

**Ellesmere Port and Neston
Borough Council**

Local Air Quality Management

Detailed Assessment, 2004



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Contents

INTRODUCTION.....	7
SUMMARY.....	8
APPENDIX TO THE UPDATING & SCREENING ASSESSMENT 2003.....	9
MONITORING.....	15
AIR DISPERSION MODELLING.....	17
METEOROLOGY.....	17
REVIEW OF STRATEGY POLLUTANTS.....	21
1. BENZENE (C ₆ H ₆).....	21
1.1. Introduction.....	21
1.2. Conclusions of the Updating & Screening Assessment 2003.....	21
1.3. Monitoring Data.....	21
1.4. Air dispersion modelling.....	23
1.5. Discussion.....	26
1.6. Conclusion.....	27
2. 1,3-BUTADIENE (C ₄ H ₆).....	29
2.1. Introduction.....	29
2.2. Conclusions of the Updating & Screening Assessment 2003.....	29
2.3. Monitoring Data.....	29
2.4. Air Dispersion Modelling.....	31
2.5. Discussion.....	33
2.6. Conclusion.....	34
3. LEAD (Pb).....	35
3.1. Introduction.....	35
3.2. Conclusions of the Updating & Screening Assessment 2003.....	35
3.3. Monitoring Data.....	35
3.4. Air Dispersion Modelling.....	36
3.5. Discussion.....	38
3.6. Conclusions.....	39
4. NITROGEN DIOXIDE (NO ₂).....	41
4.1. Introduction.....	41
4.2. Conclusions of the Updating & Screening Assessment 2003.....	41
4.3. Monitoring Data.....	41
4.4. Air Dispersion Modelling.....	45
4.4.1. Road Traffic.....	45
4.4.1.1. Modelling without chemistry.....	47
4.4.1.2. Modelling with chemistry.....	49
4.4.2. Uncertainty.....	52
4.5. Discussion.....	52
4.6. Conclusion.....	53
5. PARTICULATES (PM ₁₀).....	55
5.1. Introduction.....	55
5.2. Conclusions of the Updating & Screening Assessment 2003.....	55
5.3. Monitoring Data.....	55
5.4. Air Dispersion Modelling.....	59
5.5. Discussion.....	61
5.6. Conclusions.....	62
6. SULPHUR DIOXIDE (SO ₂).....	63
6.1. Introduction.....	63
6.2. Conclusions of the Updating & Screening Assessment 2003.....	63
6.3. Monitoring Data.....	64
6.4. Air Dispersion Modelling.....	68
6.5. Discussion.....	71
6.6. Conclusions.....	71

7.	CONCLUSIONS	73
8.	REFERENCES	75
9.	Appendix 1 – Monitoring stations	77
10.	Appendix 2 – Monitoring data	79
11.	Appendix 3 – Monitoring techniques.....	87
12.	Glossary.....	91

List of Tables

Table 1	Summary of detailed assessment conclusions	8
Table 2	Predicted NO ₂ concentrations at relevant junctions	9
Table 3	National Air Quality Objectives.....	10
Table 4	Recommended timescale for the completion of assessments / reports.....	11
Table 5	Examples of where the Air Quality Objectives should/should not apply	12
Table 6	Benzene verification, 2001.....	26
Table 7	Benzene comparison, 2003	26
Table 8	Butadiene verification 2001.....	32
Table 9	Associated Octel lead emissions 2000 - 2003	36
Table 10	Lead comparisons 2001-03.....	36
Table 11	Modelled NO _x - non-chemistry run.	47
Table 12	Verification of modelled NO _x against real-time analyser	47
Table 13	Conversion of NO _x to NO ₂	48
Table 14	Comparison of modelled versus monitored NO ₂	49
Table 15	Verification of predicted SO ₂ (99.9 th percentile), 2001.....	69
Table 16	Comparison of predicted SO ₂ (99.9 th percentile), 2003	69
Table 17	Diffusion Tube Monitoring Stations.	77
Table 18	Real -Time Monitoring Stations.....	78
Table 19	Elm Street NO ₂ results (ratified), 2003	79
Table 20	Stanney Grange NO ₂ results (ratified), 2003.....	79
Table 21	Opsis NO ₂ results (ratified), 2001 & 2002	80
Table 22	Real-time SO ₂ results, 2001	80
Table 23	Real-time SO ₂ results, 2002.....	81
Table 24	Real-time SO ₂ results, 2003.....	81
Table 25	Stanney Grange PM ₁₀ results, 2002 & 2003	82
Table 26	Ellesmere Port PM ₁₀ results, 2002 & 2003.....	82
Table 27	Ellesmere Port lead results, 2003-4.	83
Table 28	Local bias correction factors of NO ₂ diffusion tubes, 2003.....	84
Table 29	NO ₂ diffusion tube data, 2003.	84
Table 30	Benzene diffusion tube data 2001 - 2004.	85
Table 31	Bias-correction factor for benzene diffusion tubes, 2003.	85
Table 32	Bias-corrected benzene data 2001 – 2004.	85
Table 33	Butadiene diffusion tube data 2001 – 2003.....	86
Table 34	Diffusion tube laboratory details	87
Table 35	NO ₂ diffusion tube analytical data	87
Table 36	Benzene diffusion tube analytical data.....	87
Table 37	1,3-Butadiene diffusion tube analytical data	88
Table 38	Lead analysis data	88
Table 39	Analyser maintenance & data management – API M200a.	89
Table 40	Analyser maintenance & data management – API M100a.	89
Table 41	Analyser maintenance & data management - TEOM.....	90
Table 42	Analyser maintenance & data management - Opsis.....	90

List of Figures

Figure 1 Map of the borough showing major roads, industrial and urban area	14
Figure 2 Map showing locations of diffusion tubes	16
Figure 3 Map showing locations of automatic monitoring stations	16
Figure 4 Hawarden Airport wind rose, 2001	18
Figure 5 Ringway wind rose, 2001	19
Figure 6 Ellesmere Port wind rose, 2001	19
Figure 7 Locations of benzene monitors, 2003	22
Figure 8 Industrial sources of benzene, 2001	23
Figure 9 Benzene annual mean contour plot, 2001(unadjusted)	25
Figure 10 Benzene annual mean plot, 2003 (unadjusted)	25
Figure 11 Locations of butadiene point sources & monitors, 2003	30
Figure 12 Butadiene monitoring data	31
Figure 13 Butadiene contour plot, 2001 (unadjusted)	32
Figure 14 Butadiene contour plot, 2003 (unadjusted)	33
Figure 15 Locations of lead point sources & monitors	37
Figure 16 Lead annual mean contour plot 2001	37
Figure 17 Lead annual mean contour plot 2003	38
Figure 18 Locations of NO ₂ monitors, 2003	42
Figure 19 Diurnal profile of NO ₂ at Elm Street.	43
Figure 20 Typical diurnal traffic flow, 2003.....	44
Figure 21 Locations of NO ₂ diffusion tubes on A5032	44
Figure 22 Correlation of NO ₂ & NO _x at three local stations.	46
Figure 23 Contour plot of NO _x on the A5032, 2003.....	49
Figure 24 Contour plot of NO ₂ on the A5032, 2005	50
Figure 25 Enhanced contour plot of NO ₂ on the A5032, 2005	51
Figure 26 Locations of TEOM analysers & PM ₁₀ point sources, 2003	56
Figure 27 PM ₁₀ 24-hour means, 2002.....	57
Figure 28 PM ₁₀ 24-hour means, 2003	57
Figure 29 PM ₁₀ annual mean contour plot, 2001	59
Figure 30 PM ₁₀ 90.4th percentile contour plot, 2001.....	61
Figure 31 Trends of SO ₂ (15-minute means) 1996 - 2003	65
Figure 32 Sulphur dioxide 15-minute means, 2001	65
Figure 33 Sulphur dioxide 15-minute means, 2002	66
Figure 34 Sulphur dioxide 15-minute means, 2003	66
Figure 35 SO ₂ pollution rose for Stanney Grange & Opsis, 2001-2003	67
Figure 36 Locations of local SO ₂ point sources and monitors, 2001.....	67
Figure 37 Contour plot of the 99.9 th percentile of 15-min mean SO ₂ 2001	70
Figure 38 Contour plot of the 99.9 th percentile of 15-min mean SO ₂ 2003	70

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INTRODUCTION

This document reports on Ellesmere Port and Neston Borough Council's (EPNBC) Air Quality Review Detailed Assessment conducted to address the Authority's obligations under the Air Quality Regulations (2002) (made under the Environment Act 1995). Local Authorities are obliged to review and assess current (and future) local air quality, adopting a holistic view of industrial, transport and domestic sources of pollution.

The Government's Expert Panel on Air Quality Standards (EPAQS) has prescribed health-based standards and objectives for seven key pollutants (see Table 3). Where, as an outcome of the review and assessment process, it is anticipated that objectives may not be achieved at a particular location the Local Authority must declare an Air Quality Management Area (AQMA).

During the first round of review and assessment (completed in 2000) the Stage 2/3 review (Ref 8.5) - which entailed detailed monitoring and modelling - concluded that it was not necessary to declare any AQMAs locally.

The current (second) round of review and assessment is a continuation of the phased approach to Local Air Quality Management (LAQM), the timetable for which is shown in Table 4.

The EPNBC Updating and Screening Assessment (USA), completed in 2003, concluded that a detailed assessment was necessary for the following: a section of the A5032 (Whitby Road) and industrial sources emitting benzene, 1,3-butadiene, lead, NO₂, PM₁₀ and SO₂.

Emissions of some pollutants assessed during the first round of review and assessment had to be assessed in more detail, so a precautionary approach was adopted in progressing to a detailed assessment.

As the second step in the process, the aim of the detailed assessment is to identify with reasonable certainty whether or not a likely exceedence will occur, and thus indicate whether an AQMA needs to be declared. This report documents the outcomes of the Detailed Assessment conducted during 2004 and should be read in conjunction with the USA referred to above.

SUMMARY

The Environment Act, 1995 obliges local authorities to review and assess air quality against health-based objectives for seven key pollutants set out in the Air Quality Regulations 2000 (as amended, 2002). The regulatory framework requires assessments to be conducted in a phased approach. Completed in 2003, the Updating and Screening Assessment (USA), represents the first phase in the second round of review and assessment. Where the USA identifies an area in which an air quality objective may be at risk of being exceeded, the regulations require a Detailed Assessment to be undertaken. The council's USA concluded that it was necessary to progress to a Detailed Assessment for industrial and traffic pollution.

This report represents work undertaken, and conclusions drawn in respect of the Detailed Assessment. The role of the Detailed Assessment is to identify with reasonable certainty whether or not a likely exceedance will occur, its magnitude and geographical extent. If such an area is identified it is then necessary for the local authority to designate an Air Quality Management Area (AQMA).

Present and predicted concentrations of air pollutants have been assessed using both monitoring data (active and passive) and air dispersion modelling software (ADMS-Urban). The Detailed Assessment outcomes are listed in Table 1 below.

No AQMAs need to be declared in respect of industrial emissions. On the basis of forward projection of 2003 monitoring data and associated modelling, the Detailed Assessment concludes that it is necessary to declare an AQMA for NO₂ on sections of the A5032. Probable exceedances of the NO₂ objective have been predicted on:

- Station Road, Ellesmere Port (between the M53 and Westminster Rd)
- Whitby Road, Ellesmere Port (between Princes Rd and Enfield Rd)

Pollutant	AQMA required?	Next action
Benzene	No	Continue monitoring
1,3 butadiene	No	None
Lead	No	None
Nitrogen dioxide	Yes	Declare AQMA
Particulates (PM ₁₀)	No	Continue monitoring
Sulphur dioxide	No	Continue monitoring

Table 1 Summary of detailed assessment conclusions

APPENDIX TO THE UPDATING & SCREENING ASSESSMENT 2003

Section 5.4.2 of the council's Updating & Screening Assessment (Ref 8.4), which dealt with the assessment of NO₂ at road junctions, identified the need for further investigation of five junctions (having relevant exposure within 10 metres of the kerb) in the borough. It was stated that the assessment would be conducted as soon as traffic flow data became available. Traffic surveys have now been undertaken which can be used for input to the DMRB (Design Manual for Roads and Bridges) screening tool. In addition to this, NO₂ diffusion tubes have been established at the junctions of concern since the USA was completed.

The approach taken is to base the assessment on monitoring data in preference to DMRB as recommended in technical guidance TG03 (Ref 8.3). Tubes have now been in position since September 2003 and have generated a year's worth of data. Results, along with adjustment factors and 2005 estimates are shown in Table 2.

Monitoring Site	Nitrogen Dioxide Annual Means (µg/m ³)				
	Period Mean	Adjusted Mean (local 2003 factor x0.93)	Adjusted Mean (UWE 2003 factor x0.96)	Estimated 2005 mean (local)	Estimated 2005 mean (UWE)
HA	40.6	37.7	39.0	35.7	37.0
LE	32.4	30.1	31.1	28.5	29.5
ML	31.1	28.9	29.9	27.4	28.3
WR	34.8	32.3	33.4	30.6	31.7
PW	41.5	38.6	39.8	36.6	37.7

Table 2 Predicted NO₂ concentrations at relevant junctions

Two diffusion tube adjustment factors have been calculated for the correction of NO₂ data: a local factor based on triplicate tubes collocated with one of the council's real-time chemiluminescent analysers; and a factor derived from a number of similar exercises collated by the University of the West of England (UWE). Whilst the former is perhaps more relevant to the local environment, the UWE study is more statistically viable due to sample size. Taking this into account, and extrapolating to the target date of 2005, (columns 5 & 6, Table 2) it can be seen that none of the junctions exceed 40µg/m³. It should be noted, however, that the junction at which PW is located, forms part of the A5032 subjected to a detailed assessment in section 4 of this report.

A detailed assessment is not required in respect of this source category.

Pollutant	Air Quality Objective		Date to be achieved by
	Concentration	Measured as	
Benzene	16.25µg/m ³ (5ppb)	running annual mean	December 31, 2003
	5µg/m ³ (1.5ppb)	annual mean	December 31, 2010
1, 3-Butadiene	2.25µg/m ³ (1ppb)	running annual mean	December 31, 2003
Carbon Monoxide	10 mg/m ³ (8.6ppm)	Maximum daily running 8-hour mean	December 31, 2003
Lead	0.5 µg/m ³	annual mean	December 31, 2004
	0.25µg/m ³	annual mean	December 31, 2008
Nitrogen Dioxide	200µg/m ³ (105ppb)	1 hour mean not to be exceeded more than 18 times a year	December 31, 2005
	40µg/m ³ (21ppb)	annual mean	December 31, 2005
Particulates (PM ₁₀)	50 µg/m ³ not to be exceeded more than 35 times a year	24 hour mean	December 31, 2004
	40µg/m ³	annual mean	December 31, 2004
Sulphur Dioxide	350µg/m ³ (132ppb) not to be exceeded more than 24 times a year	1 hour mean	December 31, 2004
	125µg/m ³ (47ppb) not to be exceeded more than 3 times a year	24 hour mean	December 31, 2004
	266µg/m ³ (100ppb) not to be exceeded more than 35 times a year	15 minute mean	December 31, 2005
NB. A provisional 24-hour mean PM10 objective of 50 µg/m ³ (not to be exceeded more than 7 times a year) for 2010 is not yet included in Regulations.			
Objectives included in the Air Quality Regulations 2000 and (Amendment) Regulations 2002.			

Table 3 National Air Quality Objectives.

LAQM Activity	Completion Date	Applies to:
Updating and Screening Assessment	End of May 2003	All authorities
Detailed Assessment	End of April 2004	Those authorities which have identified the need for a Detailed Assessment in their May 2003 Updating and Screening Assessment.
Progress Report	End of April 2004	Those authorities which have identified no need for a Detailed Assessment in their May 2003 Updating and Screening Assessment.
Progress Report	End of April 2005	All authorities
Updating and Screening Assessment	End of April 2006	All authorities
Detailed Assessment	End of April 2007	Those authorities which have identified the need for a Detailed Assessment in their April 2006 Updating and Screening Assessment.
Progress Report	End of April 2007	Those authorities which have identified no need for a Detailed Assessment in their April 2006 Updating and Screening Assessment.
Progress Report	End of April 2008	All authorities
Updating and Screening Assessment	End of April 2009	All authorities
Detailed Assessment	End of April 2010	Those authorities which have identified the need for a Detailed Assessment in their April 2009 Updating and Screening Assessment.
Progress Report	End of April 2010	Those authorities which have identified no need for a Detailed Assessment in their April 2009 Updating and Screening Assessment.

Table 4 Recommended timescale for the completion of assessments / reports.

Averaging Period	Objectives should apply at:	Objectives should generally not apply at:
Annual mean	All locations where the public might be regularly exposed. Building facades of residential properties, schools, hospitals, libraries etc.	Building facades of offices or other places of work where members of the public do not have regular access. Gardens of residential properties. Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term.
24-hour mean and 8-hour mean	All locations where the above objective would apply. Gardens (seating & play areas) of residential properties.	Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term.
1-hour mean	All locations where the annual mean and 24 and 8-hour means objectives apply. Kerbside sites (eg pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc which are not fully enclosed, where the public might reasonably be expected to spend 1-hour or more.	Kerbside sites where the public would not be expected to have regular access.
15-min mean	All locations where members of the public might reasonably be exposed for a period of 15 minutes or longer.	

Table 5 Examples of where the Air Quality Objectives should/should not apply

DESCRIPTION OF ELLESMERE PORT & NESTON

The Borough of Ellesmere Port and Neston extends across the southern part of the Wirral peninsula from the Mersey to the Dee, covers 33 square miles and has a population of approximately 81,200. The town of Ellesmere Port is the largest urban area in the Borough and started where the Shropshire Union Canal joins the Manchester Ship Canal and the Mersey. The Borough itself is largely smoke controlled, with 19 Smoke Control Areas being set up between 1952 and 1982 leaving Neston and the villages of Willaston, Hooton, Ince and Burton able to burn coal and other solid fuels.

The M53 motorway runs around the north and east of Ellesmere Port, close to residential and shopping areas. The M56 motorway skirts the Borough boundary to the southeast and runs northeasterly. To the north and east of Ellesmere Port there are a number of industrial sites including an oil refinery and associated petrochemical complex, a car assembly plant, and a chemical waste incinerator.

In the Borough there are approximately 57 Authorised industrial processes which, under the provisions of the Environmental Protection Act 1990, are authorised for integrated pollution control requirements by the Environment Agency and for local pollution control purposes by the Borough Council. Industrial sources are therefore a key air quality consideration. Many of these are going through the transition to the Integrated Pollution Prevention and Control (IPPC) regime.

There remains a significant potential for development within the Borough of Ellesmere Port and Neston. The developments relate mainly to retail employment and residential use. The effect of these planned developments will have to be taken into account, particularly the potential for an increase in industrial emissions and vehicle movements.

A map of the Borough is presented as Figure 1.

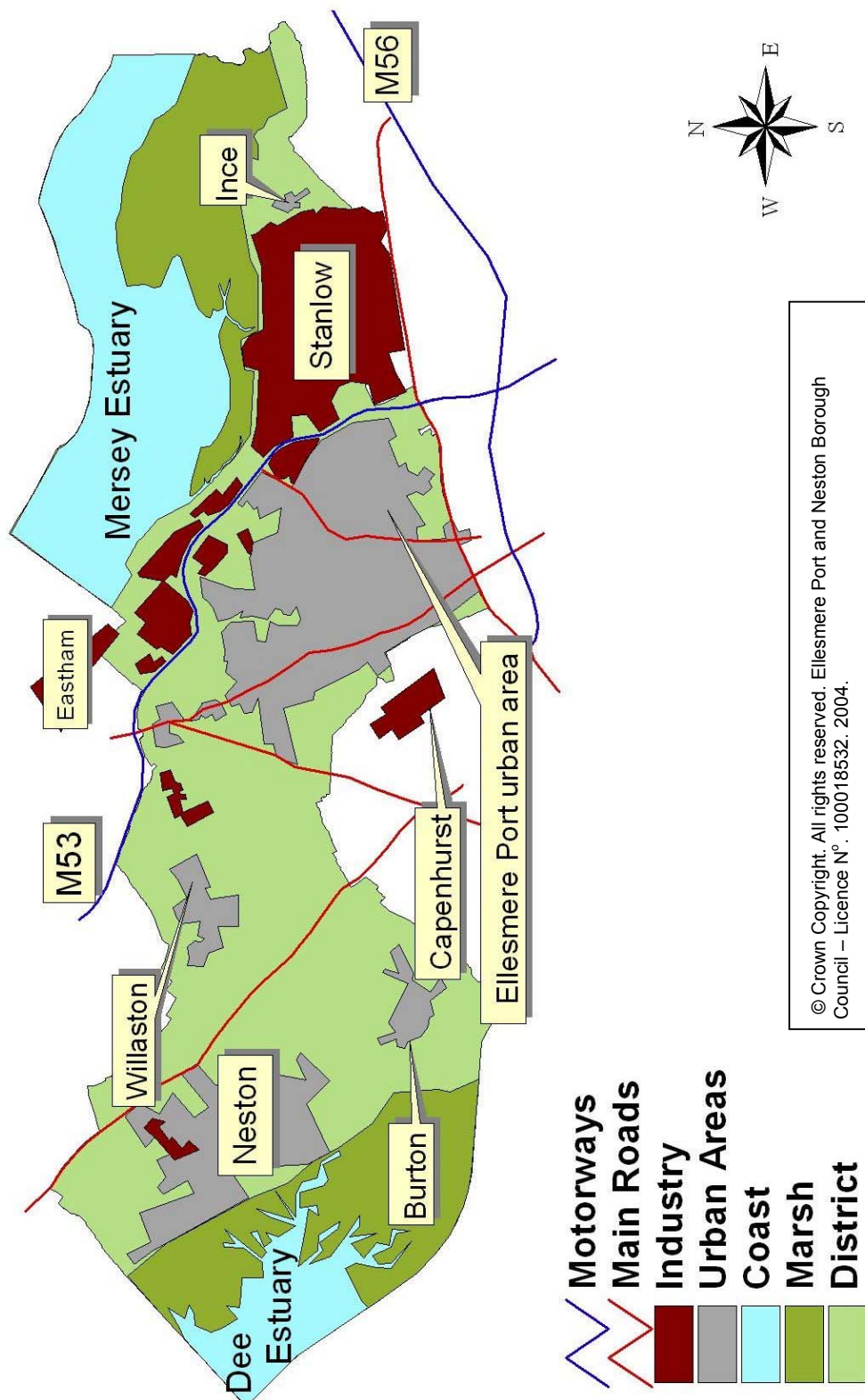


Figure 1 Map of the borough showing major roads, industrial and urban area

MONITORING

Ellesmere Port and Neston Borough Council currently operates 34 air pollution monitors at strategic locations across the borough using both passive and active techniques.

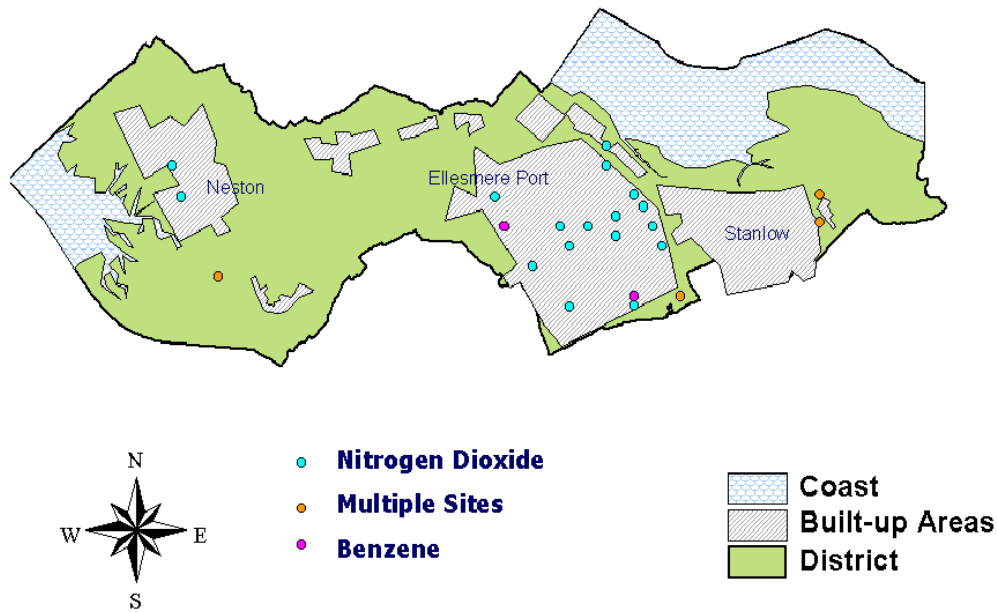
A net acidity sulphur dioxide bubbler, which previously formed part of a much larger local network, continues to operate at the council offices providing information which goes back almost 40 years. However, because ambient concentrations of SO₂ are now at or below the analytical threshold of the bubblers, their longevity is limited.

