworth Road, Brampton Mile	26.7	23.7	24.5
31	24, Derby Road, Jawbones Hill	26.1	23.2	23.9
32	Hasland By-Pass (A617)	24.8	22.8	23.9
34	451, Chatsworth Road, opposite Chapel Lane West	25.7	23.4	22.7
36	Queens Park	20.9	19.9	20.1

4.2.5 It is clear that the 2009 meteorological data produced the highest concentrations, but the objectives were not exceeded at any locations where members of the public are present. Nonetheless, there are a few areas where ground level concentrations of NO_2 are elevated; these tend to be close to roundabouts and where there is traffic congestion.

4.2.6 These results appear to differ quite considerably from the findings of the previous detailed assessment [1] and from the results contained in the Environmental Statement produced for the proposed Waterside Development in Chesterfield [14]. As mentioned in Annexe 1, the traffic data used for the current assessment was consistent with those used in the original detailed assessment (adjusted using TEMPRO and National traffic growth factors) and with those used in ES for the Waterside Development. In fact, the ES for the Waterside development included a detailed traffic study and projections for 2009, so no adjustments were necessary when using data taken from this source. Most of the other modelling conditions were similar, but there are notable differences in the background concentrations used in the current study and those used previously.

4.2.7 Table 4.2 below compares the background concentrations used for the various modelling studies. It is clear that the background NO_X concentrations in particular are notably lower than those used in the previous studies. Some of these differences are due to the background reducing in future years, but the ES for the Waterside development, for example, assumed a background NO_X concentration of 35.5 $\mu g/m^3$ for 2009 whereas a value of 26 $\mu g/m^3$ was used in the current study. As explained in Annexe 1, however, the background concentrations used in the current study were based both on the national background maps and were consistent with the background data obtained for the continuous analyser. Further, the background values used in the current study were shown to be appropriate based on the model verification process detailed in Annexe 1.

Table 4.2 – Comparison of Background Concentrations used during previous modelling studies with those used in the present study (in μg/m^3)

	Bureau Veritas - data for 2005	Waterside ES – data for 2007	Waterside ES – data for 2009	Current Study – data for 2009
NO_X	44.1	39.19	35.54	26
NO_2	23.4	21.78	20.28	18

4.2.8 As mentioned earlier, PM_{10} concentrations were also modelled, but the road contribution was found to be relatively small with the highest hourly contributions (due to the road contribution) found to be less than 2 μg/m^3. Air quality standards for PM_{10} are therefore not likely to be exceeded within the Borough.

5. SOURCE APPORTIONMENT

5.1 The source apportionment study examined the contributions from the various sources affecting air quality and, in particular, NO_X concentrations within Chesterfield. In common with many other areas, the major source of air pollution in Chesterfield is due to road transport, i.e traffic. This is confirmed by figure 5.1, which shows that road transport accounts for some 35% of all emissions of NO_X in Chesterfield. The other main sources are Industrial Combustion (25%), Other Transport (22%) and Commercial, Institutional and Residential Combustion (17%). This is based on data from the National Atmospheric Emissions Inventory (NAEI) warehouse [15] for Chesterfield using the 2007 dataset.

5.2 Closer examination of this data reveals that within the area modelled, NO_X emissions from all sources are the highest towards the north of the area in Sheepbridge, and is in fact due to industrial processes. This is demonstrated in Figure 5.2 where NO_X concentrations from all sources, expressed as a percentage of the total NO_X emissions within the Borough, are presented. Figure 5.2 also shows that only some 2 - 4% of the of the total NO_X emissions within the Borough are produced within the City Centre and an examination of the data indicates that this is approximately equally distributed among the four sources previously mentioned.