Automatic real-time analysers and meteorological equipment were first installed in late 1995. The council operates 2 Opsis beams, 3 TEOMs and five API instruments monitoring a range of NAQS pollutants (see Table 18). An indication of the locations of these analysers is given in Figure 3. There are fundamental differences in the sampling techniques. OPSIS beams determine the average concentration of pollutants over a long path length (1200m and 800m in this instance) whereas point monitors record pollution at a particular location. The contrasting approaches are important when interpreting data in relation to the NAQS objectives. In the case of industrial stack emissions, point samplers will record high readings when the centre-point of a plume grounds directly over the monitoring station, while episodes grounding just away from the monitor will produce lower readings. In contrast, the long-path monitors are likely to record many more occasions when plumes impinge upon the beam, although the concentration of pollutants will be recorded as an average over the path's full length. As a consequence of this, the maximum levels recorded by Opsis are likely to be lower than those recorded by the point monitor. Data is polled automatically four times a day by an Enviman system based at the council offices. Enviman is also used for the purposes of data scaling / ratification and publishing data on the council's web site (www.epnbc.gov.uk). All real-time monitoring equipment is serviced and calibrated by Enviro-Technology limited. Council staff perform span tests fortnightly using BOC 'Spectra-seal' span gases (Ref Table 39 - Table 42).

Supplementing the real-time analysers, over 25 diffusion tubes are positioned at strategic locations across the borough. Although diffusion tubes cannot achieve the same temporal resolution nor accuracy as more sophisticated analysers, they are cheap, technically simple, easy to deploy and do not require services such as electricity.

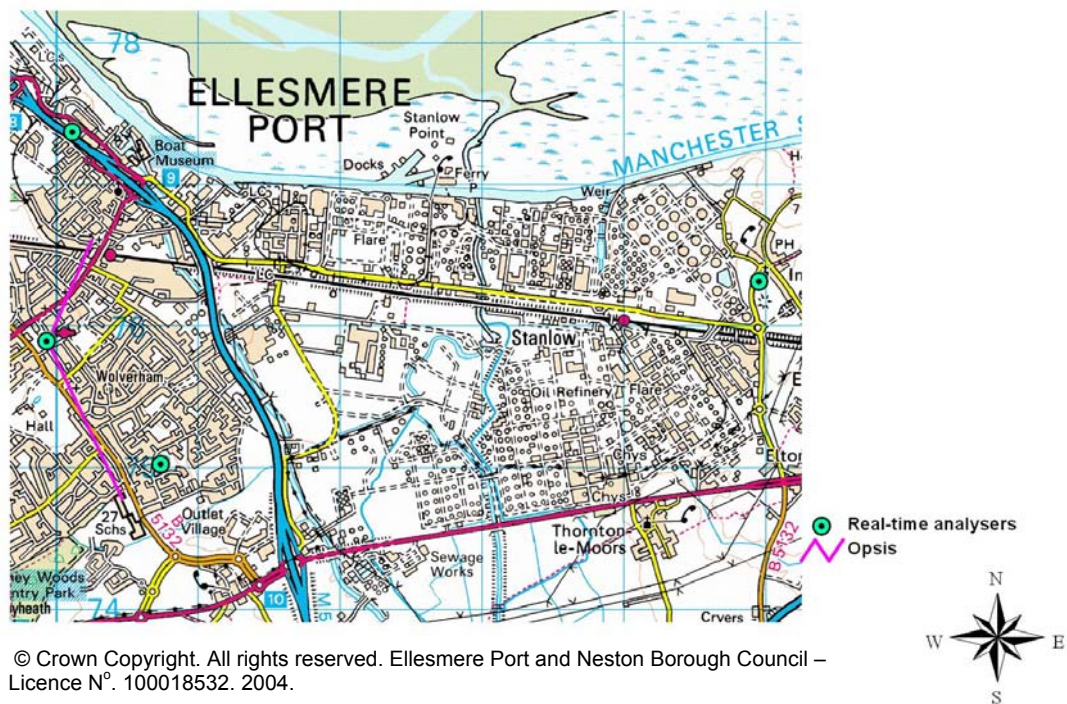
Diffusion tubes are used to monitor NO₂, benzene and 1,3-butadiene (see Table 17), analytical details for which are presented in Appendix 3. Of the four NO₂ tubes which form part of the UK network, three have been in continual operation since 1990, and therefore provide useful information on temporal trends in ambient NO₂. Approximate locations of these tubes can be seen in below Figure 2.

Locations of Diffusion tubes



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Figure 2 Map showing locations of diffusion tubes



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Figure 3 Map showing locations of automatic monitoring stations

AIR DISPERSION MODELLING

Air dispersion modelling is a technique which is capable of modelling the atmospheric dispersion of pollutants from industrial, commercial, domestic and traffic sources. Modelling has the advantage that it is able to estimate pollution concentrations at locations at which it may not be physically or financially practical to place monitoring equipment. This assessment has been conducted using ADMS-Urban, a PC-based dispersion model. ADMS-Urban is widely used by local authorities nationwide and was utilised by EPNBC during the previous round of review and assessment (Ref 8.4).

Validation studies (general comparisons of modelled results against monitoring data carried out by the model developers) have shown ADMS to perform well in comparison to monitoring data (Ref 8.8). Factors such as meteorological uncertainties and model limitations can inevitably lead to disparities between modelling and monitoring. Comparison of modelled outputs against locally monitored data is known as verification and this process has been followed during the course of the detailed assessment in order to minimise such discrepancies.

Modelling results are subject to errors due to, for example, uncertainties in emissions / traffic data and meteorological inputs. To this end, it was found necessary to adjust model input parameters such as surface roughness (land use characteristics affecting wind shear) and the Monin-Obukhov length (a measure of atmospheric stability) in several of the modelling scenarios.

ADMS-Urban modelling runs produce outputs both in the form of predicted concentrations at specific points (receptors) and as contour plots that can be used as overlays on maps. EPNBC employs ArcView – a GIS (Geographical Information System) with which ADMS is fully integrated – to overlay Ordnance Survey map tiles with contour plots.

METEOROLOGY

In order to model air pollutant dispersion effectively it is necessary to input meteorological data (comprising wind direction and speed, boundary layer height and atmospheric stability etc.) from a representative monitoring station. Two calendar years, 2001 & 2003, were chosen for the assessment. It was necessary to undertake modelling for 2001 - although 2001 is regarded as a 'low' pollution year – for the purposes of comparison with, and verification against monitoring data using the most recent local inventory database (Ref 8.2). Data for 2003 was selected, on the advice of the modelling helpdesk (Ref 8.7), in order to reflect both up-to-date meteorological data and which, in terms of background pollution concentrations, was a worst-case year.

Although attempts are made to get the closest possible match between modelled and monitored results, it should be noted that a number of factors may adversely affect the comparison and thus any conclusions drawn. These would include: calculated emissions, emission profiles, roughness length, building effects and the meteorological dataset itself (Ref 8.3).

The nearest weather station from which an hourly-sequential dataset could be sourced is Hawarden Airport (Grid Ref SJ350650) – 12km SSW of Ellesmere Port. A wind rose for Hawarden is shown in Figure 4 below. Unfortunately, the number of valid lines^a of data in the Hawarden dataset was low, so Ringway (Grid Ref SJ818847 – 43km ENE of the borough) was selected as the next nearest relevant meteorological station. Prevailing wind directions indicated by the wind rose for Ringway (Figure 5) contrast with those recorded at Hawarden. This is possibly due to the differences in local topography, in particular, estuarine influences. Whilst probably of little consequence for the prediction of long-term averages from ground level emissions, this could have a bearing on the spatial distribution of contour plots for short-term averaging periods of emissions from elevated sources. For this reason, some of the modelling runs have been performed using wind data from Ellesmere Port library (Figure 6) - which is comparable to that for Hawarden (Figure 4) - merged with other meteorological parameters from the Ringway dataset.

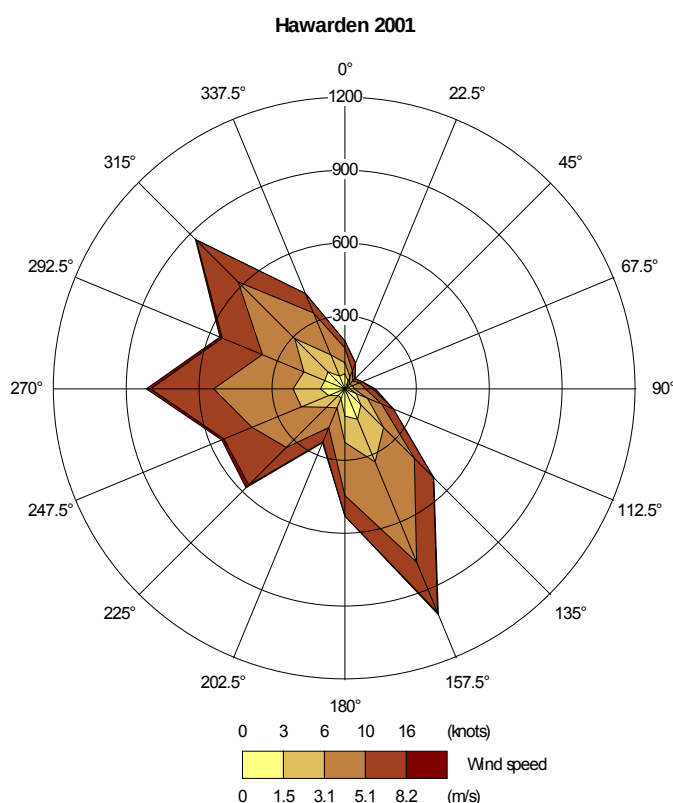


Figure 4 Hawarden Airport wind rose, 2001.

^a Dispersion models cannot perform calculations where there is missing meteorological data. Where the dataset contains calm winds ADMS-Urban uses a default minimum wind speed of 0.75m/s.

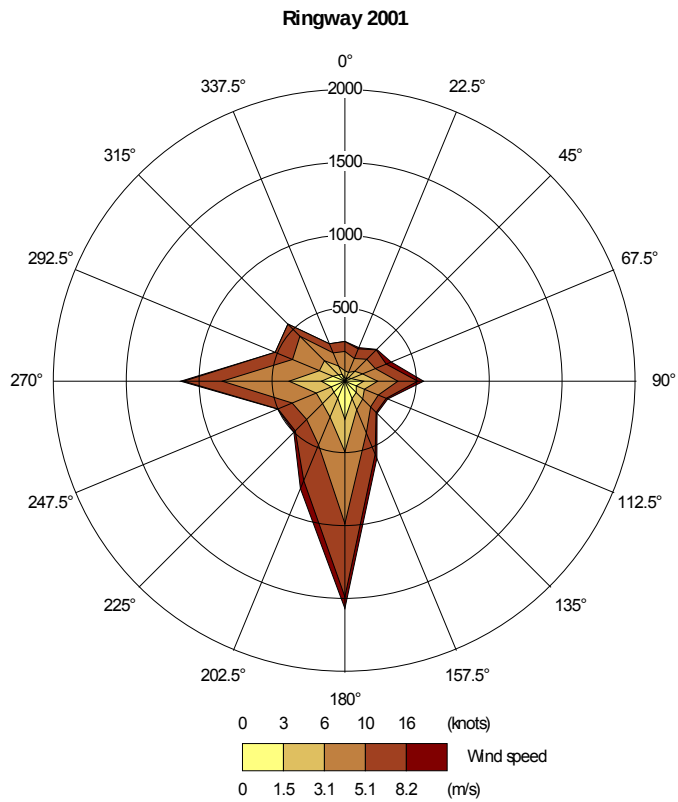


Figure 5 Ringway wind rose, 2001

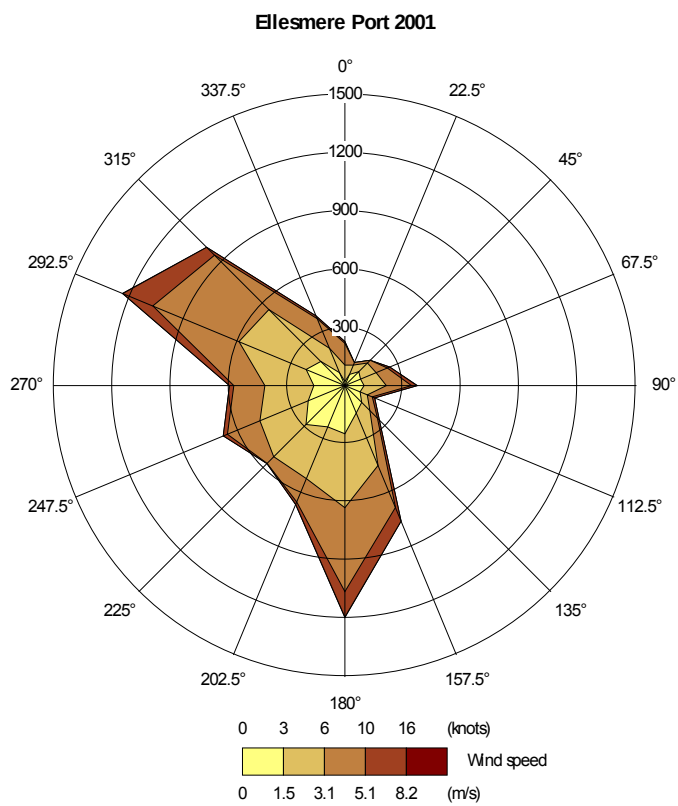


Figure 6 Ellesmere Port wind rose, 2001

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REVIEW OF STRATEGY POLLUTANTS

1. BENZENE (C₆H₆)

1.1. *Introduction*

Atmospheric benzene is present almost entirely as a result of human activities. In the UK road transport emissions (both from evaporative emissions and from the combustion of petrol) predominate. The introduction of petrol vapour recovery systems at filling stations; tighter limits on the benzene content of petrol (less than 1% benzene) and the introduction of catalytic converters has resulted in significant reductions in recent years. Fugitive emissions from the manufacture and use of benzene are also important sources.

Benzene is a recognised genotoxic carcinogen in humans; it is therefore not possible to state an absolute safe level for ambient air concentrations of benzene. The EPAQS standard is, however, designed to reflect a level at which there is an exceedingly small risk to health.

The National Air Quality objective is

- A running annual mean level of 16.25µg/m³ (5ppb)
This must be met by December 2003.

A revised objective of 5µg/m³ (1.5ppb) as an annual mean has been set. This must be achieved by December 2010.

1.2. *Conclusions of the Updating & Screening Assessment 2003*

The council's Updating and Screening Assessment (2003) identified that it was necessary to proceed to a detailed assessment for benzene due to the complexity of local industrial emissions from the refinery site.

1.3. *Monitoring Data*

Benzene monitoring - using passive diffusion tubes prepared and analysed by Gradko Ltd. (see Table 36) - is now conducted at two relevant receptor sites to the east of the refinery. As there is a relatively low number of residential

properties in proximity to the refinery, these can be considered to be worst-case locations.

The Updating & Screening Assessment, 2003 (Ref 8.4) identified the need to calibrate the diffusion tubes against a reference sampler and, to this end, a further three tubes are now collocated with the UK Hydrocarbon Network (UKHN) site at Speke (Grid Ref SJ438835). Triplicate tubes, which themselves are travel-blank adjusted, are used in order to minimise potential variability in tube preparation and analysis. Data obtained from the UKHN site is audited and ratified by the National Physical Laboratory. Benzene monitoring sites currently operated by EPNBC are depicted in Figure 7 below.

Monitoring results, along with correction factors applied in respect of collocation, are presented in Table 30 - Table 32. Whereas the UKHC monitor recorded a mean of $1.85\mu\text{g}/\text{m}^3$, the collocated tubes registered $1.29\mu\text{g}/\text{m}^3$ showing that the passive diffusion tubes tend to under-read by about 30% (see Table 31). With reference to Table 32 it can be seen that WF (which was established in July 2003) recorded the highest period mean ($5.31\mu\text{g}/\text{m}^3$ after adjustment) in 2003, although the data capture rate here was low. At VI, benzene levels ranged from $3.58\mu\text{g}/\text{m}^3$ to $5.11\mu\text{g}/\text{m}^3$ between 2001 and 2003.

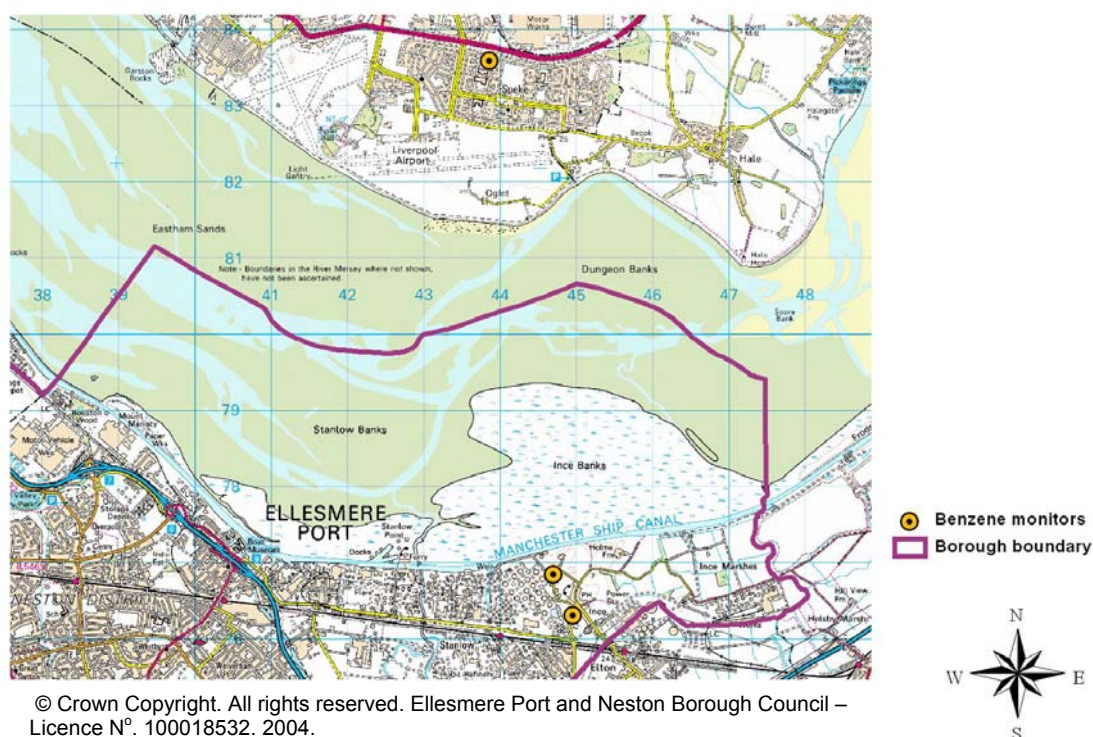


Figure 7 Locations of benzene monitors, 2003

1.4. Air dispersion modelling

Of the 57 sources of benzene identified in the council's USA (Ref 8.4), the greater majority are storage tanks associated with the oil refinery. Following discussions with the ADMS-Urban helpdesk at CERC (Cambridge Environmental Research Consultants) (Ref 8.9), it was determined that the most effective way to represent tank emissions – which comprise roof venting and leaks around seals – was to treat each tank as an area source with an emission velocity close to zero. In addition to this a number of line and volume sources were included in the modelling scenarios (see Figure 8).

Emissions for the year 2001 were modelled with 2001 Ringway meteorological data, in order that they could be compared against local monitoring data for the same year. Background concentrations were not included at this stage so that the source contributions could be assessed. Background concentrations derived from NETCEN's LAQM website (Ref 8.9) national background maps were added subsequently.

A number of modelling runs have been carried out using a range of different input parameters such as surface roughness and minimum Monin-Obukhov (MO) lengths. The best comparison for benzene (Table 6) was obtained using a surface roughness of 0.5m, an MO of 30m.

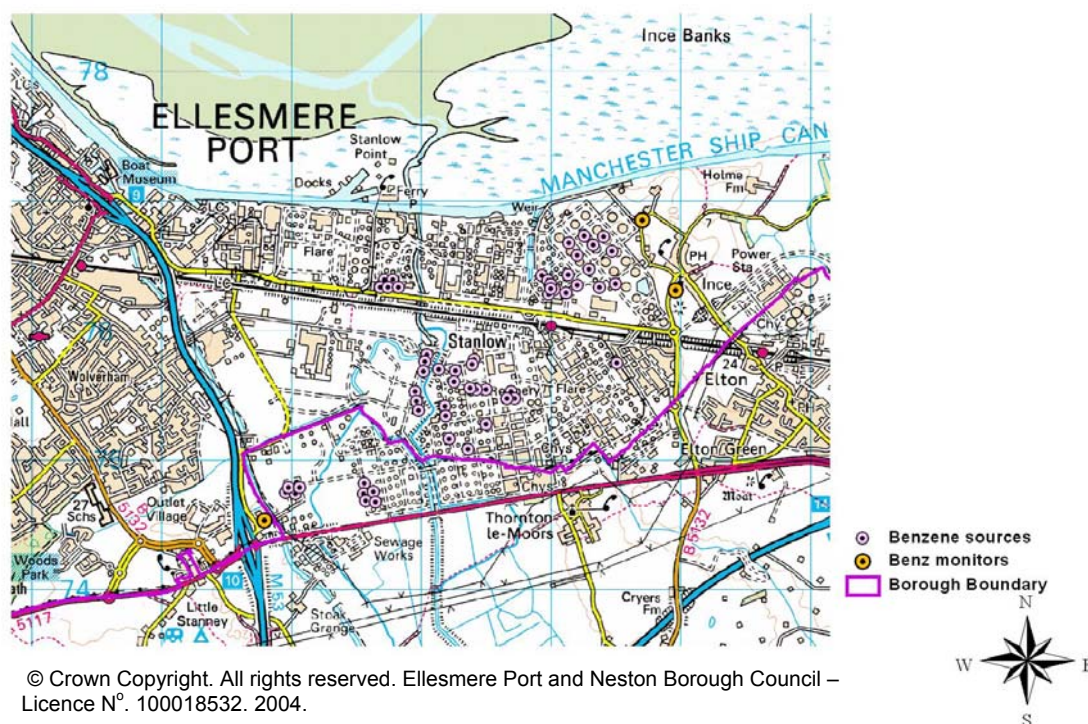


Figure 8 Industrial sources of benzene, 2001

Figure 9 shows the modelled contour plot of the predicted annual mean for the 2001 scenario. Model output concentrations at the relevant receptors VI and MM were $1.91\mu\text{g}/\text{m}^3$ and $1.24\mu\text{g}/\text{m}^3$ respectively when combined with background data (see Table 6). The same input data were also modelled against 2003 Ringway meteorological data for assessment against the 2003 objective ($16.25\mu\text{g}/\text{m}^3$). In this instance emissions data for 2001 have been used since the local emissions inventory is based on 2001, and indications from the public register (Ref 8.11) are that benzene emissions were broadly similar for both years. As such the results do not truly reflect 2003 emissions, however, the exercise offers the benefit of ascertaining whether a different year's weather has an effect on modelled outputs.

With reference to Figure 10 it can be seen that the predicted spatial dispersion of benzene differs little to that for 2001 and indeed the modelled annual mean concentrations at receptor sites were very similar.

As the emissions are primarily attributable to storage tanks and vents it is appropriate to verify the modelled results against monitored data (Para 3.52, Ref 8.3). Benzene monitoring sites were established at the nearest relevant locations following completion of the last round of review and assessment (Ref 8.5) and the results obtained have been used in the comparisons below.

Table 6 summarises this comparison at the monitoring sites in existence in 2001, while Table 7 relates to those present in 2003. The modelled outputs are approximately 50% of the monitored results, but the resultant under-prediction can be used to derive a bias adjustment factor. By applying this factor it can be seen that the modelled outputs are readily comparable to the monitoring results.

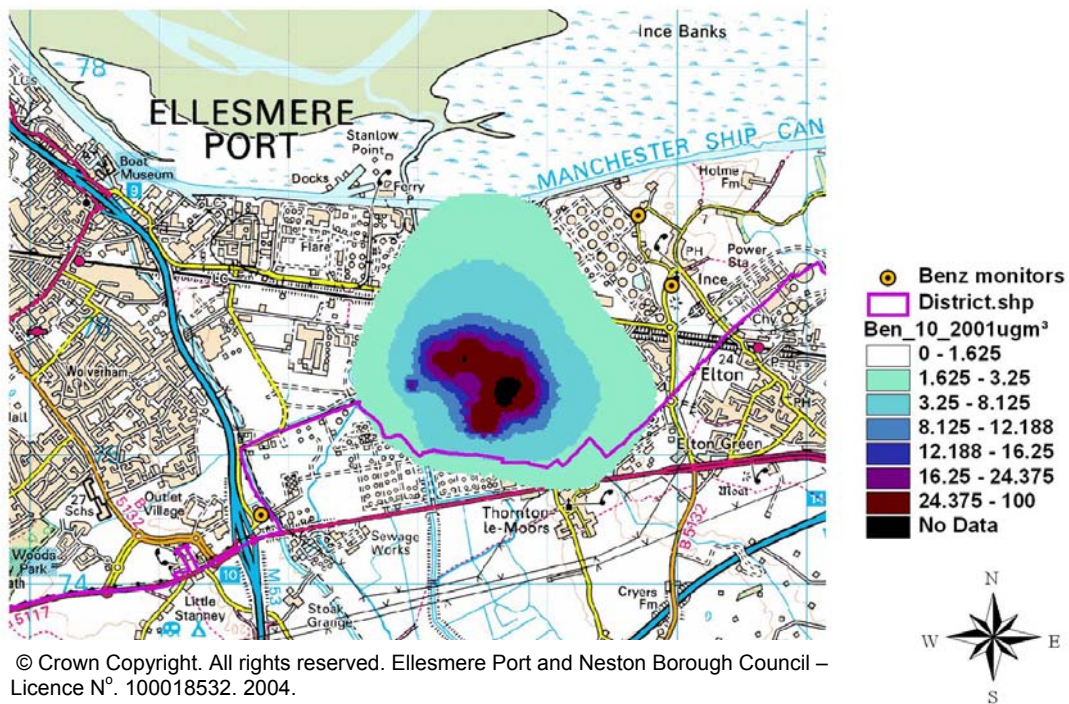


Figure 9 Benzene annual mean contour plot, 2001(unadjusted)

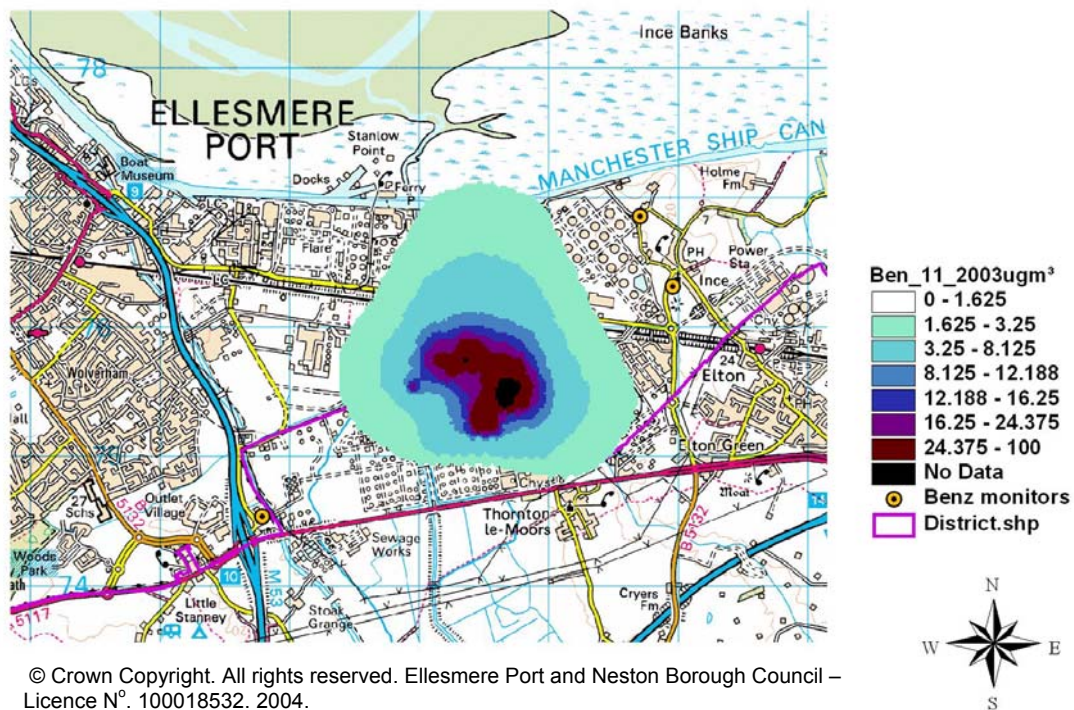


Figure 10 Benzene annual mean plot, 2003 (unadjusted)

Receptor Site code	2001 Modelled Concentration + background ($\mu\text{g}/\text{m}^3$)	2001 Monitored Concentration (corrected) ($\mu\text{g}/\text{m}^3$)	% Difference (under-prediction negative)	Average under-prediction (%)
VI	1.91	5.11	-63	58%
MM	1.24	2.62	-53	

Table 6 Benzene verification, 2001

Receptor Site code	2003 Modelled Concentration + background ($\mu\text{g}/\text{m}^3$)	2003 Monitored Concentration (corrected) ($\mu\text{g}/\text{m}^3$)	% Difference (under-prediction negative)	Average under-prediction (%)
VI	1.69	3.58	-53	60%
WF	1.76	5.31	-67	

Table 7 Benzene comparison, 2003

1.5. Discussion

Modelled contour plots (Figure 9 & Figure 10) have confirmed that the sites selected for benzene monitoring are the most appropriate within the borough to allow assessment against the NAQS annual mean objective.

The collocation monitoring exercise has demonstrated that the passive diffusion tubes tend to under-read in comparison to the UKHN reference monitor. Also, the quoted uncertainty of measurement using the diffusion tube technique is $\pm 21\%$. It is important, therefore, to make use of the calculated bias adjustment factor to aid interpretation of the data. After adjustment, current ambient concentrations of benzene are comfortably below the 2003 objective. It is recognised that bias adjustment factors for one particular period may not necessarily be applicable to another. However, time constraints did not allow for a more extensive collocation study to be undertaken.

Attempts were made to minimise the disparity between monitoring and modelling by adjusting model inputs such as surface roughness and by altering the efflux velocities from tank sources. In spite of this, investigations have shown that ADMS tends to under-predict local benzene concentrations by a factor of two. While the extent of disparity is possibly to be expected (Ref 8.7), it is worthwhile speculating as to the potential causes. On a complex industrial site, buildings, structures and the presence of high temperature processes can have a significant effect on the predicted ground-level concentrations. Furthermore, the representivity of meteorological data from a

station over 30km away from the modelling area may be low (Ref 8.3, chapter A3.114). Differences between monitored and modelled results can also be expected as the 'buildings' module in ADMS-Urban can only simulate the effects of a single building upon airflow.

Modelling scenarios for the years 2001 & 2003 predicted very comparable contour plots despite the use of different meteorological datasets.

Local industrial benzene emissions have remained between 85 and 95 tonnes during the 4 years from 2000 to 2003. At the same time, ambient concentrations at the longest established monitoring station have deviated little in the last three years (Table 32). If this remains to be the case, and indeed it is not known to what extent industrial emissions might be abated in future years, ambient levels may be close to the 2010 revised objective of $5\mu\text{g}/\text{m}^3$. However, background benzene is likely to decline further due to changes in vehicle fleet composition and improved engine technologies such as catalytic converters (Ref 8.14). Declaration of an AQMA, therefore, is not appropriate at this time. It is proposed, therefore, to maintain the benzene monitoring campaign to inform future assessments of local air quality.

1.6. Conclusion

- The detailed assessment demonstrates that the 2003 objective ($16.25\mu\text{g}/\text{m}^3$) for benzene has been complied with at all relevant receptors.
- Benzene monitoring should be continued for the foreseeable future.
- An AQMA does not need to be declared.

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2. 1,3-BUTADIENE (C₄H₆)

2.1. *Introduction*

Nationally, about 80% of atmospheric 1,3-butadiene (butadiene) is present as a result of the combustion of petrol. With the introduction of catalytic converters, however, ambient concentrations are now 70% lower than those in 1990. Some specific petrochemical processes, such as the production of synthetic rubber for tyres, can be locally important.

As it is a recognised genotoxic carcinogen, there is no absolutely safe level of butadiene. However the Government's EPAQS set a health based air quality objective below which the risks are likely to be exceedingly small and detection impractical. A recent review of available evidence by EPAQS concluded that the original limit continues to be appropriate for the purposes of protection of public health.

The National Air Quality objective is

- A running annual mean level of 2.25µg/m³ (1ppb)

This must be met by December 2003.

2.2. *Conclusions of the Updating & Screening Assessment 2003*

In 2003 EPNBC conducted an updating and screening assessment (Ref 8.4) for butadiene following the checklist-based approach recommended by DEFRA's technical guidance note TG03 (8.3). The report identified that it was necessary to proceed to a detailed assessment for butadiene due to the extent of industrial emissions.

2.3. *Monitoring Data*

Passive diffusion tubes supplied and analysed by Gradko International Ltd are used to monitor butadiene at relevant receptors in the borough. The monitoring sites were established at relevant locations (residential premises at which the NAQS applies) closest to the industrial sources following completion of the last round of review and assessment (see Figure 11).

Details of analysis and uncertainty of measurement are contained in Appendix 3. Monitoring results are presented in Table 33. Butadiene monitoring sites operated by EPNBC are depicted in Figure 11 below, and the site details in Table 17.

Although the technical guidance (Ref 8.3) advocates the calibration of passive diffusion tubes against a reference sampler, this was not practicable for local butadiene monitoring. However, the tube results are adjusted against laboratory blanks at the time of analysis.

The highest running annual mean was $1.00\mu\text{g}/\text{m}^3$ at Ince during 2001. This declined to $0.92\mu\text{g}/\text{m}^3$ in 2002 and again to $0.20\mu\text{g}/\text{m}^3$ last year. A similar downwards trend has been experienced at other monitoring sites and monitoring data is now consistently below the limit of detection (see Table 33).

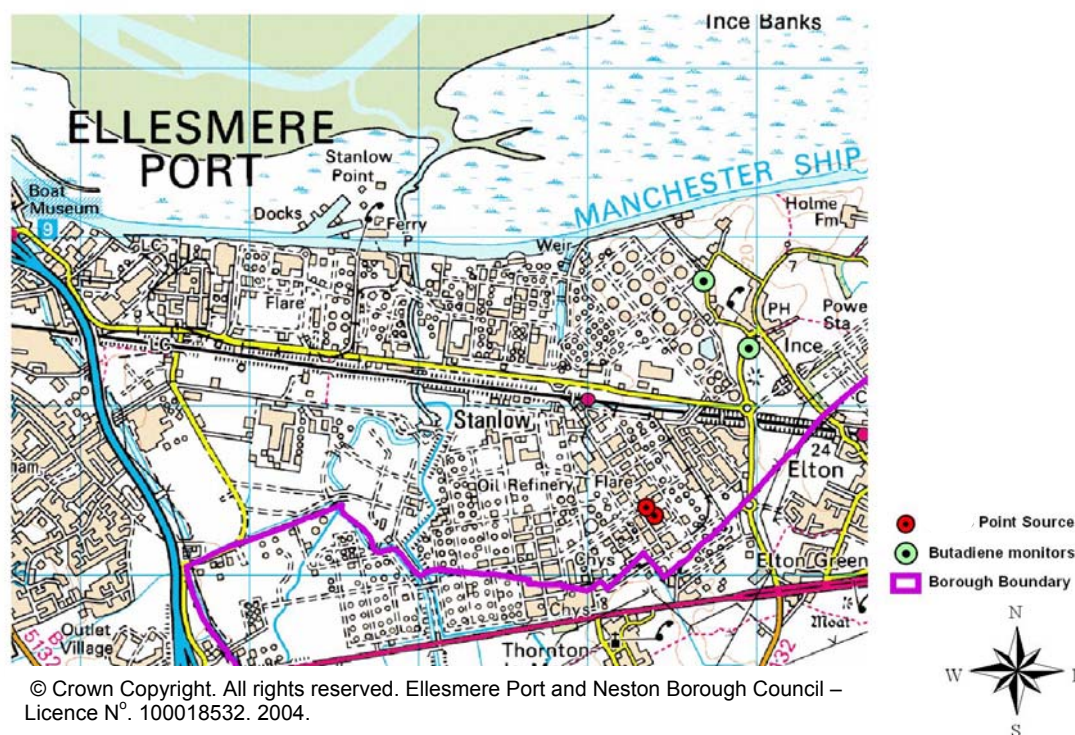


Figure 11 Locations of butadiene point sources & monitors, 2003

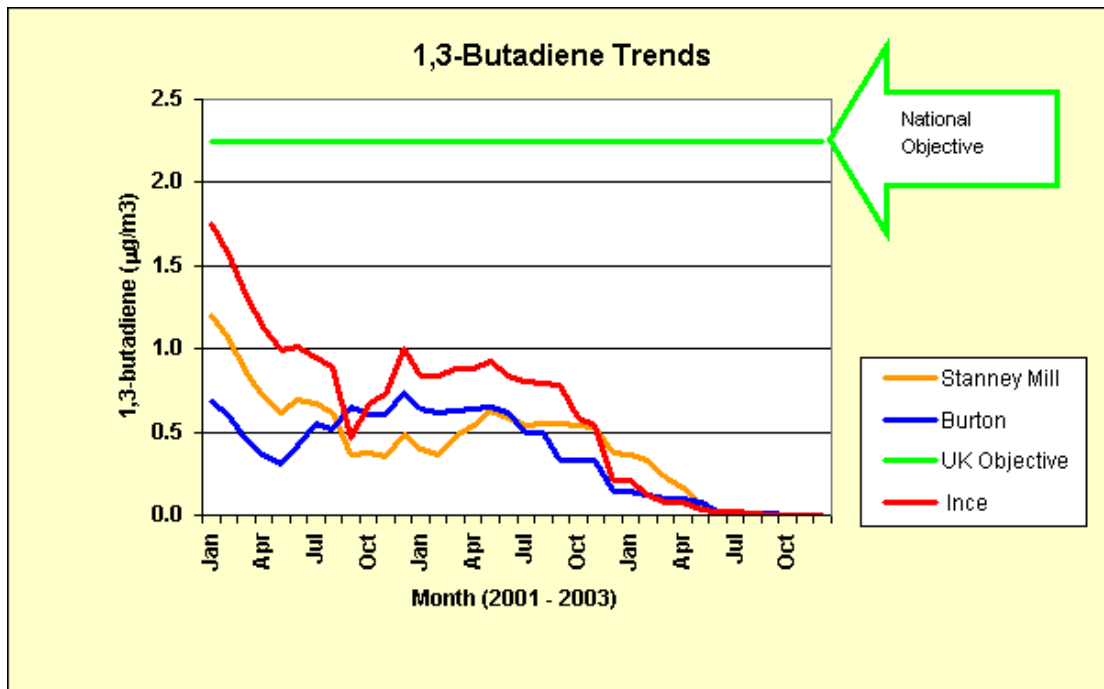


Figure 12 Butadiene monitoring data

2.4. Air Dispersion Modelling

The council's USA (Ref 8.4) identified two point sources - whose 2001 emissions totalled 8.5 tonnes – on the refinery site requiring a detailed assessment. Emissions from these sources were modelled with 2001 Ringway meteorology data, in order that they could be compared against 2001 monitoring data. The technical guidance (Ref 8.3) does not advocate the adjustment of modelled results against monitoring data because of the expected difficulties in obtaining suitable monitoring data. However, butadiene monitoring sites were established at the nearest relevant locations following completion of the last round of review and assessment (Ref 8.5) and the results obtained have been used in the comparisons below. In this case, the receptors represent the worst case in respect of the annual mean since the number of residential properties in proximity to the point sources is low.

In an attempt to achieve the closest possible match between modelling and monitoring results, a number of modelling runs have been carried out using a range of different parameters such as surface roughness and minimum Monin-Obukhov (MO) lengths. The best comparison for butadiene (Table 8) was obtained using a surface roughness of 0.75m, an MO of 30m and background data derived from NETCEN's LAQM website (Ref 8.9) national background maps.

Contour plots for 2001 and 2003 are shown in Figure 13 and Figure 14 respectively. For each scenario 2001 emissions data was used for modelling and there is relatively little difference between the resulting predictions

showing that a different year's meteorology had little bearing on the outcome. Modelled airborne concentrations of butadiene at relevant receptors are well below the NAQS objective.

Receptor Site code	2001 Modelled Concentration ($\mu\text{g}/\text{m}^3$)	2001 Monitored Concentration ($\mu\text{g}/\text{m}^3$)	% Difference (under-prediction negative)	Average under-prediction (%)
VI	0.32	1.00 ^a	-68	61
MM	0.24	0.52 ^a	-54	

Table 8 Butadiene verification 2001.

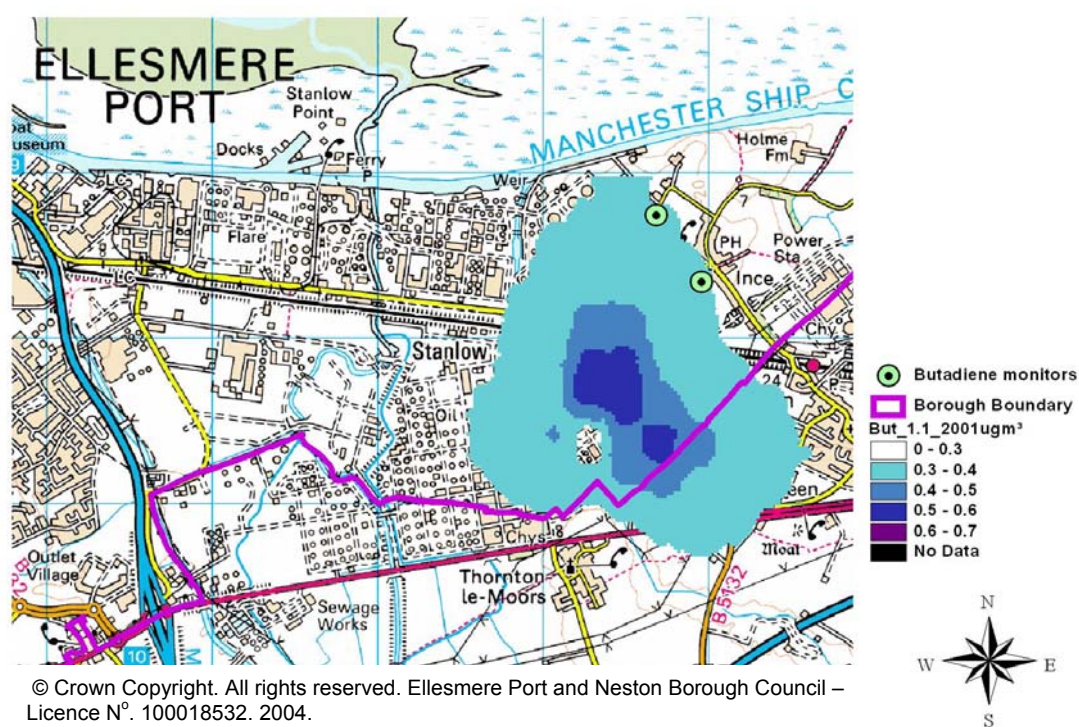


Figure 13 Butadiene contour plot, 2001 (unadjusted)

^a Note: the 2001 results quoted in the updating & screening assessment (Ref 8.4) were higher due to the inclusion of spurious data.

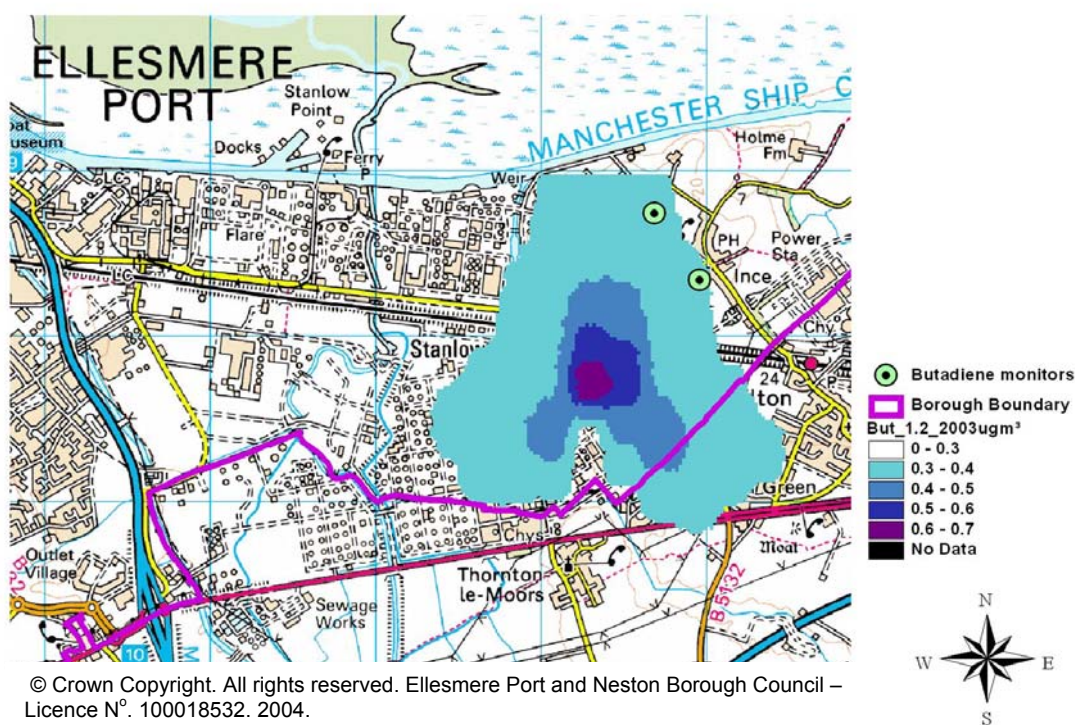


Figure 14 Butadiene contour plot, 2003 (unadjusted)

2.5. Discussion

Butadiene monitoring sites were chosen following the last round of Review and Assessment to be representative of the worst-case exposure (Ref 8.5). With reference to Table 8 the verification exercise showed that the modelling predictions are 2-3 times lower than the monitored results. Factors likely to affect the performance of a model have been explored in the section on benzene (see 1.5 above).

It is recognised that the accuracy of butadiene diffusion tubes is limited when ambient concentrations are close to background. However, the diffusion tubes are blank-corrected. The technical guidance (Ref 8.3) recommends placing more reliance in monitoring results than modelling and this approach has been followed in reaching the conclusions below.

During the course of the monitoring exercise, levels have declined markedly and are now typically below the limit of detection. Since the local emissions inventory was compiled (2001 data) industrial emissions of butadiene have also declined to 5.2 tonnes in 2003 (Ref 8.11). At the same time, road transport emissions of butadiene continue to decline with technological improvements in vehicle exhaust control. It is these reductions which are most likely to account for the fall-off in the ambient levels of butadiene locally.