5.3 Examination of the contribution of road transport to total NO_X emissions in the Borough, as in Figure 5.3, indicates that within the modelled area, the highest NO_X emissions due to road transport are produced within the City Centre area. Not surprisingly, this tends to follow the main roads and heavily trafficked routes, and account for more that 1% of the total NO_X emissions, whereas rural areas account for 0.2% (i.e five times less). It must be stressed that Figure 5.3 expresses the contribution of road transport locally to the **total** NO_X emissions within the entire Borough of Chesterfield, so although the percentages shown in any given area is relatively small, the point to note is that the most heavily trafficked areas produce more than 5 times the NO_X emissions that are produced in rural areas.

5.4 Figure 5.3 also shows the location of recent hot spots within the Borough where the highest concentrations were obtained. The three locations within the City Centre (locations 2, 24, and 29) were within areas of the highest road contribution to NO_X emissions. Location 6, north east of the City Centre was within an area where the road contribution was slightly less than that within the City Centre (0.6%) but as Figure 5.3 shows, there as a local peak here due to the roundabout and the hill with slow moving traffic. Similarly, location 11 was on a hill and in an area of relatively slow moving traffic.

5.5 For locations 6 and 11, it is clear that elevated levels of NO_X (and hence NO_2 concentrations) arise because of highly localised effects. In fact at both of these locations, although the HGV traffic is less than 5% of the total traffic, it is responsible for almost 60% of NO_X emissions. The most effective method of improving air quality in these areas would therefore be to reduce the percentage of HGV traffic. Clearly also, any methods that result in a reduction in congestion would also be beneficial.

5.6 With regards to the locations within the City Centre, the situation is slightly more complex as several roads contribute to NO_X emissions at these locations. Nonetheless, even though HGV traffic in the Compton Street area is only just over 3%, this is responsible for some 50% of NO_X emissions. In addition, congestion is also responsible for the elevated emissions at all of the City Centre locations and improvements will require measures to improve traffic flow within the City Centre.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 This detailed assessment of air quality within Chesterfield was commissioned by Chesterfield Borough Council as part of their responsibilities under Part IV of the Environment Act (1995). Previous assessments had recommended the declaration of an Air Quality Management Area (AQMA), because concentrations of Nitrogen Dioxide (NO_2), due to road traffic, were predicted to exceed the air quality objectives. This appeared to have been confirmed by recent measurements of NO_2 using diffusion tubes, which also indicated an additional area (outside the originally proposed AQMA); this was along Compton Street near to the junction with Saltergate.

6.2 This assessment therefore examined all of the areas within Chesterfield where elevated levels of NO_2 concentrations were reported. The assessment was based on detailed dispersion study using the ADMS Roads model together with a detailed review of all recent monitoring data within the Borough. In addition to the assessment of air quality, this study also included a source apportionment assessment. The main findings and recommendations from this assessment were as follows.

6.3 Chesterfield Borough Council operates two air quality stations which form part of the Automatic Urban and Rural Network (AURN). As such these stations are subject to strict Quality Assurance and Quality Control. Nonetheless, NO_2 and PM_{10} data from April 2008 and through to December 2009 were examined and found to be largely in agreement with those obtained from neighbouring stations. In fact the trends were remarkably similar, suggesting that, there were strong regional influences on air quality within Chesterfield. It was also concluded that the available continuous monitoring data for oxides of nitrogen (NO_X), NO_2 and PM_{10}, could be used with confidence.

6.4 No exceedances of the air quality objectives for NO_2 or PM_{10} were found in the data from the continuous analysers. It was, however, somewhat surprising to observe that whilst NO_X concentrations from the roadside analyser were notably higher than those from the background analyser (as they should be), both the roadside and background analyser produced similar levels of NO_2 concentrations. Nonetheless, there is no reason to doubt the validity of the results obtained from either of the two analysers.

6.5 Some 38 diffusion tubes are also used within Chesterfield to monitor NO_2 concentrations. Three tubes are co-located with each analyser and these were used to calculate bias factors for the diffusion tube data. For the roadside analyser using the data for 2009, a bias factor of 0.7 was derived, whereas for the background analyser, the bias factor was 0.9. Data from the national data base of diffusion tube bias factors indicate that similar tubes deployed elsewhere in the UK had bias factors of 0.9 and this was the factor that was historically used to adjust the diffusion tube data in Chesterfield.