2.6. Conclusion

- Both modelling and monitoring exercises have demonstrated that the NAQS objective will not be exceeded anywhere in the borough.
- As the ambient levels of butadiene, monitored by diffusion tube, are now below the limit of detection it is recommended that monitoring should cease.
- It is not necessary to declare an AQMA in respect of butadiene.

3. LEAD (Pb)

3.1. *Introduction*

The main sources of airborne lead include the manufacture of batteries, pigments, alloys, and ammunition as well as industrial combustion processes. In the past it was widely used as an organic 'anti-knock' additive in petrol. However, this has now largely ceased with the use of unleaded petrol. Airborne lead is absorbed into the body through the lungs and accumulates particularly in bone, teeth, skin and muscle. The effects of low levels of exposure to lead on health relate to effects on the central nervous system and, in particular, on the development of the brain.

The National Air Quality objectives are:

- An annual mean level of $0.5\mu\text{g}/\text{m}^3$ which must be met by December 2004
- An annual mean level of $0.25\mu\text{g}/\text{m}^3$ must be met by December 2008.

3.2. *Conclusions of the Updating & Screening Assessment 2003*

- Industrial processes within the borough emitted over 13 tonnes of lead in 2001.
- The council's Updating and Screening Assessment (Ref 8.4) identified that it was necessary to proceed to a detailed assessment for lead due to the extent of industrial emissions.

3.3. *Monitoring Data*

During the first round of review and assessment use was made of data from a national heavy metals survey conducted by Stanger Science and Environment (Ref 8.6). The monitoring station at Elton (GR 345635 375580), located 3.75km east of the Associated Ocel site was in operation between December 1999 and May 2000. Data from this site has also been used for comparison against modelling predictions (see 3.4) in the present study.

The local lead monitoring (Ref 8.4) has now produced almost 12 months' worth of data covering 2003-4. No M-type samplers were available for lead monitoring so TEOM filters from existing sites were submitted for ICP analysis (see Table 38), as per the R&P technical note (Ref 8.12). Results of local

monitoring are presented in Table 27. Extrapolation of the period mean for each site gives a maximum annual mean of $0.015\mu\text{g}/\text{m}^3$. During the national heavy metals survey in 2001 the running annual mean at Elton was $0.016\mu\text{g}/\text{m}^3$ - which is about 6% of the 2008 objective.

3.4. Air Dispersion Modelling

Lead emissions for the year 2001 from the seven local point sources (see Figure 15) were modelled with 2001 and 2003 meteorological data from Ringway. Modelling scenarios did not take into account background concentrations of lead, as this data is not available from the national air quality archive. With reference to the contour plots (see Figure 16 & Figure 17 below), it is clear that emissions from the Associated Ocel point source predominate. Emissions from this source have remained between 9 and 13 tonnes (see Table 9) from 2000 to 2003, and the highest of the four years, 2001, was used in the model runs. Figure 17 shows that 2003 meteorological data was likely to produce slightly, but not significantly, higher airborne lead concentrations. The highest predicted lead concentration at a relevant receptor was $0.021\mu\text{g}/\text{m}^3$ at Crescent Road for 2003. This represents less than 10% of the NAQS objective for 2008. No exceedences of the NAQS objective have been predicted anywhere in the borough.

Year	2000	2001	2002	2003
Lead emissions (tonnes)	10.2	12.7	9.5	12.4

Table 9 Associated Ocel lead emissions 2000 - 2003

Comparison of the modelled outputs against monitored results shows the model to be performing very well. Table 10 illustrates that a close match was achieved at all sites from which monitoring data were available, with an average under-prediction of just 19%.

Receptor Site code	2001 Modelled Concentration ($\mu\text{g}/\text{m}^3$)	Monitored Concentration ($\mu\text{g}/\text{m}^3$)	% Difference (under-prediction negative)	Average under-prediction (%)
Elton	0.012	0.016	-25	19
LR	0.012	0.015	-20	
SG	0.008	0.009	-11	

Table 10 Lead comparisons 2001-03

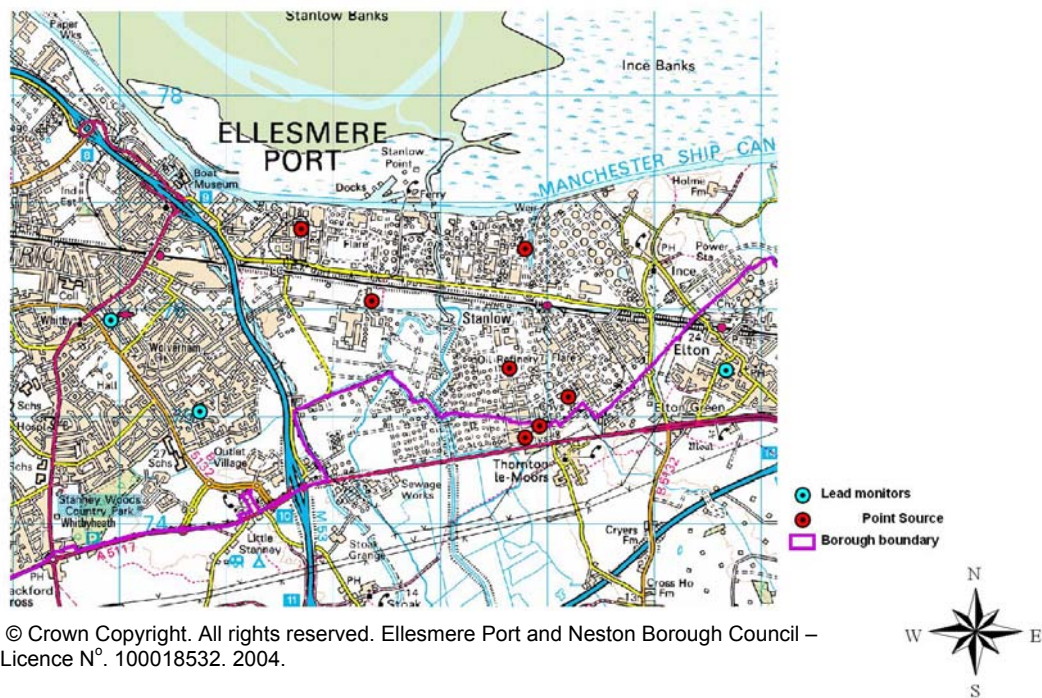


Figure 15 Locations of lead point sources & monitors

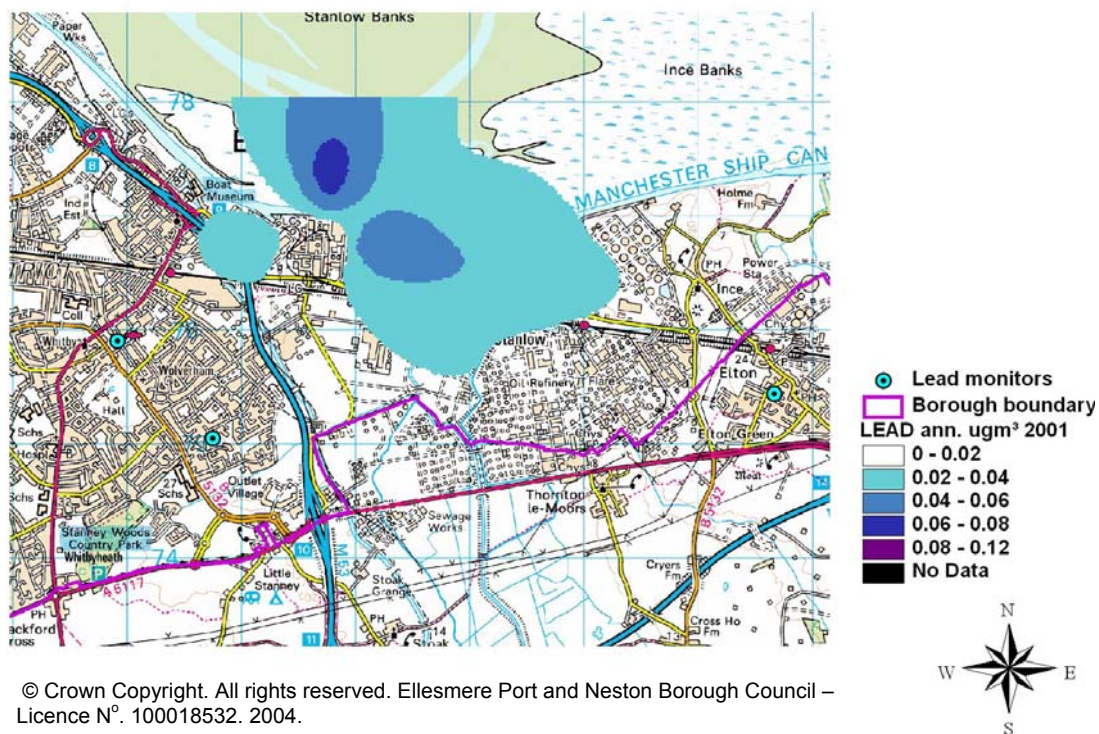


Figure 16 Lead annual mean contour plot 2001

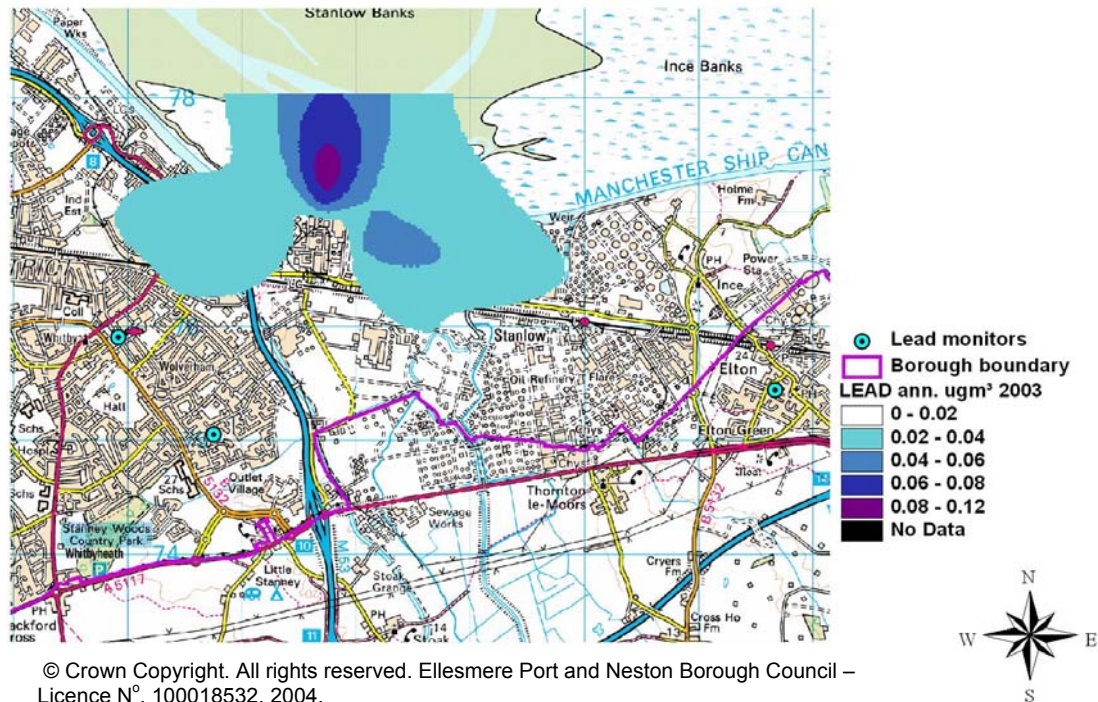


Figure 17 Lead annual mean contour plot 2003

3.5. Discussion

The investigations conducted during the assessment were able to draw comparisons between monitored and modelled concentrations of lead in air. This represents a significant improvement on the situation prevailing during the stage 2/3 review (Ref 8.5).

It is recognised that the monitoring stations from which lead data was obtained do not represent worst-case relevant receptors but, for reasons discussed earlier, generation of data from other sites was not possible. Furthermore it is unfortunate that the periods of monitoring were not concurrent with the inventory year. In spite of this reasonable comparisons can be drawn from the outputs, as emissions from the main source have not varied greatly over the four-year period (see Table 9). Taking this caveat into account monitoring and modelling results are comparable, and show that the objectives will not be exceeded.

The highest predicted lead concentrations occur away from relevant receptors (ie residential properties etc) but do not exceed 50% of the revised (2008) NAQS objective.

3.6. *Conclusions*

- Both modelling and monitoring exercises have demonstrated that the NAQS objective will not be exceeded anywhere in the borough.
- As the ambient levels of lead are well below both the current and the revised NAQS objectives it is recommended that monitoring should cease.
- It is not necessary to declare an AQMA in respect of lead.

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4. NITROGEN DIOXIDE (NO₂)

4.1. *Introduction*

Most nitrogen dioxide (NO₂) in ambient air results from the atmospheric transformation of nitric oxide (NO) which itself is produced during high temperature combustion processes. Road transport accounts for about 50% of the total UK emissions, although power stations are also important. The introduction of catalytic converters along with tighter controls on industrial emissions has resulted in a halving of emissions since 1990.

Nitrogen dioxide is an irritant gas, and high exposures can affect the way that the lungs and airways function - aggravating asthma, for example. It can have short and long-term health effects; a one-hour and annual mean objective has therefore been specified as well as an annual mean.

The National Air Quality objectives are

- A 1-hour mean of 200µg/m³ (105ppb) not to be exceeded more than 18 times a year
- An annual mean level of 40µg/m³ (21ppb)

These objectives must be met by December 2005.

4.2. *Conclusions of the Updating & Screening Assessment 2003*

The council's Updating and Screening Assessment (2003) identified that it was necessary to proceed to a detailed assessment for NO₂ due to road traffic on the A5032.

4.3. *Monitoring Data*

Ellesmere Port & Neston Borough Council monitors NO₂ using both passive (diffusion tubes) and real-time (chemiluminescent and differential optical absorption) techniques at a total of 24 sites (see Table 17, Table 18 & Figure 18). Real-time results are presented in Table 19 to Table 21 whilst diffusion tube results are shown in Table 29. Analytical details can be found in Appendix 3.

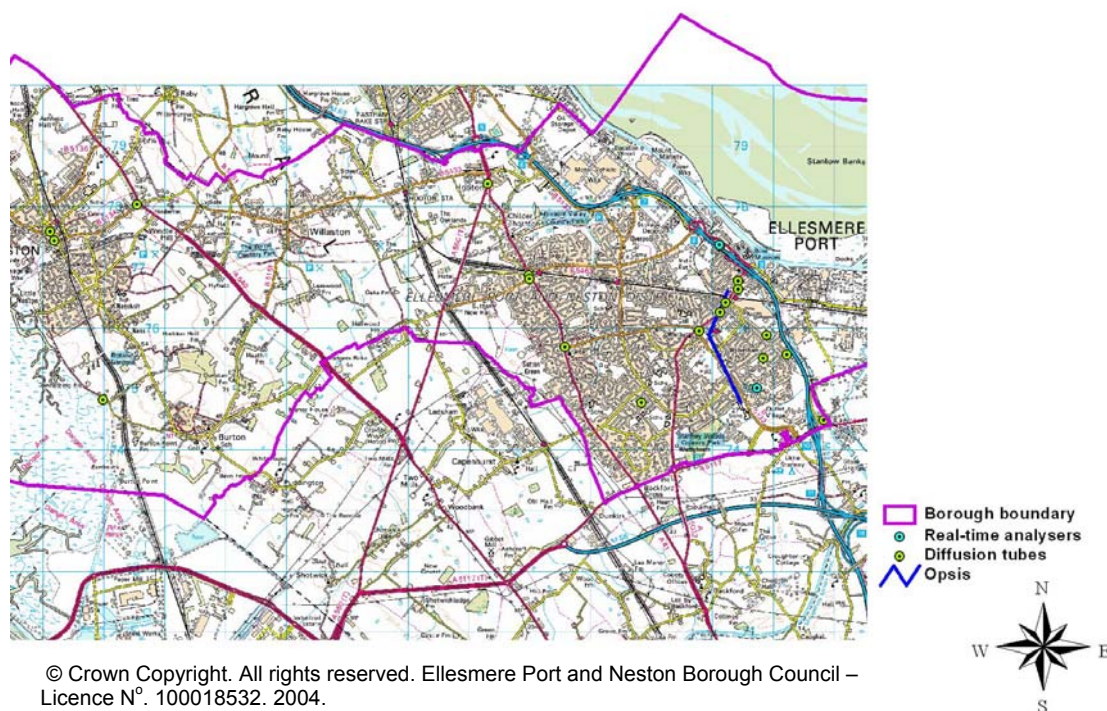


Figure 18 Locations of NO₂ monitors, 2003

Real-time NO₂ monitoring is currently carried out at four stations (see Table 18), the results for which are presented in Table 19 - Table 21. All real-time monitoring data used for the assessment has been scaled and ratified in accordance with the guidance in Annex 1(p A1-32) of the technical guidance TG03.

The highest annual mean recorded by a real-time analyser during 2003 was 38.52µg/m³ at Elm Street, which is in proximity to the M53 (Table 19). This is below the NAQS objective for NO₂. Using the adjustment factors provided in TG03 - which take into account the estimated reductions in road traffic emissions for future years – this is predicted to decline to 36.51µg/m³ by December 2005. Elm Street also registered the highest 99.8th percentile of hourly means at 114.47µg/m³. This is well below the NAQS objective of 200µg/m³.

The diurnal profile of data from the Elm Street site (see Figure 19) shows that traffic emissions are primarily responsible for fluctuations across the day as peak concentrations coincide with rush-hour traffic. For the purposes of comparison, hourly traffic flows for the A5032 have been plotted (see Figure 20).

As stated in the technical guidance, it is imperative that diffusion tubes are validated against a reference method so that a 'bias correction' can be

applied. To this end, triplicate tubes are collocated with the Elm Street chemiluminescent analyser. Whereas the factor for 2002 quoted in the USA was 1.02, the local bias adjustment factor calculated during 2003 was 0.93 (see Table 28). Data from eleven similar studies conducted by other local authorities have been collated by the University of the West of England (Ref 8.16), producing an adjustment factor of 0.96. Adjustments using both the local factor and the one from UWE are shown in Table 29. However, any conclusions drawn from the monitoring data use the latter factor, as it is more conservative in nature and more viable statistically. Columns 6 & 7 of Table 29 show diffusion tube results that have been further adjusted to account for the reductions in vehicle emissions anticipated by the NAQS target date of December 2005 (Ref 8.3).

With reference to Table 29, annual mean NO₂ was below the NAQS objective at the majority of diffusion tube sites in 2003. A number of these were relocated during 2003 to assess NO₂ at busy junctions as required by the USA (see page 9).

After applying the bias correction and forward projection factors, it can be seen that tubes located at SK and WV are unlikely to comply with the 2005 NAQS annual objective. Both tubes are on the section of the A5032 that was selected for detailed assessment (on the basis of 2002 monitoring data) in the USA report (Ref 8.4).

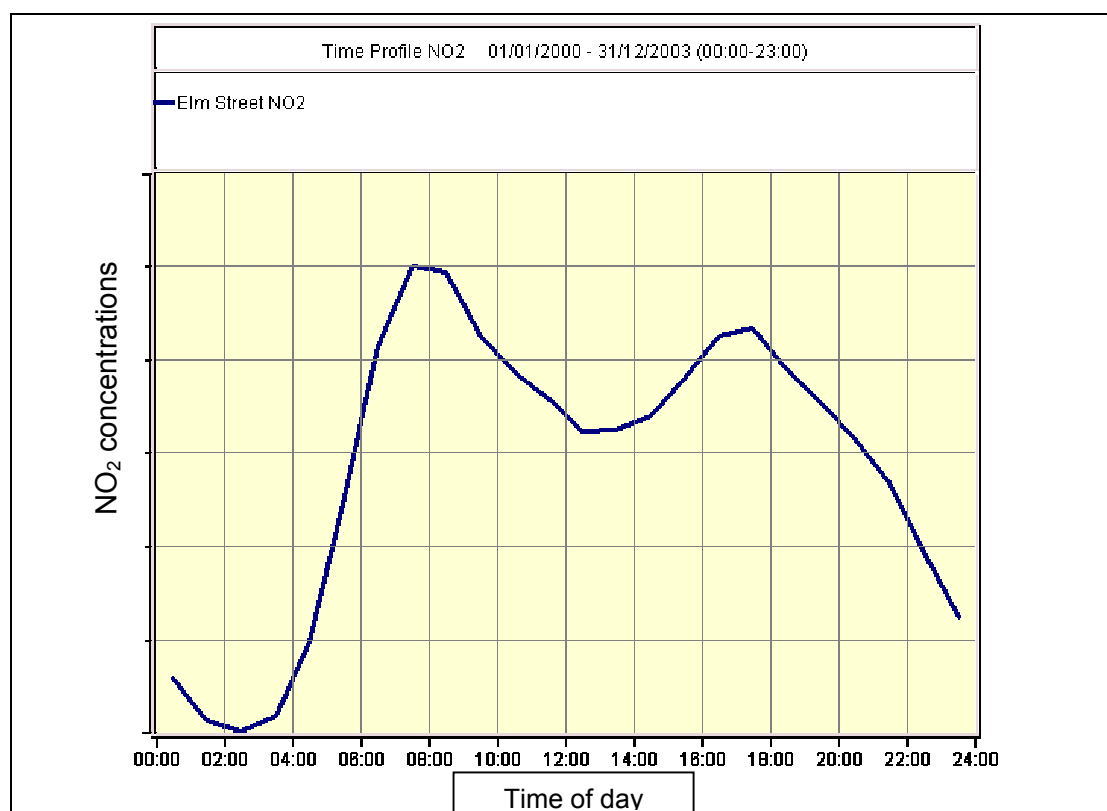


Figure 19 Diurnal profile of NO₂ at Elm Street.

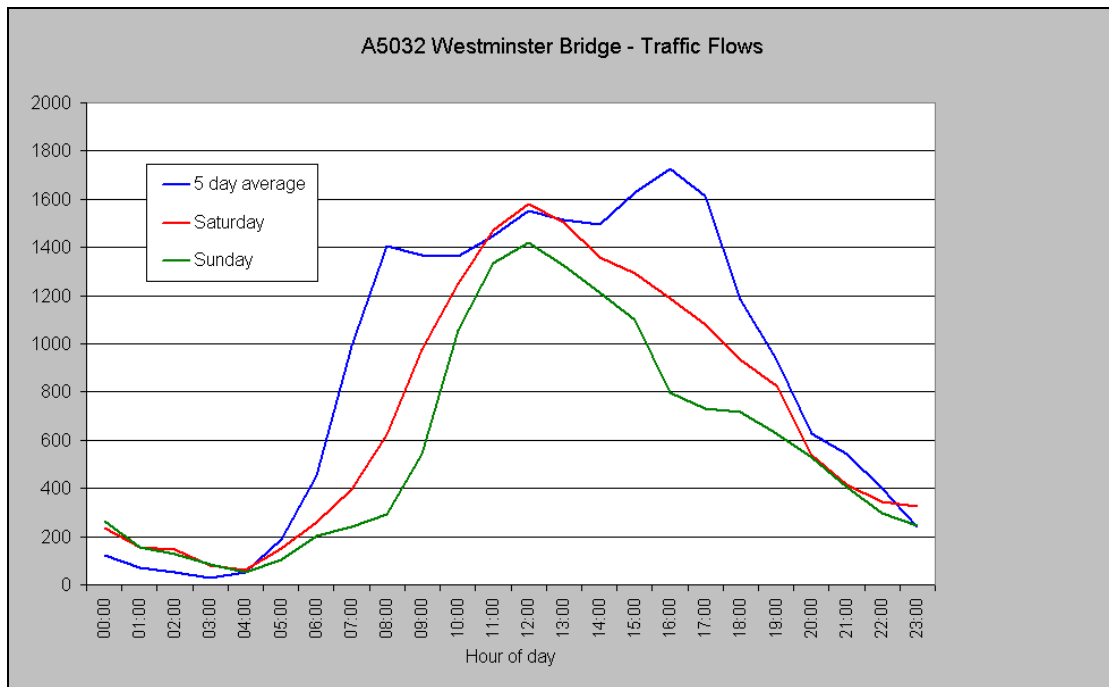


Figure 20 Typical diurnal traffic flow, 2003

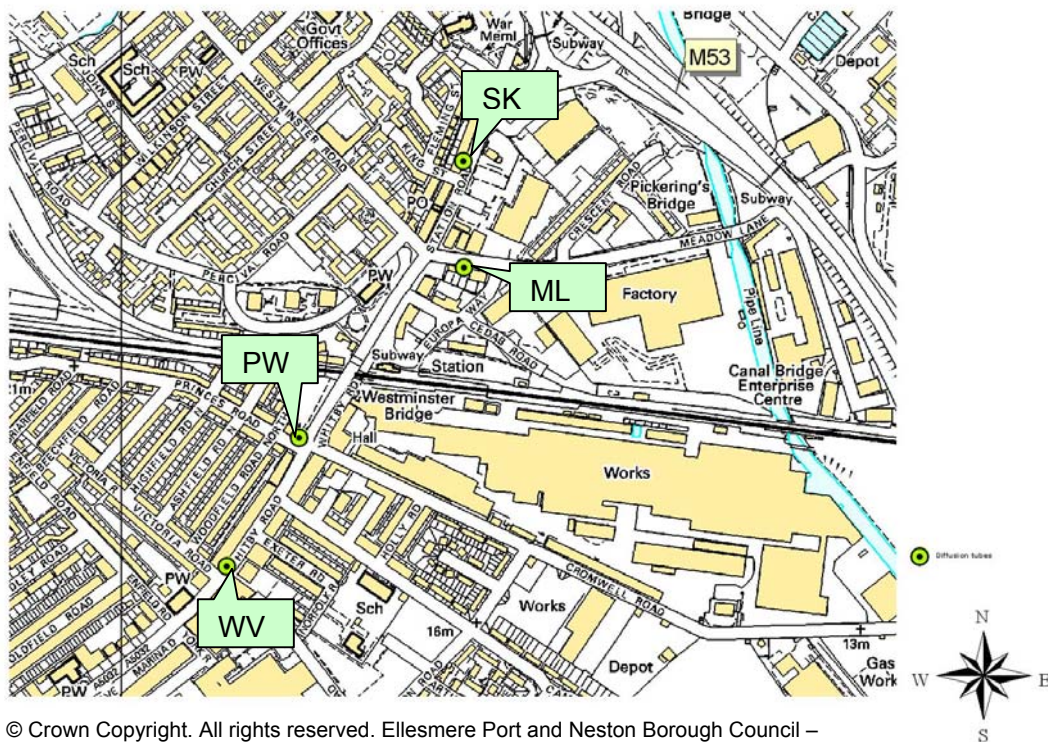


Figure 21 Locations of NO₂ diffusion tubes on A5032

4.4. Air Dispersion Modelling

4.4.1. Road Traffic

The focus of the modelling assessment was the section of the A5032 from junction 9 of the M53 (Station Road) along Whitby Road to the junction with Enfield Road. A number of terraced houses on Station Road and residential first-floor flats on both Station Road and Whitby Road qualify as relevant receptors in respect of the NAQS annual objective for NO₂. The remaining properties on this part of the A5032 are commercial at which the objective does not apply.

Road traffic data used in modelling were sourced both from automatic permanent counting sites and from manual counts. Traffic counts for the junction of Princes Road / Cromwell Road and Westminster Road / Meadow Lane, which feed into the A5032 were also included. Input data included heavy duty / light duty vehicle splits and speeds. A section of the M53 was assessed for the purposes of verification as the nearest real-time analyser is adjacent to the motorway. The 'street canyon' module built in to ADMS-Urban was used to assess whether the portion of Whitby Road between the Princes Road junction and Enfield Road is subject to elevated NO₂ due to recirculation effects. Background road data, including contributions from minor roads, brake and tyre wear, and 'cold start' / 'hot soak' emissions, were calculated during compilation of the local emissions inventory, and incorporated into gridded emissions for modelling.

Annual mean nitrogen dioxide concentrations are primarily influenced by ground-level sources of which road traffic emissions predominate. Although emissions from elevated point sources tend to affect short-term averages, there will also be some contribution to annual means. With this in mind, emissions from local industrial processes (which totalled 6 kilotonnes in 2001 – see 8.4) were included in initial NO₂ modelling scenarios.

Within any modelling area, a certain percentage of NO₂ is present as background concentrations. This will include local contributions from minor roads and other disparate sources as well as inputs from sources outside of the immediate area. Background pollution concentrations are available from the LAQM tools website as background maps (8.10) or can be obtained from an appropriate local monitoring station.

It was concluded that the national background maps tended to over-estimate ambient concentrations when compared to those shown to be present at established local background sites. Therefore, background data used for modelling were sourced from Stanney Grange monitoring site (see Table 20). It is recognised that these data may potentially include some contributions from local industry.

Although some NO₂ is emitted as a primary pollutant, the majority is present as result of atmospheric oxidation of NO driven by a suite of reactions involving ozone, sunlight and, to a lesser extent, hydrocarbons. For this reason it is necessary to model NO_x (NO and NO₂) rather than just NO₂.

Modelling runs were performed both with and without the ADMS 'chemistry' module in an effort to obtain the closest possible match between modelled and monitored results. Where chemistry was included, the 'NO_x-NO₂ correlation', which is based on the Derwent-Middleton correlation, was used. The local correlation between NO₂ and NO_x concentrations is shown in Figure 22 below. Local background NO_x data included in the modelling inputs was supplemented with background ozone concentrations from the national network site at Glazebury.

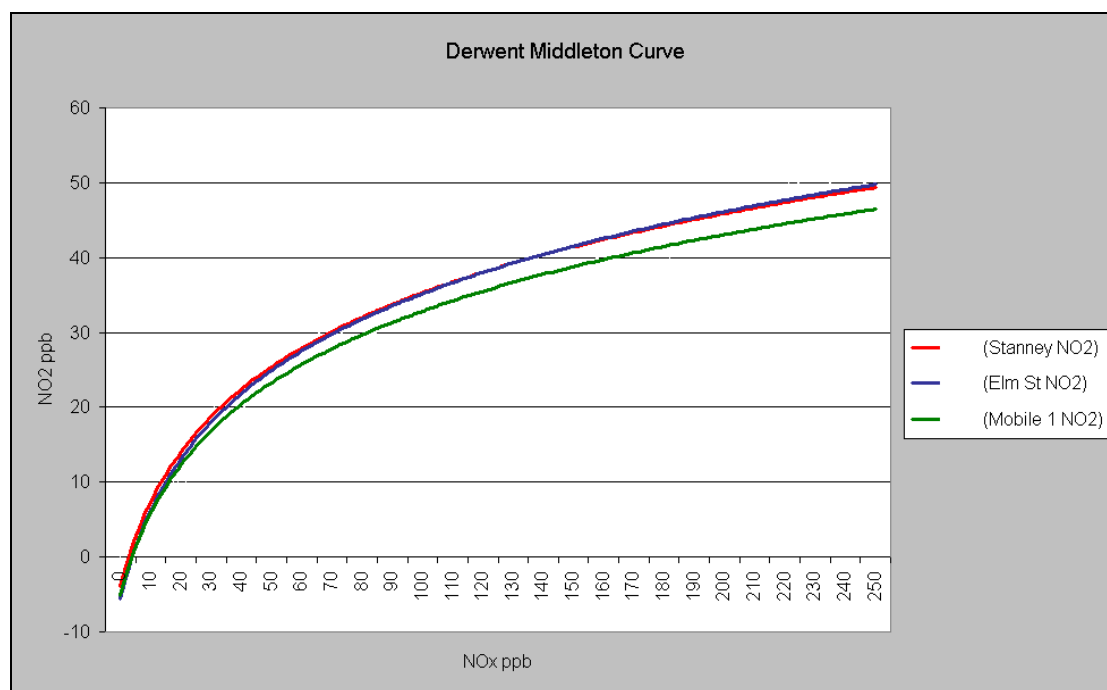


Figure 22 Correlation of NO₂ & NO_x at three local stations.

4.4.1.1. Modelling without chemistry

Figure 23 shows the predicted contours of NO_x for 2003 using ADMS-Urban (without use of the chemistry module) before background data have been applied. Results for the run are shown in Table 11.

Monitoring Station	Modelled NO _x (total) µg/m ³	Modelled NO _x (roadside) µg/m ³	Monitored NO _x µg/m ³
SK	29.12	11.00	-
WV	33.70	15.56	-
PW	28.41	10.34	-
ES	58.90	47.10	83.57

Table 11 Modelled NO_x - non-chemistry run.

Verification of NO_x data requires the addition of background concentrations. As discussed earlier these were sourced from the local real-time analyser at Stanney Grange (see Table 20). Of the various methods of verification described in the technical guidance TG03 (Ref 8.3), example1 (page A3-37) was used for this assessment, as shown in Table 12. It can be seen that there was good agreement between the monitored and modelled results at the real-time analyser as the NO_x adjustment factor (the ratio of the monitored to modelled NO_x from roads) is close to one. This factor was then used in the conversion of modelled NO_x at the remaining (diffusion tube) sites to NO₂, using the method shown in box 6.9 of the technical guidance (see Table 13). The table shows that the model is under-predicting by about 50% when comparing monitored NO₂ against NO₂ converted from modelled NO_x.

Monitoring Station	Elm Street
Model Run	NO ₂ -5
NO ₂ total monitored roadside	38.51
NO _x total monitored roadside	83.57
NO ₂ background	24.47
NO _x background	35.1
Modelled roadside NO _x contribution	47.1
NO _x roads monitored	48.47
NO ₂ roads monitored	14.04
NO _x adjustment factor, roads modelled	1.029
F (proportion of NO _x converted to NO ₂)	0.23
NO _x corrected roads modelled	48.47
NO ₂ roads mod (Modelled roadside NO ₂ contribution)	11.10
NO ₂ Total modelled	35.57

Table 12 Verification of modelled NO_x against real-time analyser

Monitoring Station	NOx road mod	NOx Corr Roads Mod	NO ₂ roads mod	NO ₂ tot mod	NO ₂ monitored
SK	11.00	11.32	2.59	27.06	44.47
WV	14.80	15.23	3.49	27.96	41.73
PW	10.34	10.64	2.44	26.91	39.80

Table 13 Conversion of NOx to NO₂

The review and assessment modelling helpdesk advises that it is not uncommon for a model to give different results at urban roads to those at motorway sites. An alternative means of verifying the model is to use a number of diffusion tube results in combination and derive an adjustment factor from this. A prerequisite for this is to have good quality data, bias adjusted against real-time data, which has been ratified to a high degree. All local diffusion tube data has been subjected to this procedure as documented in section 4.3 above.

Prior to verification it is necessary to estimate NOx concentrations from NO₂ diffusion tube data using the calculator provided on the LAQM tool website (Ref 8.10). The verification method used for real-time data (see Table 12) was used here for each diffusion tube site in turn, producing an average NOx adjustment factor of 4.123 (this is the factor by which all modelled roads contributions would need to be adjusted). Subsequent conversion of NOx to NO₂ resulted in an average under-prediction by the model of 14% at diffusion tube sites.



Modelling runs were also performed with the ADMS-Urban 'NO_x-NO₂ correlation' module, relying upon the model itself to simulate atmospheric NO_x chemistry. In this case it is possible to make a direct comparison of NO₂ although the technical guidance does advise that NO_x predictions should be verified. Table 14 shows how modelled NO₂ compares with monitored concentrations. Again, there is a disparity between the model's performance at the motorway site (ES) and at the diffusion tube sites. The overall under prediction of NO₂ at the diffusion tube sites is 13%.

Table 14 Comparison of modelled versus monitored NO₂

Deriving NO_x from NO₂ monitoring data using the same approach used earlier (see 4.4.1.1), verification produced an average NO_x adjustment factor of 1.69. Contours of NO₂ from the modelling run, projected forward to 2005, are depicted in Figure 24. On the advice of the local highways authority, traffic flows for 2005 were calculated from a base year of 2003 assuming a year-on-year growth of +0.9%. Traffic emissions estimates for 2005 were addressed using the DMRB factors built in to ADMS-Urban.

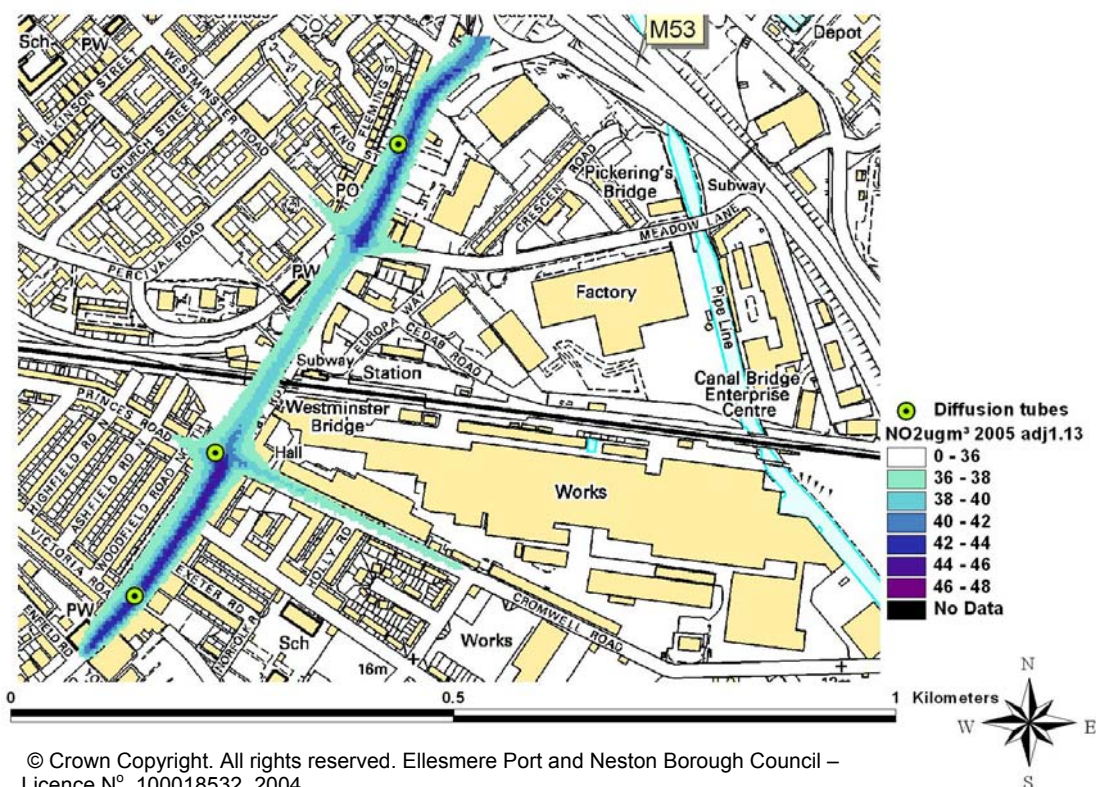


Figure 24 Contour plot of NO₂ on the A5032, 2005

The 2005 contours have been re-plotted as an overlay to OS landline data highlighting residential properties on the A5032 at which the NAQS objective applies (see Figure 25). Contours at the 36µg/m³ and 40µg/m³ are also highlighted.

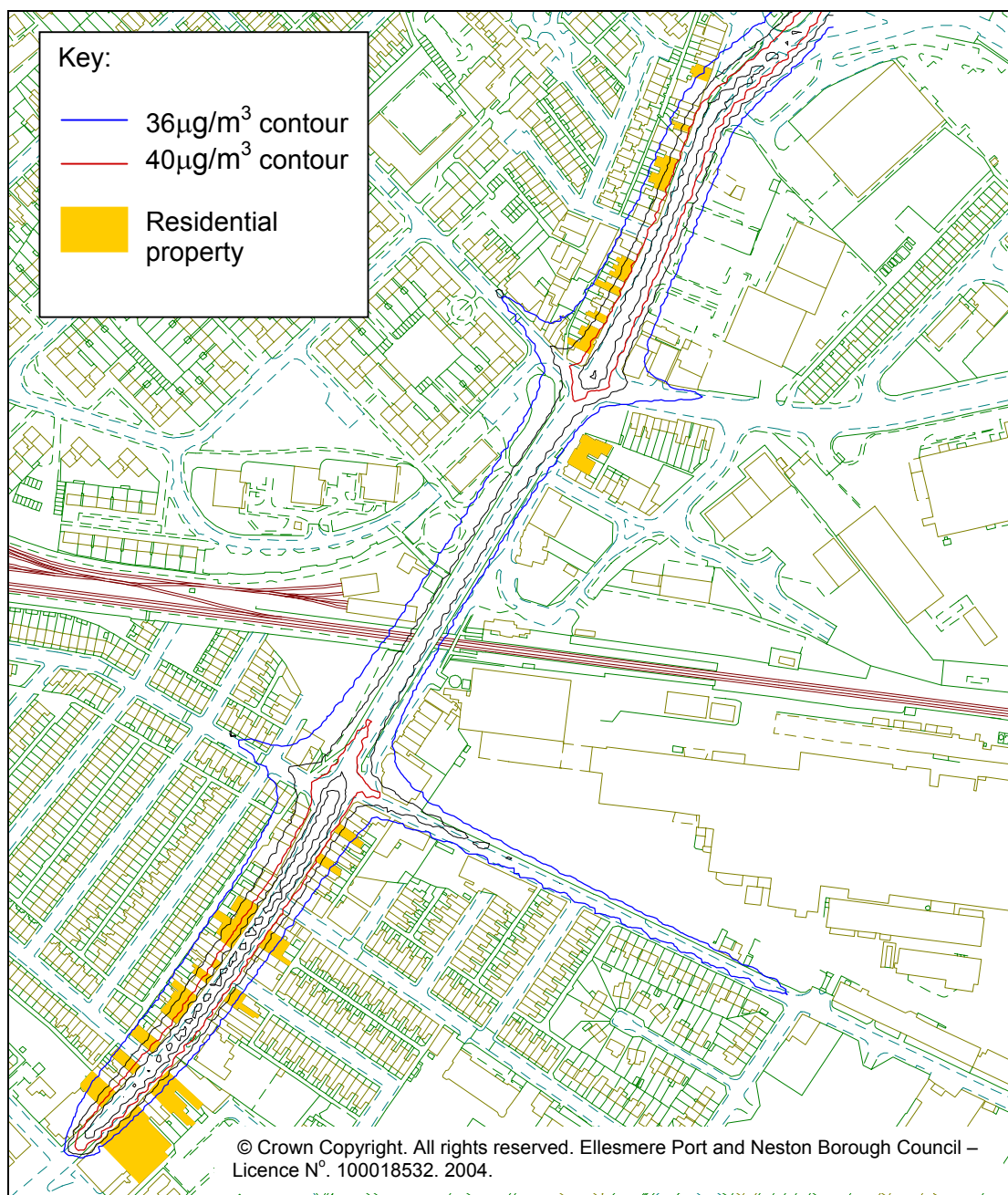


Figure 25 Enhanced contour plot of NO₂ on the A5032, 2005

4.4.2. Uncertainty

In addition to errors that can be accounted for in the verification process, dispersion modelling will also be subject to random errors that cannot be easily quantified (8.3). Consideration of uncertainty is particularly important where exceedences of the NAQS are predicted. While it is possible to calculate uncertainty given sufficient monitoring data, the NSCA guidance note (8.18) provides a range of stock uncertainty values (U) based upon previous modelling studies, which can be used to calculate standard deviation of the model (SDM):

$$\text{SDM} = U \times \text{NAQS objective}$$

$$\text{SDM} = 0.1 \times 40\mu\text{g}/\text{m}^3 = 4\mu\text{g}/\text{m}^3$$

Therefore contour lines relating to the NAQS objective would have an associated uncertainty of $\pm 4\mu\text{g}/\text{m}^3$.

4.5. Discussion

Verification showed that the model tends to under predict NO_x / NO₂ concentrations along the urban roads studied. It is likely that this is due to inadequate representation of factors such as: traffic queueing at junctions / pedestrian crossings, vehicle movements in car parks, and idling vehicles. These factors are, by their nature, difficult to characterize. However, verification exercises showed the model to be performing well in comparison to the bias-adjusted diffusion tubes (see Table 14).

Ambient concentrations of monitored NO₂ in 2003, both locally and across the UK, tended to be higher than in the years immediately preceding. Data polled for 2004 to date indicate that the 2004 annual mean NO₂ will be much lower than 2003. It might be questioned therefore whether it is appropriate to base the assessment of air quality in future years on this. A study by Laxen & Marner (Ref. 8.15) looking at year-to-year variations of NO₂, NO_x, and PM₁₀ for the previous 11 years concluded that, 'While levels were generally higher in 2003 than in both 2001 and 2002, the increases were not outside the normal year to year variation seen in the data over a long period. The values in 2003 are thus not considered exceptional and authorities should include them in the Review & Assessment decision-making process.' Furthermore, an assessment based on 'low' years may miss potential exceedences. It is of course, likely that NO₂ levels will decline in future years due to improvements in vehicle emissions technology across the fleet as a whole.

Exceedences of the annual mean NAQS objective for NO₂ have been predicted both by forward projection of 2003 monitoring data and via dispersion modelling. The 40 $\mu\text{g}/\text{m}^3$ contour for 2005 impinges on a number of

dwelling fronting the A5032 (see Figure 25). Taking model uncertainty into account (see 4.4.2), possible exceedences occur within one standard deviation of the modelled $40\mu\text{g}/\text{m}^3$ contour, that is, the $36\mu\text{g}/\text{m}^3$ line. A number of residential properties on Princes Road would be included within this region in addition to those lying along the $40\mu\text{g}/\text{m}^3$ contour.

Five additional diffusion tubes have been positioned on the A5032 in order to obtain a better characterisation of the spatial extent of elevated NO_2 . Subject to the availability of a suitable location and planning constraints, continuous monitoring will be installed within the exceedence area as soon as practicably possible. The analyser located at Elm Street has served its purpose at the current site and is available for relocation. Further road traffic data would also assist in the refinement of modelling inputs.

4.6. Conclusion

- The detailed assessment has demonstrated that the 2005 objective for NO_2 is likely to be exceeded at relevant receptors on the A5032.
- An AQMA needs to be declared in respect of road traffic emissions on those parts of the A5032 identified in Section 4.5 above. Taking uncertainty into account, the boundary of the AQMA should, as a minimum, include all residential properties lying along the modelled $36\mu\text{g}/\text{m}^3$ contour.
- Further air pollution monitoring needs to be carried out on the A5032

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5. PARTICULATES (PM₁₀)

5.1. *Introduction*

Airborne particulate matter originates from a variety of sources. Primary sources include combustion processes, mineral extraction, wind-blown surface dust and sea salt whilst chemical transformations of sulphates and nitrates can produce secondary particulates. Episodes of particulate pollution can occur on regional and even continental scales.

PM₁₀ - that is particulate matter with an aerodynamic diameter less than 10 microns - can be readily inhaled and is associated with a range of effects on health including lung function, exacerbation of asthma and cardiovascular diseases.

The National Air Quality objectives are

- A 24-hour mean of 50µg/m³ not to be exceeded more than 35 times a year
- An annual mean level of 40µg/m³.

These objectives must be met by December 2004.

New objectives not currently in regulations are

- A 24-hour mean of 50µg/m³ not to be exceeded more than 7 times a year
- An annual mean level of 20µg/m³.

These objectives must be met by December 2010.

5.2. *Conclusions of the Updating & Screening Assessment 2003*

The council's Updating and Screening Assessment (2003) identified that it was necessary to proceed to a detailed assessment for PM₁₀ due to the extent of industrial emissions.

5.3. *Monitoring Data*

PM₁₀ is monitored at two locations in the borough using real-time TEOM analysers (see Table 18 & Figure 26). Because the heated manifold of the TEOM results in the volatilisation of some fractions of PM₁₀ it is necessary to apply an adjustment factor to the data in order that it can be compared against the NAQS objective, which is based on gravimetric measurement techniques. Although the factor will be, to some extent, site-specific, the generally accepted approach is to multiply TEOM data by 1.3 (Ref 8.3). This has been applied to all PM₁₀ monitoring data used for the review.