6.6 Given that there is a high level of confidence in the continuous monitoring data from the roadside analyser, and that most of the tubes are located close to the roads, the bias factor of 0.7 derived from the continuous data was used throughout this study, for the 2009 data. There was insufficient data to establish the bias factor for 2008 as the analysers were moved to their present location in March 2008 – so a complete calendar year of data was not available. Nonetheless if the 9 months of data for 2008 were used, the bias factor for the roadside analyser would have been 0.82. Additional examination of the diffusion tube data reveals that the bias factor appeared to have decreased from the values used prior to 2008. Further, any attempt to use bias factors similar to that contained in the national database would lead to diffusion tube data which would be inconsistent with the continuous monitoring data and by implication, inconsistent with that from neighbouring AURN stations also.

6.7 Based on the bias adjusted diffusion tube data, there were no exceedances of the air quality objectives for NO_2 in 2009, but there were a few locations where elevated levels of NO_2 concentrations were obtained.

6.8 Dispersion modelling was conducted using the ADMS Roads model. The model was verified by comparing the modelled data for 2009 with the monitoring data for the same period. Reasonably good agreement was obtained between the modelled results and those obtained from the monitoring with a root mean square error of 2.23 $\mu g/m^3$ in the modelled concentrations.

6.9 The predicted NO_2 concentrations did not exceed the air quality objectives at any location where they apply. This finding appears to contradict that obtained from the earlier modelling studies, despite similar traffic and input data being used. It is likely that this is due at least in part to previous studies using background levels of NO_X and NO_2 concentrations which were higher than those believed to be valid for 2009. In the present study the most recent data for background concentrations were used and these were found to be consistent with the background data available for the background analyser. In addition the model was verified and found to be performing reasonably well. The findings of this study, based both on monitoring data, and dispersion modelling, is therefore that the air quality objectives are not being exceeded. Further, given current projections in traffic growth and vehicle emissions, it is unlikely that air quality objectives will be exceeded in future.

6.10 A source apportionment study was also conducted, and it was found that within Chesterfield as a whole, road transport accounted for some 35% of all NO_X emissions. Other significant sources of NO_X emissions within the Borough were Industrial Combustion (25%), Other Transport (22%) and Commercial, Institutional and Residential Combustion (17%). It was also found that within Chesterfield, not surprisingly, the areas where road transport produced the highest concentrations were within the City Centre and along the major roads and heavily

trafficked routes. Further, these were also the areas where the highest NO_2 concentrations were obtained.

6.11 The two locations outside the City Centre where high NO_2 concentrations were obtained were found were both on hills and in one case close to a roundabout and in the other, close to a junction. Further, at these two locations, HGV's were responsible for more than 50% of emissions even though HGV traffic was less than 5% of the total traffic flow. Improvements at these locations can therefore be made by reducing HGV traffic and / or by improving traffic flow.

6.12 Within the City Centre, although the contribution from HGV's to NO_X emissions was still relatively high, the most practical method of improving air quality appears to be to reduce congestion and increase traffic flow.

6.13 No other pollutants were found to be in danger of exceeding their air quality objectives.

6.14 Despite none of the air quality objectives being exceeded, it is recommended that monitoring be continued and if possible increased. A thorough review should also be made of each monitoring location to ensure that any local factors that are likely to affect or influence the measurements be noted. If possible additional monitoring should also be conducted at the hot spots identified.

6.15 It is also recommended that traffic flow assessments be conducted at the hot spots to supplement the source apportionment study and that this information be used to develop possible mitigation measures to ensure that air quality within the Borough is well managed.

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FIGURES

ANNEXE 1 : MODELLING METHODOLOGY, VERIFICATION AND UNCERTAINTY