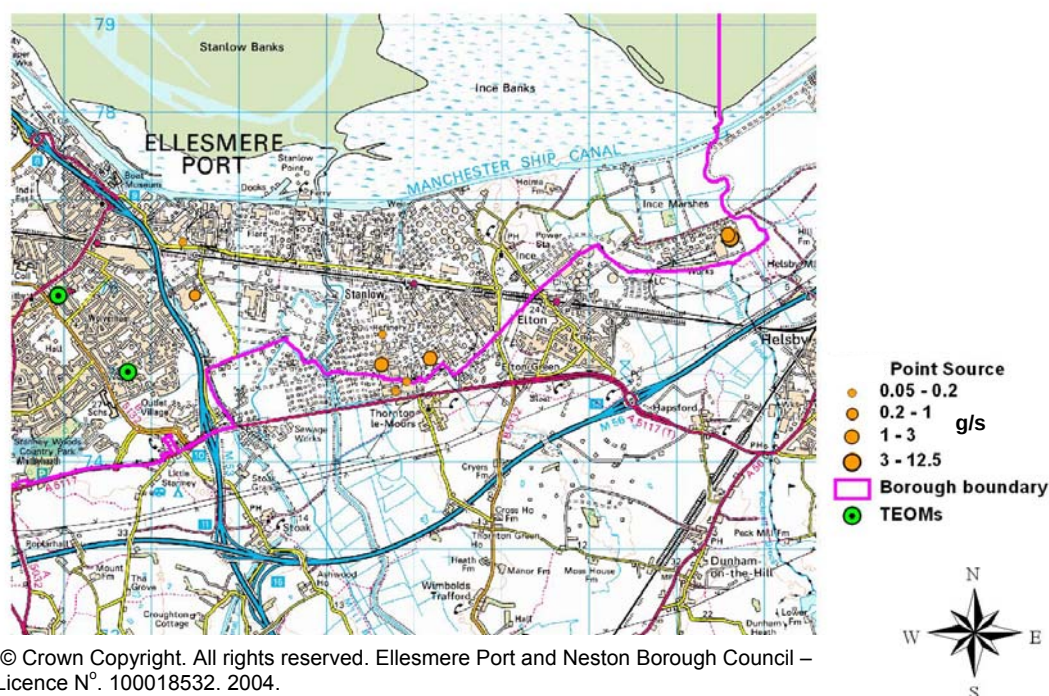


Figure 26 Locations of TEOM analysers & PM₁₀ point sources, 2003

Monitoring data for 2002 and 2003 is shown in Table 25 & Table 26. It can be seen that the highest recorded annual mean (Ellesmere Port library) was $23.98\mu\text{g}/\text{m}^3$ in 2003 and as such was well below the NAQS annual objective of $40\mu\text{g}/\text{m}^3$. Indeed each annual mean value was about half of the 2004 objective.

In 2003 there was a marked increase in the 90.4th percentile (a 90.4th percentile of $50\mu\text{g}/\text{m}^3$ is the equivalent of 35 exceedences of the objective) due to more frequent exceedences of the 24-hour mean objective, with Ellesmere Port library recording 19 such occurrences. These were, in the main, due to warm, dry conditions coupled with regional / continental episodic phenomena such as moor fires and wind-blown dust. The NAQS allows 35 exceedences of the objective across the calendar year.

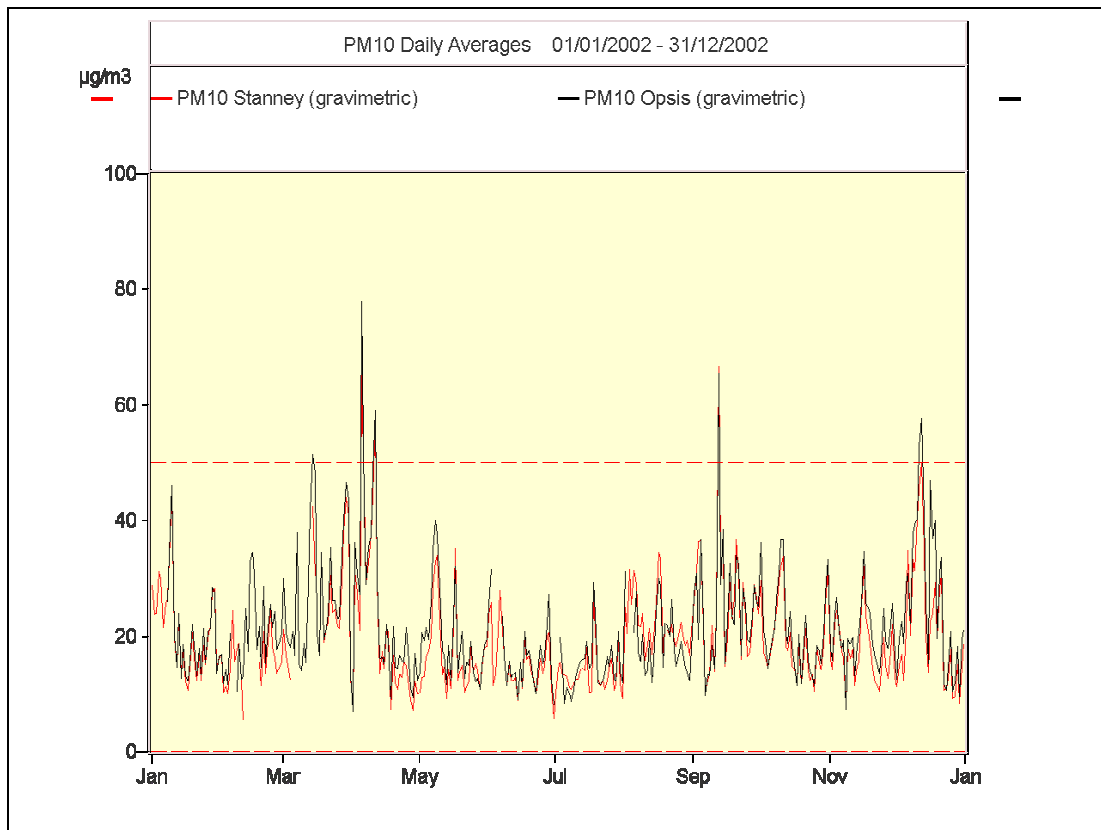


Figure 27 PM₁₀ 24-hour means, 2002

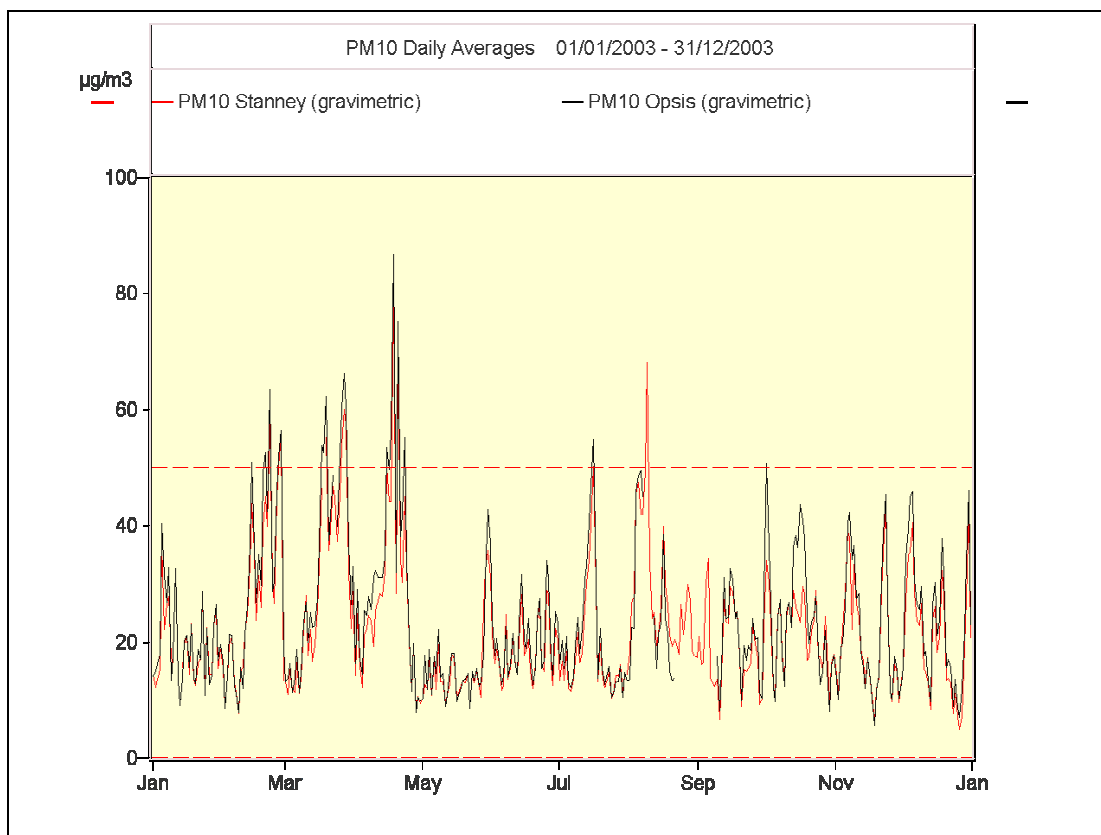


Figure 28 PM₁₀ 24-hour means, 2003

In order to demonstrate compliance with the objectives it is necessary to project forward to the date by which they must be met. Since PM₁₀ is comprised of primary, secondary and coarse fractions, and that the relationship between them is not expected to remain constant across future years, it is necessary to forward-project each component separately then recombine to derive an overall estimate (Ref 8.3 p8-10 and 8.13). In the calculations below the annual recorded at EP library in 2002 was used as the 2003 figure was heavily influenced by atypical episodes of PM₁₀.

Estimation of 2004 PM₁₀

2002 gravimetric PM₁₀ [C_G 02]: 21.34µg/m³

2001 secondary PM₁₀ [C_S 01]: 5.96µg/m³ (from Ref 8.10)

2002 secondary PM₁₀ [C_S 02]: 5.96 x 0.977 = 5.82µg/m³

coarse PM₁₀ [C_C] : 10.5µg/m³

2002 primary PM₁₀ [C_P 02] = C_G 02 - C_S 02 – C_C

$$= 5.02\mu\text{g}/\text{m}^3$$

2004 primary PM₁₀ [C_P 04] = C_P 02 x (0.930/0.977)

$$= 4.78\mu\text{g}/\text{m}^3$$

2004 secondary PM₁₀ [C_S 04] = 5.96 x 0.932 = 5.55µg/m³

2004 gravimetric PM₁₀ = [C_P 04] + [C_S 04] + [C_C]

$$= \underline{20.83\mu\text{g}/\text{m}^3}$$

Estimation of 2010 PM₁₀

2002 gravimetric PM₁₀ [C_G 02]: 21.34µg/m³

2001 secondary PM₁₀ [C_S 01]: 5.96µg/m³ (from Ref 8.10)

2002 secondary PM₁₀ [C_S 02]: 5.96 x 0.977 = 5.82µg/m³

coarse PM₁₀ [C_C] : 10.5µg/m³

2002 primary PM₁₀ [C_P 02] = [C_G 02] – [C_S 02] – [C_C]

$$= 5.02\mu\text{g}/\text{m}^3$$

2010 primary PM₁₀ [C_P 10] = [C_P 02] x (0.815/0.977)

$$= 4.19\mu\text{g}/\text{m}^3$$

2010 secondary PM₁₀ [C_S 10] = 5.96 x 0.795 = 4.74µg/m³

2010 gravimetric PM₁₀ = [C_P 10] + [C_S 10] + [C_C]

$$= \underline{19.43\mu\text{g}/\text{m}^3}$$

The estimated 2004 PM₁₀ annual mean concentration of 20.83µg/m³ is well below the NAQS objective of 40µg/m³. By 2010 the estimated annual mean is 19.43µg/m³ which is just below the proposed objective to be met by that date.

5.4. Air Dispersion Modelling

Primary PM₁₀ emissions from 75 point sources were modelled across a 32km² grid centred on the refinery site. As noted in the council's USA (Ref 8.4), size fractions of particulate matter from a number of industrial processes are not defined, so a precautionary approach was adopted whereby total suspended particulates were modelled as PM₁₀. Background data were not included in the modelling run because of the difficulties of addressing secondary particulate formation. These data were obtained from NETCEN's LAQM website (Ref 8.10). Emissions data for 2001 was modelled against the 2001 Ringway meteorological dataset.

Figure 29 shows the 2001 contour plot for annual mean PM₁₀. On the basis of the modelling results, the highest industrial source contribution to primary PM₁₀ is 1.75µg/m³. This occurs outside the borough boundary in grid square SJ470 770.

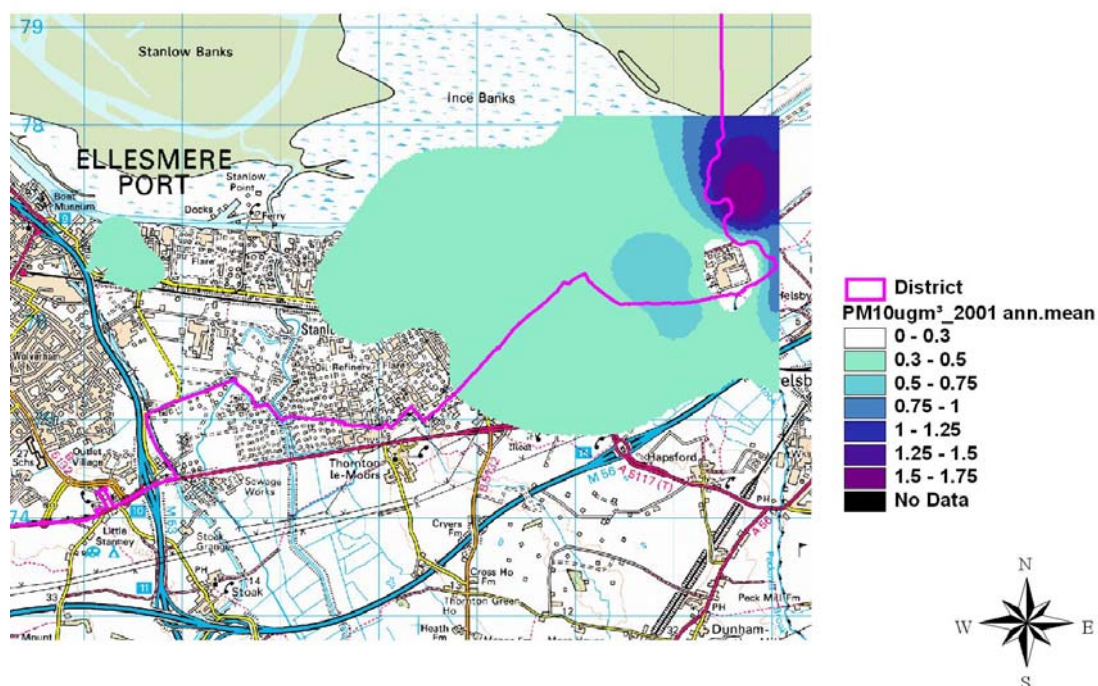


Figure 29 PM₁₀ annual mean contour plot, 2001

Taking the secondary and coarse fractions into account, the modelling exercise predicted a 2001 annual mean of $18.21\mu\text{g}/\text{m}^3$. Ordinarily, this would need to be verified against a nearby monitoring station. The monitored annual mean at the nearest relevant monitoring station, located in Ince during 2001, was $20.54\mu\text{g}/\text{m}^3$ (gravimetric), which indicates that the model is under-predicting by about 11%. Unfortunately, the data capture rate was just 60% so any comparisons drawn should be viewed with caution. However, the next nearest monitoring station, Stanney Grange, situated 7.5km west of the contour area, registered an annual mean of $20.83\mu\text{g}/\text{m}^3$, which is readily comparable to the Ince figure.

For assessment against the 2004 objective it is necessary to project forward the modelling prediction adopting a similar approach to that used for monitored data (see 5.3):

Estimation of 2004 PM₁₀

2001 primary PM₁₀ [C_P 01] = $1.75\mu\text{g}/\text{m}^3$ (modelled)

2001 secondary PM₁₀ [C_S 01]: $5.96\mu\text{g}/\text{m}^3$ (from Ref 8.10)

coarse PM₁₀ [C_C] : $10.5\mu\text{g}/\text{m}^3$

$$\begin{aligned} 2001 \text{ gravimetric PM}_{10} [C_G 01] &= [C_P 01] + [C_S 01] + [C_C] \\ &= 18.21\mu\text{g}/\text{m}^3 \end{aligned}$$

$$2004 \text{ primary PM}_{10} [C_P 04] = C_P 01 \times (0.930) = 1.63\mu\text{g}/\text{m}^3$$

$$2004 \text{ secondary PM}_{10} [C_S 04] = 5.96 \times 0.932 = 5.55\mu\text{g}/\text{m}^3$$

$$2004 \text{ gravimetric PM}_{10} = [C_P 04] + [C_S 04] + [C_C]$$

$$= \underline{17.68\mu\text{g}/\text{m}^3}$$

Modelling showed that the highest predicted increment to the 24-hour mean was $5\mu\text{g}/\text{m}^3$ as a 90.4th percentile (see Figure 30). As for the annual mean, modelling in respect of the daily mean cannot account for secondary or coarse fractions of PM₁₀. However it would not be correct to follow the procedure used above for the estimation of the annual mean as this would result in the under-estimation of PM₁₀. The Environment Agency's technical guidance, H1 (Ref 8.17), recommends adding twice the annual average background to the modelled output. Application of this method gives a 24-hour of $42\mu\text{g}/\text{m}^3$ in grid square SJ470 770. This is below the NAQS objective of $50\mu\text{g}/\text{m}^3$, but also occurs at location at which the objective does not apply (see Table 5).

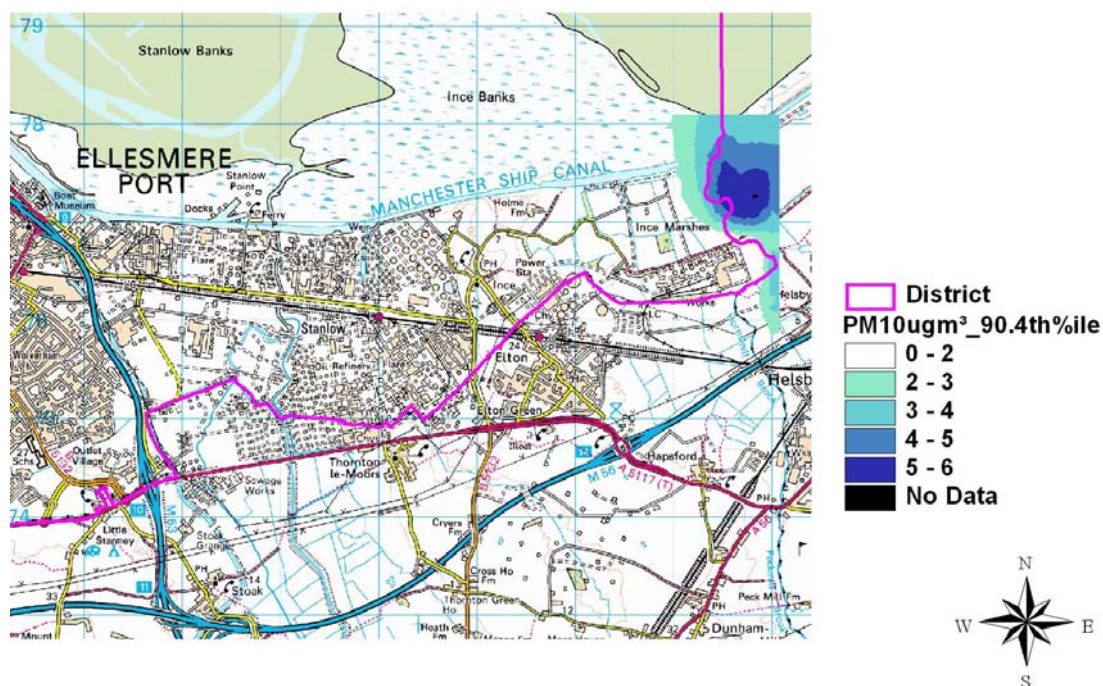


Figure 30 PM₁₀ 90.4th percentile contour plot, 2001

5.5. Discussion

Due to the deficiencies in monitoring data during 2001 it was not possible to undertake an adequate verification of modelled results. However, the comparison between modelling and monitoring was generally good (11-13% under-prediction). TG03 (Ref 8.3) advises that monitoring data should give a more accurate indication of PM₁₀ concentrations than modelling studies. With this in mind, greater emphasis has been placed on local monitoring of PM₁₀.

Neither real-time monitoring equipment nor modelling recorded any exceedences of the current annual mean objective. Forward projections of monitoring show that the objective will be met by the target date of December 2004.

It is recognised that elevated point sources are likely to have little impact upon the annual mean concentration, and that the assessment should focus on the 24-hour mean (Ref 8.3). Ideally, seasonal and daily variations in emissions data should be modelled; as these will have a relatively large influence on short term peaks. Unfortunately, these data were not available, although worst-case conditions were considered by treating total particulates from two processes as PM₁₀. In common with the results of monitoring, modelling studies did not predict any exceedences of the 24-hour mean objective in

2001. During 2003, however, 19 exceedences were recorded at Ellesmere Port library (Ref Table 26).

As mentioned earlier, these episodes are most likely to be due to regional phenomena such as wind-blown dust and moor fires. The number of exceedences is well below the NAQS objective, which allows 35 exceedences. Furthermore, the technical guidance notes that the relationship between the number of daily exceedences and the annual mean is such that the 24-hour mean objective is likely to be complied with if the annual mean is less than $32\mu\text{g}/\text{m}^3$ (Ref 8.3). Due to the episodic nature of the 2003 peaks, the council has confidence that the 24-hour objective will be complied with.

5.6. Conclusions

- The detailed assessment has demonstrated that the 2004 objectives for PM_{10} will be complied with at all relevant receptors.
- Projections of PM_{10} monitoring show that further work will be required when the proposed annual mean objective for 2010 is adopted
- PM_{10} monitoring should be continued for the foreseeable future.
- An AQMA does not need to be declared.

6. SULPHUR DIOXIDE (SO₂)

6.1. *Introduction*

The main source of sulphur dioxide in the UK is the combustion of sulphur-containing fossil fuels; principally coal and heavy oils. The shift of domestic heating away from coal fires (aided by the imposition of smoke control areas), conversion of large industrial plant to gas and improvements in pollution abatement technologies has resulted in a dramatic reduction in ambient SO₂ over the last 40 years.

Sulphur dioxide acts as an irritant when it is inhaled, because of its acidic nature, and high concentrations may cause breathing difficulties. People suffering from respiratory ailments may be especially susceptible to the adverse effects of sulphur dioxide and, within the range of concentrations that occur in pollution episodes, it may provoke attacks in asthma sufferers.

The National Air Quality objectives are:

- A 1-hour mean of 350 µg/m³ (132ppb) not to be exceeded more than 24 times per year,
- A 24-hour mean of 125µg/m³ (47ppb) not to be exceeded more than 3 times a year,
- A 15-minute mean of 266µg/m³ (100ppb) not to be exceeded more than 35 times a year.

The objectives for the 1-hour and 24-hour mean must be met by December 2004. The objective for the 15-minute mean must be met by December 2005.

6.2. *Conclusions of the Updating & Screening Assessment 2003*

The council's Updating and Screening Assessment (2003) identified that it was necessary to proceed to a detailed assessment for sulphur dioxide due to the extent of industrial emissions.

6.3. *Monitoring Data*

Three real-time automatic analysers monitor SO₂ at strategic locations in the borough, and a fourth, VI, was in use until 2002 (see Table 18 and Figure 36). The analyser sited at Stanney Grange is an API M100a UV-fluorescence point monitor as used in the UK national network, whereas the other two are long-path DOAS Opsis beams.

Airborne sulphur dioxide levels have declined markedly over the eight years that real-time monitoring has been conducted in Ellesmere Port (see Figure 31) due to factors such as improvements in emissions control. It can be seen long-term averages are now much lower, as are the number of exceedences of the NAQS objective.

Scaled and ratified monitoring data for the years 2001 – 2003 are shown in Table 22 – 20, and are presented graphically as 15-minute averages in Figure 32 – 33. Although no exceedences of the NAQS 15-minute objective were recorded in either 2001 or 2003, the objective was exceeded 11 times in 2002. A virtual doubling of the frequency of easterly winds during 2002, bringing more industrial emissions towards the urban area, is likely to be the root cause of this increase. While this is well below the 35 allowable exceedences it does demonstrate that prevailing weather conditions have a significant bearing on ambient concentrations of air pollutants.

A comparison of maximum SO₂ concentrations for two monitoring stations against wind direction (see wind rose Figure 35) shows that the highest levels of SO₂ occur when winds approach from eastern and southeastern sectors confirming that industrial emissions are the cause of excursions above the NAQS objective.

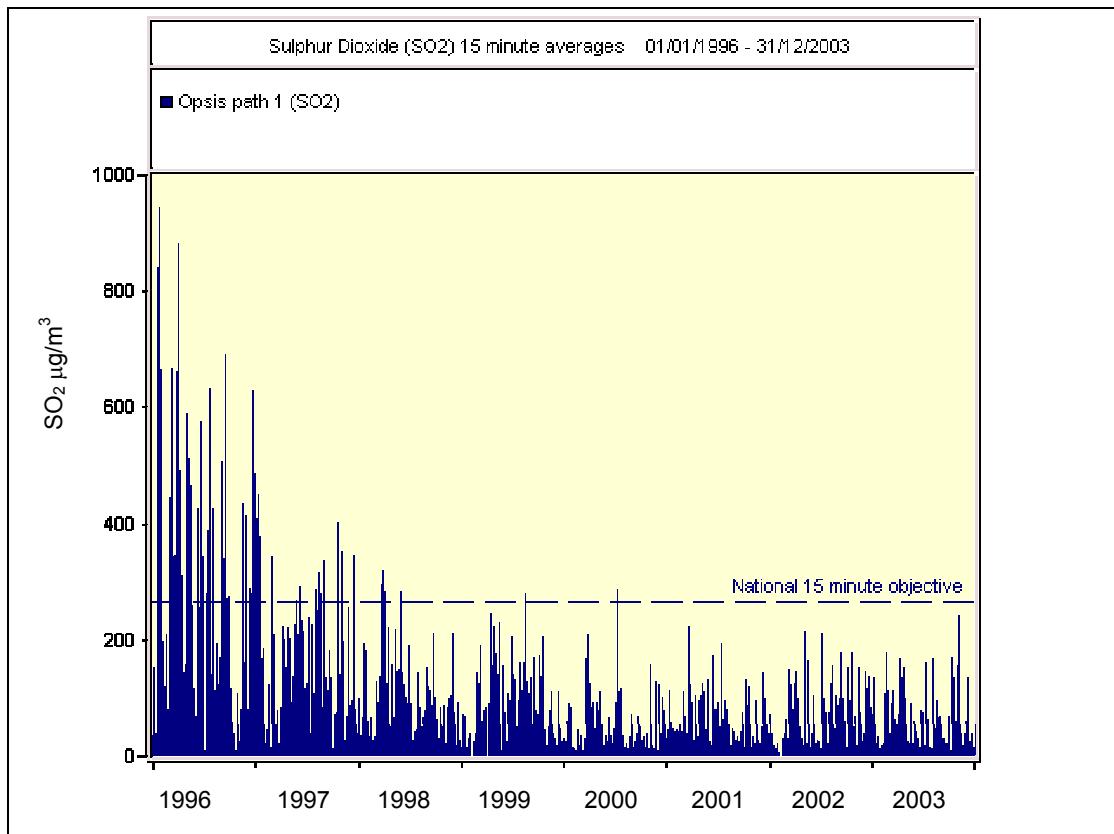


Figure 31 Trends of SO₂ (15-minute means) 1996 - 2003

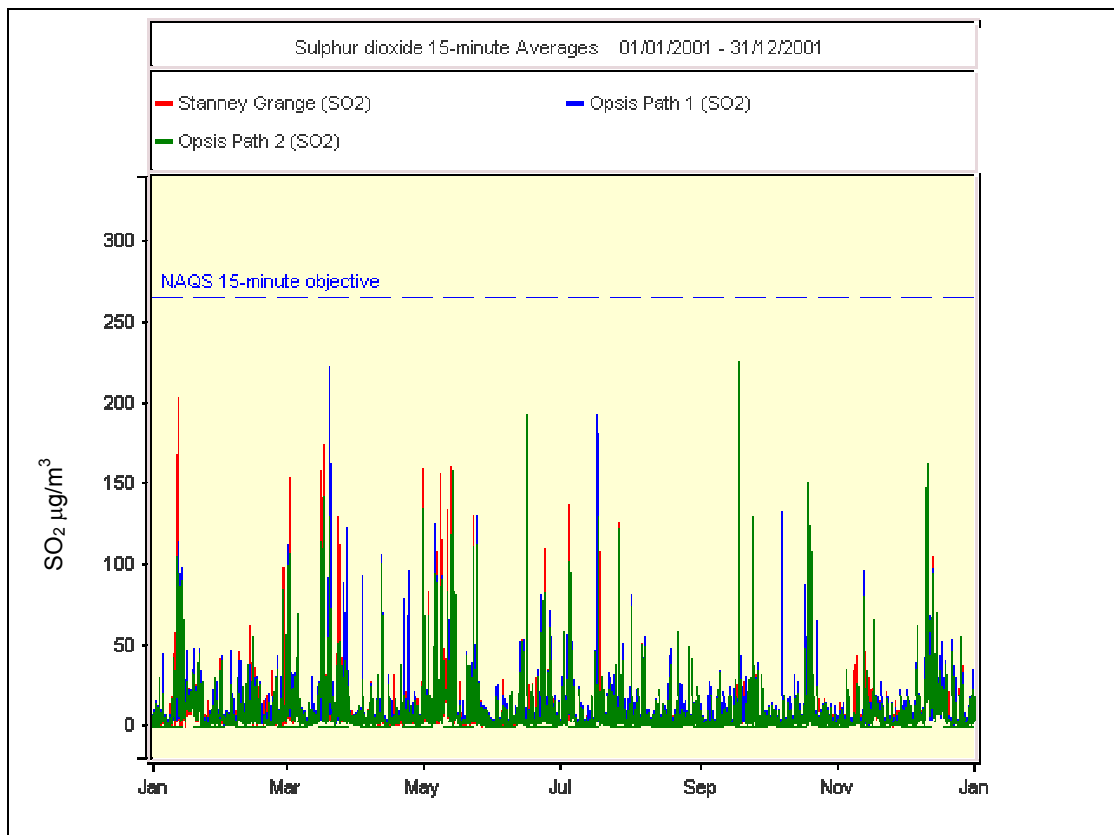


Figure 32 Sulphur dioxide 15-minute means, 2001

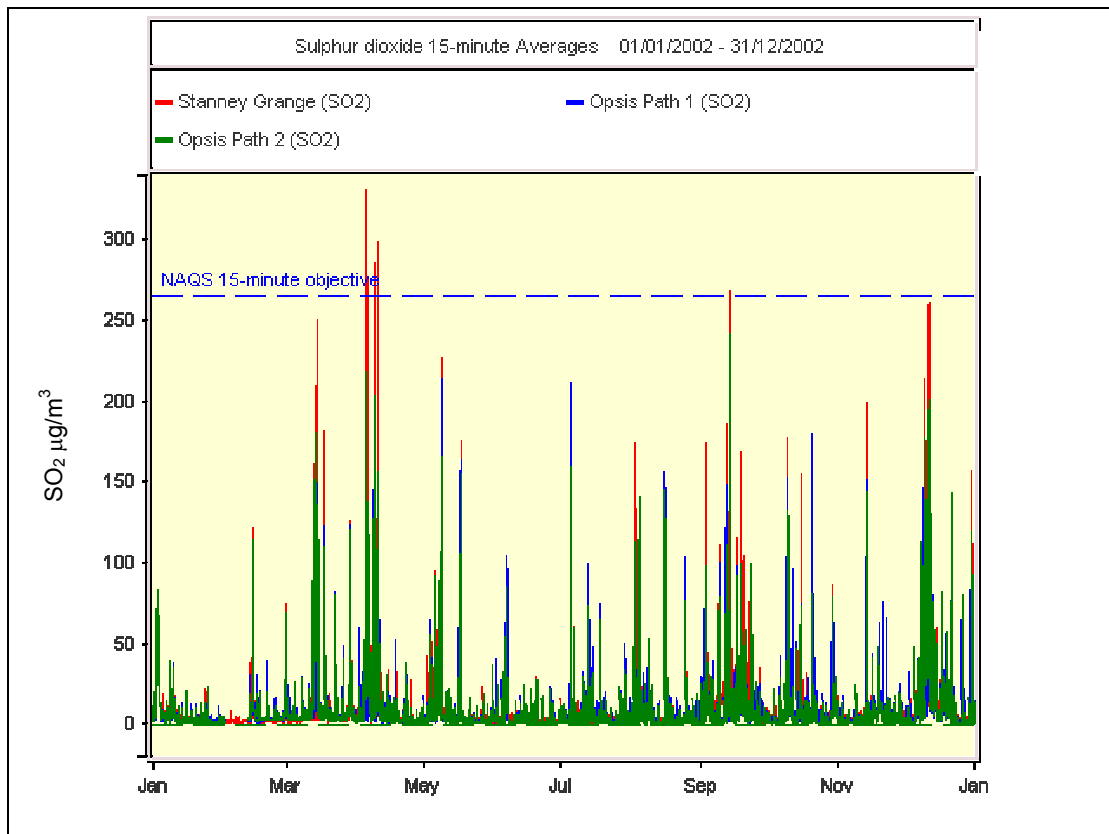


Figure 33 Sulphur dioxide 15-minute means, 2002

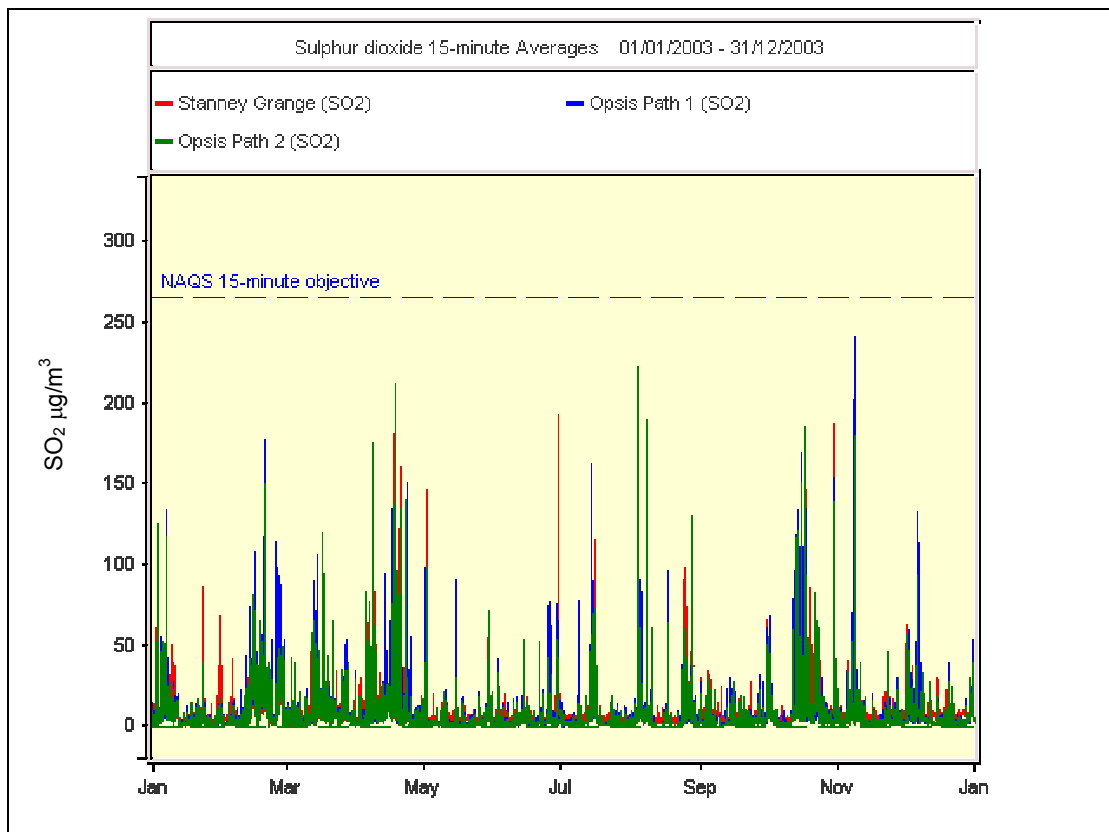


Figure 34 Sulphur dioxide 15-minute means, 2003

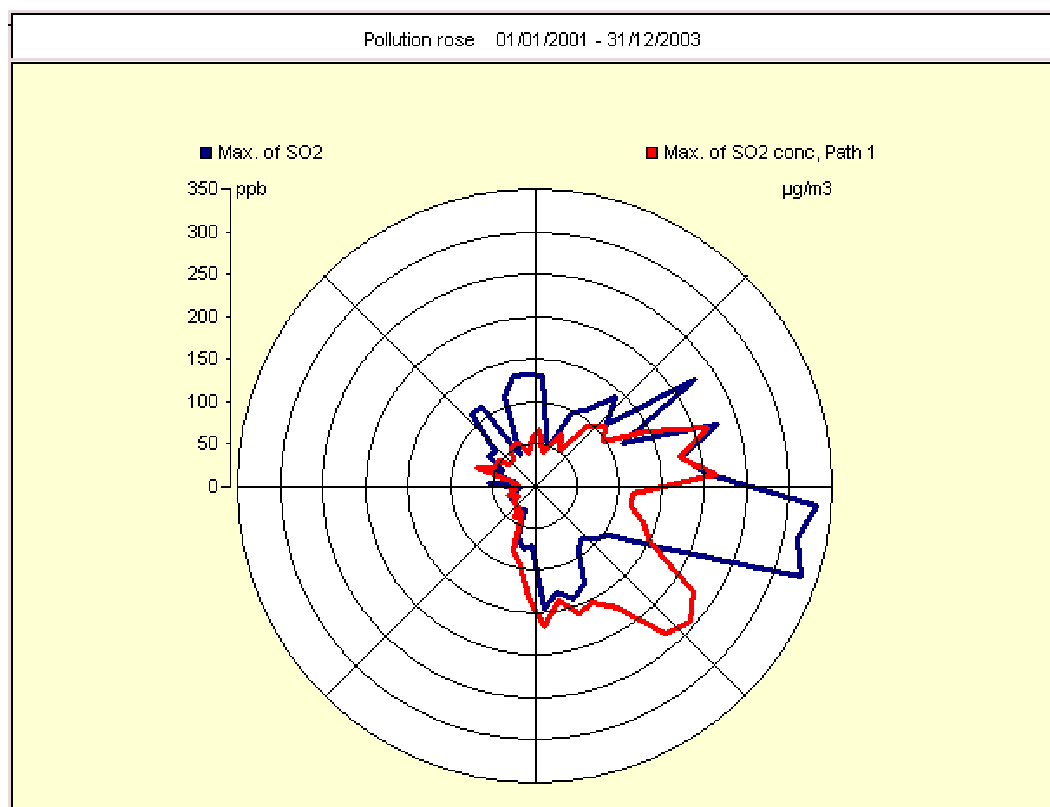


Figure 35 SO₂ pollution rose for Stanney Grange & Opsis, 2001-2003

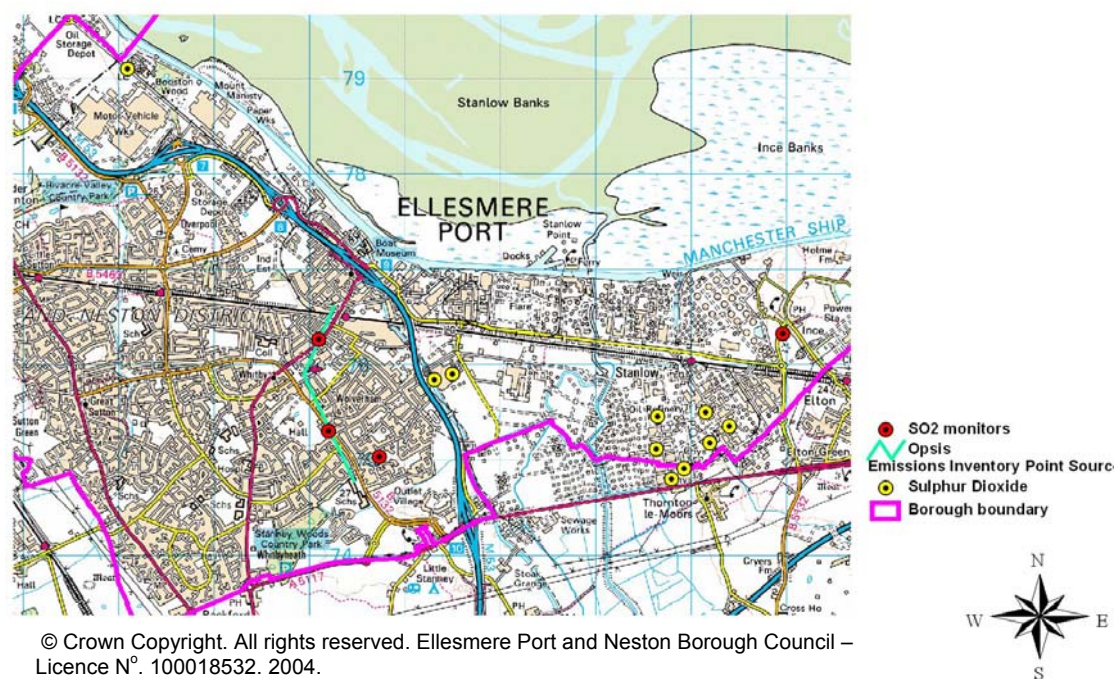


Figure 36 Locations of local SO₂ point sources and monitors, 2001

6.4. Air Dispersion Modelling

The predominant 12 industrial sources of SO₂ – out of 29 for which emissions have been modelled in the assessment – are shown in Figure 36 above. Local emissions totalled almost 13,000 tonnes during 2001 (the year used for modelling). A modelling output grid of ~24km² centred on the refinery site, having a receptor spacing of 50 metres was used for sulphur dioxide.

Emissions data for 2001 were modelled against 2001 meteorological data for the purposes of verification (in this instance it was found that the combined Ringway / Ellesmere Port dataset gave the best comparisons), and also against the 2003 dataset for inter-year comparisons. ADMS default settings for the Monin-Obukhov length and surface roughness were used. Background concentrations were not included at this stage in order that source contributions could be assessed. Time-varying emissions data were not available for the majority of sources so annual average emissions data were used for all modelling scenarios.

Contour plots in Figure 37 & Figure 38 show the spatial dispersion of SO₂ for the years 2001 & 2003 in respect of the 15-minute mean NAQS objective. It can be seen that a different year's meteorology has a noticeable effect on the extent of plume grounding with both the magnitude and spatial dispersion of SO₂ affected. In 2001 the higher ground level concentrations were predicted to occur to the southwest of the refinery site. However, in 2003 the maxima were concentrated to the east of the main stacks. Before taking account of background SO₂, the highest predicted 99.9th percentile (a 99.9th percentile of 266µg/m³ is the equivalent of 35 exceedences of the objective) in 2001 was 242µg/m³, whilst the peak was 361µg/m³, both of which occurred in grid square SJ430 740. For 2003, modelling placed the maximum level (344µg/m³) in grid square SJ430 740, with the highest 99.9th percentile (290µg/m³) shifted to SJ440 750.

Predicted concentrations of SO₂ at various monitoring sites are presented in Table 15 and Table 16 along with comparisons against monitoring data. Where sequential real-time background data are unavailable for modelling short averaging periods, the accepted approach is to use double the annual mean value derived from either local monitoring or the national background maps (Ref 8.7). In this case background concentrations were obtained from NETCEN's LAQM website (Ref 8.10). The verification exercise (Table 15) showed that over- or under-prediction is within 10% at three of the four monitoring sites. Performance of the model is therefore good. No exceedences were predicted at any of the receptors.

Table 16 shows a comparison of 2001 emissions data modelled using 2003 meteorological data against 2003 monitoring data. Again, no exceedences were predicted and the disparity between the two scenarios is minimal.

Receptor Site code	2001 Modelled Concentration + 2x background ($\mu\text{g}/\text{m}^3$)	2001 Monitored Concentration ($\mu\text{g}/\text{m}^3$)	% Difference (under-prediction = negative)	Average ratio (%)
SG	116.05	128.29	-10	+17
VI	165.40	125.79	+31	
LR-JG	130.41	127.20	+2	
LR-SH	115.56	122.40	-6	

Table 15 Verification of predicted SO₂ (99.9th percentile), 2001

Receptor Site code	2003 Modelled Concentration + 2x background ($\mu\text{g}/\text{m}^3$)	2003 Monitored Concentration ($\mu\text{g}/\text{m}^3$)	% Difference (under-prediction = negative)	Average ratio (%)
SG	127.4	138.7	-8	-4
VI	186.9	N/A	-	
LR-JG	135.5	150.9	-10	
LR-SH	127.4	121.3	+5	

Table 16 Comparison of predicted SO₂ (99.9th percentile), 2003

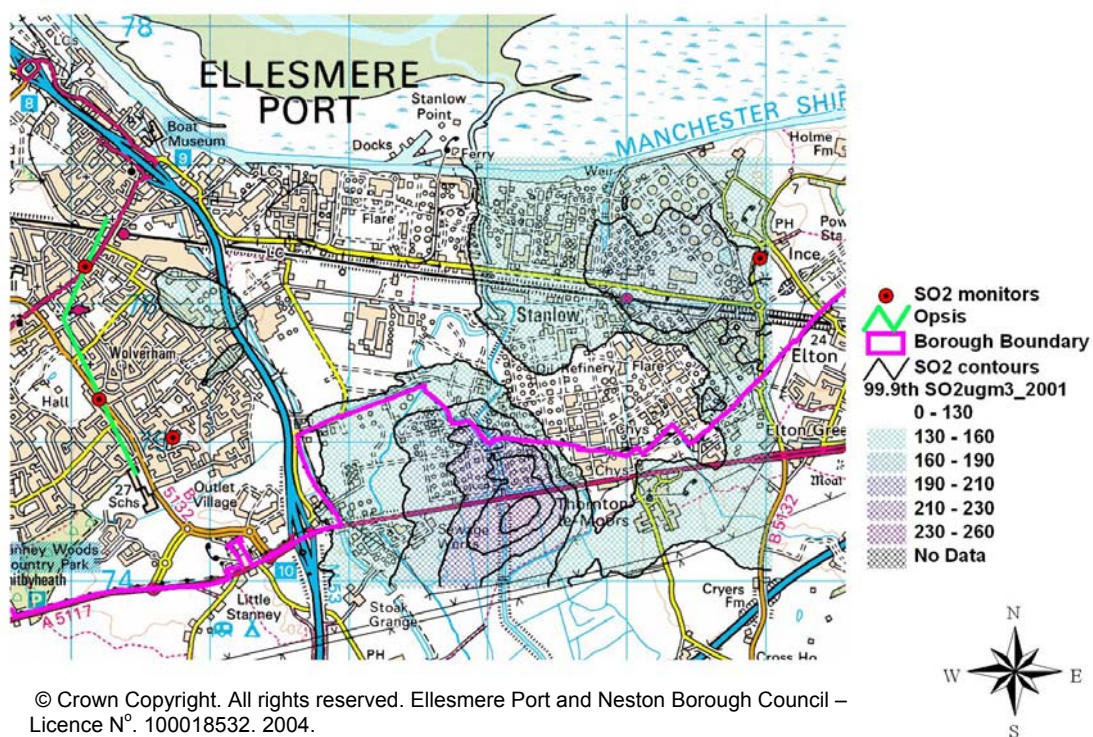


Figure 37 Contour plot of the 99.9th percentile of 15-min mean SO₂ 2001

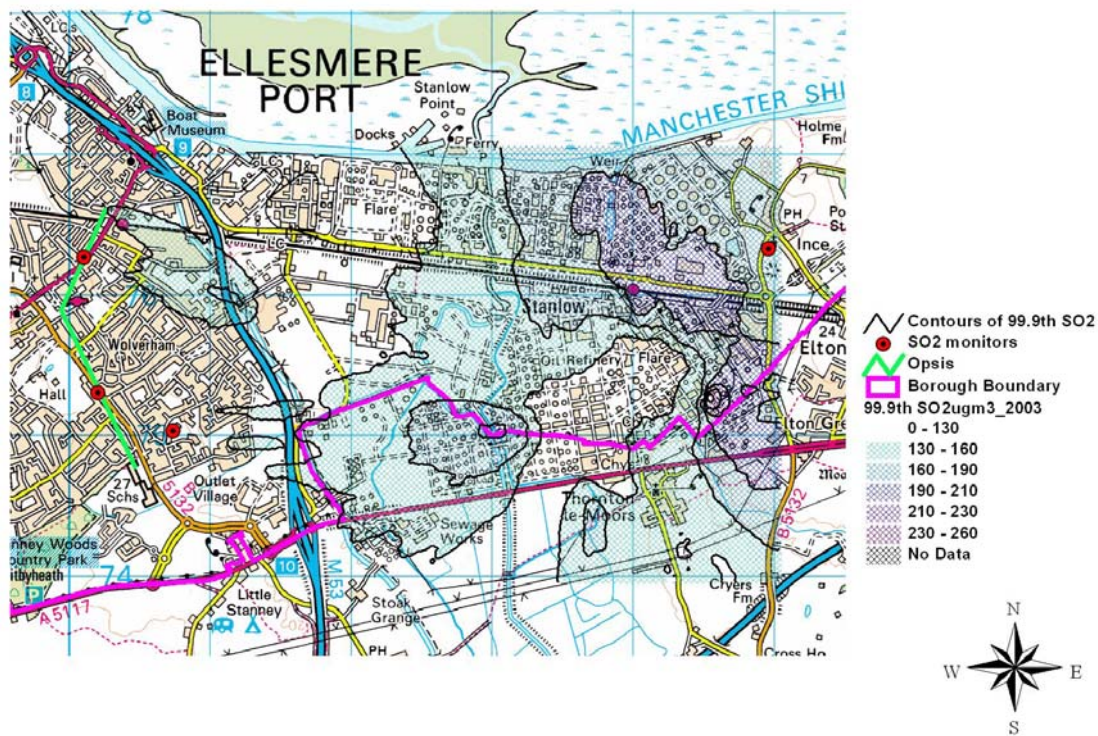


Figure 38 Contour plot of the 99.9th percentile of 15-min mean SO₂ 2003

6.5. Discussion

The verification exercise (Table 15) has demonstrated that there is good agreement between modelling and monitoring. On the whole, the results are within 10% of each other, and it is possible to place confidence in the performance of the model. Although acceptable, the comparison at VI is more of an outlier at 31% over prediction. A potential cause of this difference is that the monitoring location was in the lee of a village hall and was enclosed on three sides by trees, leading to artificially low readings. Using a different meteorological dataset the modelling scenario for 2003 also showed a good comparison against monitoring (Table 16).

No exceedences of the 15 minute mean objective were recorded at monitoring sites in either 2001 or 2003 (Table 22 & Table 24) and those that were predicted by modelling did not occur at relevant receptors (see Table 5).

Eleven exceedences of the 15-minute mean objective were observed at SG (see Table 23) in 2002 due to more frequent easterly winds. Meteorological data for 2002, which could have enabled further modelling investigations, was not purchased. The number of exceedences is comfortably below the 35 permitted, and no further episodes were recorded at other monitoring stations. It is not necessary, therefore, to declare an AQMA in respect of SO₂.

6.6. Conclusions

- The detailed assessment has demonstrated that the 2005 objective (266µg/m³) for SO₂ will be complied with at all relevant receptors.
- SO₂ monitoring should be continued for the foreseeable future.
- An AQMA does not need to be declared.

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7. CONCLUSIONS

- **Benzene**

It is not necessary to declare an AQMA.

- **1,3-Butadiene**

It is not necessary to declare an AQMA.

- **Lead**

It is not necessary to declare an AQMA.

- **Nitrogen dioxide**

An AQMA needs to be declared in respect of road traffic emissions on those parts of the A5032 identified in Section 4 of this report.

- **PM₁₀**

It is not necessary to declare an AQMA.

- **Sulphur dioxide**

It is not necessary to declare an AQMA.

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9. Appendix 1 – Monitoring stations

Code	Grid Reference	NO ₂	Benzene	1,3 Butadiene	Type	Start Date	End date
CL	336990 376863	●			Roadside	Sep-00	current
CO	339788 375958	●			Roadside	1990	current
CS	337582 375692	●			Kerbside	Sep-00	current
DL	329997 374825	●			Rural	Sep-00	current
ES1-3	340127 377356	●			Roadside	Dec-00	current
HA	330556 378039	●			Roadside	Sep-03	current
LE	337001 376816	●			Roadside	Sep-03	current
ML	340430 376642	●			Roadside	Sep-03	current
MM	341839 374493	●	●	●	Urban industrial	Sep-00	Aug-03
MR	340843 375509	●			Urban background	1990	current
MW	340893 375892	●			Urban background	May-01	Aug-03
NH	329204 377438	●			Kerbside	Feb-99	current
NT	329128 377594	●			Roadside	Feb-99	current
PW	340463 376410	●			Roadside	Feb-99	current
SK1-3	340432 376776	●			Roadside	Sep-00	current
ST	339449 373766		●		Suburban	May-01	Jun-03
VI	344961 376311		●	●	Special – industrial	Sep-00	current
WF	344707 376850		●	●	Special – industrial	Jul-03	current
WL	338837 374776	●			Suburban	1990	current
WR	336312 378374	●			Roadside	Sep-03	current
WV	340133 376267	●			Kerbside	Sep-00	current

Table 17 Diffusion Tube Monitoring Stations.

Real-time Monitoring Stations					
Site	Pollutants	Grid Ref.	Date	Site Type	Monitor
ES	NO, NO ₂ , NO _x	340117 377346	Dec 2000 – present	Roadside	API M200a
SG	NO, NO ₂ , NO _x , SO ₂ , PM ₁₀	340742 375023	1999 – present	Urban Background	API M200a API M100a TEOM
VI	NO, NO ₂ , NO _x , SO ₂ , PM ₁₀	344961 376311	Nov 2000 – Sep 2002	Industrial	API M200a API M100a TEOM
LR-JG	NO ₂ , SO ₂ , O ₃ (Benz)	340258 376602 - 339947 375889	Jan 1996 – present	Urban Background	DOAS Opsis AR500
LR-SH	NO ₂ , SO ₂ , O ₃	340482 374751- 339947 375889	Jan 1996 – present	Urban Background	DOAS Opsis AR500
LR	PM ₁₀	339947 375889	Jan 1996 – present	Urban Background	TEOM

Table 18 Real -Time Monitoring Stations.

10. Appendix 2 – Monitoring data

Real-time monitoring

Elm Street (ES) NO ₂		
	2003	2005
		Predicted from 2003
Mean (µg/m ³)	38.52	36.51
Max (µg/m ³)	139.18	
Coverage (%)	99.3	
Observations	8700	
Exceedence Limit (µg/m ³)	200	
Exceedence Count	0	
99.8th percentile (µg/m ³)	114.47	

Table 19 Elm Street NO₂ results (ratified), 2003

Stanney Grange (SG) NO ₂		
	2003	2005
		Predicted from 2003
Mean (µg/m ³)	24.47	23.20
Max (µg/m ³)	135.47	
Coverage (%)	93.1	
Observations	8151	
Exceedence Limit (µg/m ³)	200	
Exceedence Count	0	
99.8th percentile (µg/m ³)	109.06	
Mean NO _x (µg/m ³)	35.10	

Table 20 Stanney Grange NO₂ results (ratified), 2003

OPSIS NO ₂				
	2003		2005	
	NO ₂ Path 1 (Whitby Rd)	NO ₂ Path 2 (Stanney Lane)	Path 1	Path 2
			Predicted from 2003	Predicted from 2003
Mean (µg/m ³)	28.40	31.97	26.92	30.31
Max (µg/m ³)	132.67	159.84		
Coverage (%)	95.21	96.66		
Observations	8340	8467		
Exceedence Limit (µg/m ³)	200	200		
Exceedence Count	0	0		
99.8th percentile (µg/m ³)	87.97	98.47		

Table 21 Opsis NO₂ results (ratified), 2001 & 2002

Sulphur dioxide 15-minute Averages			
Period: 01/01/2001 - 31/12/2001			
	Stanney Grange (SO ₂)	Opsis Path 1 (SO ₂)	Opsis Path 2 (SO ₂)
	µg/m ³	µg/m ³	µg/m ³
Mean	7.02	8.45	6.71
Max	202.96	222.30	225.00
Coverage (%)	97.33	97.19	97.96
Observations	34105	34055	34324
Exceedence Limit	266	266	266
Exceedence Count	0	0	0
99.9 th percentile	128.24	129.49	123.24

Table 22 Real-time SO₂ results, 2001

Sulphur dioxide 15-minute Averages			
Period: 01/01/2002 - 31/12/2002			
	Stanney Grange (SO ₂)	Opsis Path 1 (SO ₂)	Opsis Path 2 (SO ₂)
	µg/m ³	µg/m ³	µg/m ³
Mean	9.11	6.98	7.62
Max	329.84	213.57	241.93
Coverage (%)	98.10	96.67	96.55
Observations	34373	33872	33832
Exceedence Limit	266	266	266
Exceedence Count	11	0	0
99.9 th percentile	208.94	132.94	158.08

Table 23 Real-time SO₂ results, 2002

Sulphur dioxide 15-minute Averages			
Period: 01/01/2003 - 31/12/2003			
	Stanney Grange (SO ₂)	Opsis Path 1 (SO ₂)	Opsis Path 2 (SO ₂)
	µg/m ³	µg/m ³	µg/m ³
Mean	8.14	7.62	6.24
Max	191.65	240.36	221.85
Coverage (%)	98.25	94.35	96.55
Observations	34426	33059	33832
Exceedence Limit	266	266	266
Exceedence Count	0	0	0
99.9 th percentile	138.71	152.73	125.97

Table 24 Real-time SO₂ results, 2003

Stanney Grange (SG) PM ₁₀		
	2002	2003
PM ₁₀ (gravimetric)	Ratified	Ratified
Mean	19.57µg/m ³	22.30µg/m ³
Max	66.63µg/m ³	80.09µg/m ³
Coverage	95.1%	98.9%
Observations	347	361
Exceedence Limit	50µg/m ³	50µg/m ³
Exceedence Count	4	11
90.4th percentile	31.34µg/m ³	38.96µg/m ³

Table 25 Stanney Grange PM₁₀ results, 2002 & 2003

Ellesmere Port Library (LR) PM ₁₀		
	2002	2003
PM ₁₀ (gravimetric)	Ratified	Ratified
Mean	21.34µg/m ³	23.98µg/m ³
Max	77.79µg/m ³	66.73µg/m ³
Coverage (%)	95.1%	93.7%
Observations	347	342
Exceedence Limit	50µg/m ³	50µg/m ³
Exceedence Count	6	19
90.41th percentile	35.42µg/m ³	43.52µg/m ³

Table 26 Ellesmere Port PM₁₀ results, 2002 & 2003

Lead Analysis							
Library Roof (LR)							
Start	Finish	Exposure (hours)	TEOM flow rate (l/min)	Period flow (m3)	Gross lead on filter (µg)	Blank filter lead (µg)	Net lead on filter (µg)
25/06/2003	06/08/2003	1008	2.99	180.84	2.184	0.009	2.175
11/09/2003	14/10/2003	792	2.99	142.08	1.894	0.009	1.885
14/10/2003	11/11/2003	672	2.99	120.56	3.558	0.009	3.549
11/11/2003	11/12/2003	720	2.99	129.17	2.401	0.009	2.392
11/12/2003	16/01/2004	840	2.99	150.70	1.495	0.009	1.486
16/01/2004	26/02/2004	984	2.99	176.53	2.378	0.009	2.369
26/02/2004	28/04/2004	1488	2.99	266.95	1.855	0.009	1.846
28/04/2004	04/06/2004	888	2.99	159.31	1.567	0.009	1.558
	Totals	7392		1326.12			17.260
Data capture (%)		84.4			Period Mean (µg/m3)		0.013
					Annual Mean (µg/m3)		0.015
Stanney Grange (SG)							
Start	Finish	Exposure (hours)	TEOM flow rate (l/min)	Period flow (m3)	Gross lead (µg)	Blank filter lead (µg)	Net lead (µg)
13/05/2003	13/08/2003	2208	2.99	396.1152	2.198	0.009	2.189
13/08/2003	10/11/2003	2136	2.99	383.1984	3.626	0.009	3.617
10/11/2003	05/01/2004	1344	2.99	241.1136	3.463	0.009	3.454
05/01/2004	24/03/2004	1896	2.99	340.1424	2.752	0.009	2.743
24/03/2004	30/04/2003	888	2.99	159.3072	1.344	0.009	1.335
	Totals	8472		1519.88			13.338
Data capture (%)		96.7			Period Mean (µg/m3)		0.009
					Annual Mean (µg/m3)		0.009

Table 27 Ellesmere Port lead results, 2003-4.

NO₂ Diffusion Tubes

NO ₂ Diffusion tube bias correction 2003			
	Annual Mean (µg/m ³)	Co-location factors (TG03 - p6-7)	
Diffusion Tube (triplicate)	41.59	Diffusion Tube Bias (%)	8.0
Chemiluminescent	38.50	Bias adjustment factor	0.93

Table 28 Local bias correction factors of NO₂ diffusion tubes, 2003.

NO ₂ Diffusion Tube Data						
	2003					
Site Code	Duration (months)	Annual Mean (µg/m ³)	Ann Mean (corrected)		2005 estimated annual mean (corrected)	
			Local factor (0.93)	UWE factor (0.96)	Local factor (0.93)	UWE factor (0.96)
CL	12	39.81	36.86	38.22	34.94	36.23
CO ¹	11	34.39	31.85	33.01	30.19	31.29
CS	12	38.66	35.80	37.11	33.93	35.18
DL	12	15.54	14.39	14.92	13.64	14.14
ES ²	12	41.59	38.51	39.93	36.51	37.85
MM	8	32.51	30.10	31.21	28.54	29.58
MR ¹	12	31.79	29.44	30.52	27.90	28.93
MW	8	26.93	24.94	25.85	23.64	24.51
NH	12	39.23	36.33	37.66	34.43	35.70
NT ¹	12	40.98	37.95	39.34	35.97	37.29
PP	12	34.15	31.62	32.78	29.98	31.08
PW	12	41.46	38.39	39.80	36.39	37.73
RA	7	27.4	25.37	26.30	24.05	24.93
SK ²	12	46.32	42.89	44.47	40.66	42.15
SN	12	35.99	33.33	34.55	31.59	32.75
SP	11	37.12	34.37	35.64	32.58	33.78
TR	8	31.16	28.85	29.91	27.35	28.36
WL ¹	9	26.02	24.09	24.98	22.84	23.68
WV	12	43.47	40.25	41.73	38.16	39.56
'Corrected' mean values were adjusted using the bias adjustment factor shown in Table 28. Data for 2005 was estimated using adjustment factors in TG03 (Ref 8.3)						

Table 29 NO₂ diffusion tube data, 2003.

¹ Diffusion tubes forming part of the UK NO₂ network

² Triplicate tubes

Benzene Diffusion Tubes

Benzene diffusion tube results				
	2001	2002	2003	2004
Site Code	Annual Mean ($\mu\text{g}/\text{m}^3$)	Annual Mean ($\mu\text{g}/\text{m}^3$)	Annual Mean ($\mu\text{g}/\text{m}^3$)	Period Mean ($\mu\text{g}/\text{m}^3$)
MM	1.83	-	-	-
VI	3.57	3.27	2.50	2.73
WF	-	-	3.71 ^a	2.34

Table 30 Benzene diffusion tube data 2001 - 2004.

Benzene diffusion tube bias correction			
	Annual Mean ($\mu\text{g}/\text{m}^3$) 2003	Co-location factor (TG03 - p6-7)	
Triplicate diffusion tubes	1.29	Bias adjustment factor	1.43
UKHC reference monitor	1.85		

Table 31 Bias-correction factor for benzene diffusion tubes, 2003.

Bias-corrected benzene diffusion tube results				
	2001	2002	2003	2004
Site Code	Annual Mean ($\mu\text{g}/\text{m}^3$)	Annual Mean ($\mu\text{g}/\text{m}^3$)	Annual Mean ($\mu\text{g}/\text{m}^3$)	Period Mean ($\mu\text{g}/\text{m}^3$)
MM	2.62	-	-	-
VI	5.11	4.68	3.58	3.90
WF	-	-	5.31 ^a	3.35

Table 32 Bias-corrected benzene data 2001 – 2004.

^a Site established July 2003. Mean calculated from 6 months of data.

1,3-Butadiene Diffusion Tubes

1,3-Butadiene diffusion tube results						
	2001		2002		2003	
Site Code	Annual Mean ($\mu\text{g}/\text{m}^3$)	Highest Running Annual Mean ($\mu\text{g}/\text{m}^3$)	Annual Mean ($\mu\text{g}/\text{m}^3$)	Highest Running Annual Mean ($\mu\text{g}/\text{m}^3$)	Annual Mean ($\mu\text{g}/\text{m}^3$)	Highest Running Annual Mean ($\mu\text{g}/\text{m}^3$)
MM	0.48	0.61	0.37	0.63	0	0.37
VI	1.00	1.00	0.21	0.92	0	0.20

Table 33 Butadiene diffusion tube data 2001 – 2003

11. Appendix 3 – Monitoring techniques

Diffusion Tubes

Analytical Laboratory	
Prepared by	Gradko International Ltd. Winchester
Analysed by	Gradko International Ltd. Winchester
Laboratory accreditation	UKAS testing No. 2187
Inter-laboratory participation	WASP performance: classification Good z-score range: -0.4 to 0.877. Ranked 1-3. UK NO ₂ interfield comparison
Tube exposure	Monthly (in common with UK NO ₂ diffusion tube network calendar).

Table 34 Diffusion tube laboratory details

NO ₂ diffusion tubes	
Method of preparation	20% Triethanolamine in water
Analysis	UV Spectrophotometry
Blank correction	Travel blank
Uncertainty of measurement	± 7.6%
Limit of detection	0.01 µg/m ³

Table 35 NO₂ diffusion tube analytical data

Benzene diffusion tubes	
Absorbent	Chromasorb 106
Uptake rate	1.28 ng.ppm ⁻¹ min ⁻¹
Analysis	Thermal desorption / Gas chromatography
Peak identification	NIST reference library
Blank correction	Laboratory blank
Uncertainty of measurement	± 21.00%
Limit of detection	2.80ng

Table 36 Benzene diffusion tube analytical data

1,3-Butadiene diffusion tubes	
Absorbent	Molecular sieve 13x
Uptake rate	1.3 ng.ppm ⁻¹ min ⁻¹
Analysis	Gas chromatography / Mass Spectroscopy
Peak identification	NIST reference library
Blank correction	Laboratory blank
Uncertainty of measurement	± 21.00%
Limit of detection	2.80ng

Table 37 1,3-Butadiene diffusion tube analytical data

Lead monitoring

Lead filters	
Analytical laboratory	Casella CRE Air – Runcorn
Laboratory Accreditation	UKAS testing No. 0869
Monitoring technique	TEOM filters
Preparation	Microwave-assisted acid digestion of filter membrane
Analysis	ICP-OES (Proc. AQ03)
Blank correction	Unexposed filter
Uncertainty of measurement	±18%
Limit of detection	0.09µg/m ³

Table 38 Lead analysis data

Real-time monitoring

API M200a	
Method	Chemiluminescence
Species monitored	NO ₂ , NO, NO _x
Service & maintenance	Enviro Technology plc
Breakdown callout	5-day
Service & calibration interval	6 months
Zero & span checks	Internal: automated, daily
	External: manual, fortnightly
Calibration gas	BOC Spectra Seal. Nominal concentration: 450ppb NO Certified accuracy $\pm 1\%$
Primary average	15 minutes
Data logger	Internal
Remote data collection	Enviman Comvisioner, 3x daily
Precision	$\pm 0.5 \%$
Weekly zero / span drift	$<1\mu\text{g}/\text{m}^3$
Limit of detection	$0.76\mu\text{g}/\text{m}^3$ NO ₂

Table 39 Analyser maintenance & data management – API M200a.

API M100a	
Method	UV fluorescence
Species monitored	SO ₂
Service & maintenance	Enviro Technology plc
Breakdown callout	5-day
Service & calibration interval	6 months
Zero & span checks	Internal: automated, daily
	External: manual, fortnightly
Calibration gas	BOC Spectra Seal. Nominal concentration: 450ppb NO Certified accuracy $\pm 1\%$
Primary average	15 minutes
Data logger	Internal
Remote data collection	Enviman Comvisioner, 3x daily
Precision	$\pm 0.5 \%$
Weekly zero / span drift	$<1\mu\text{g}/\text{m}^3$
Limit of detection	$1.1\mu\text{g}/\text{m}^3$ SO ₂

Table 40 Analyser maintenance & data management – API M100a.

PM₁₀	
Analyser	R&P TEOM 1400a
Service & maintenance	Enviro Technology plc
Breakdown callout	5-day
Service & calibration interval	6 months
Primary average	15 minutes
Data logger	Internal
Remote data collection	Enviman Comvisioner, 3x daily
Limit of detection	3µg/m ³

Table 41 Analyser maintenance & data management - TEOM.

Opsis AR500	
Method	Long path DOAS (Differential Optical Absorption Spectroscopy)
Service & maintenance	Enviro Technology plc
Species monitored	NO ₂ , SO ₂ , O ₃ ,
Breakdown callout	5-day
Service & calibration interval	3 months
Calibration gas	BOC Certified accuracy $\pm 1\%$
Primary average	15 minutes
Data logger	DL 010
Remote data collection	Enviman Comvisioner, 3x daily
Limit of detection	2µg/m ³

Table 42 Analyser maintenance & data management - Opsis.

12. Glossary

$\mu\text{g}/\text{m}^3$	micrograms per cubic metre ($1\mu\text{g}/\text{m}^3 = 1$ millionth of a gram in a cubic metre of air)
mg/m^3	milligrams per cubic metre ($1\text{mg}/\text{m}^3 = 1$ thousandth of a gram in a cubic metre of air)
ng	nanograms
AADT	Annual Average Daily Traffic Flow
ADMS-Urban	Atmospheric Dispersion Modelling System – capable of modelling industrial, domestic and traffic sources in urban areas
AQMA	Air Quality Management Area
CERC	Cambridge Environmental Research Consultants Ltd.
CO	Carbon monoxide
DEFRA	Department for Environment, Food and Rural Affairs
DMRB	Design Manual for Roads and Bridges
EPAQS	Expert Panel on Air Quality Standards
EPNBC	Ellesmere Port & Neston Borough Council
GIS	Geographical Information System
GR	Ordnance Survey national grid reference
LAQM	Local Air Quality Management
m/s	metres per second
MO	Monin-Obukhov length – a measure of atmospheric stability
NAQS	National Air Quality Strategy
NETCEN	National Environmental Technology Centre
NO	Nitric oxide
NO ₂	Nitrogen dioxide

NO _x	Oxides of nitrogen (NO and NO ₂)
NSCA	National Society for Clean Air
ppb	Parts per billion
ppm	Parts per million
PM ₁₀	Particulate matter less than 10µg/m ³ aerodynamic diameter
SO ₂	Sulphur dioxide
Surface roughness	Land-use characteristics affecting wind shear
TEOM	Tapered Element Oscillating Micro-balance
TG03	LAQM Technical Guidance (see Ref 8.3)
UWE	University of the West of England
VOC	Volatile Organic Compound