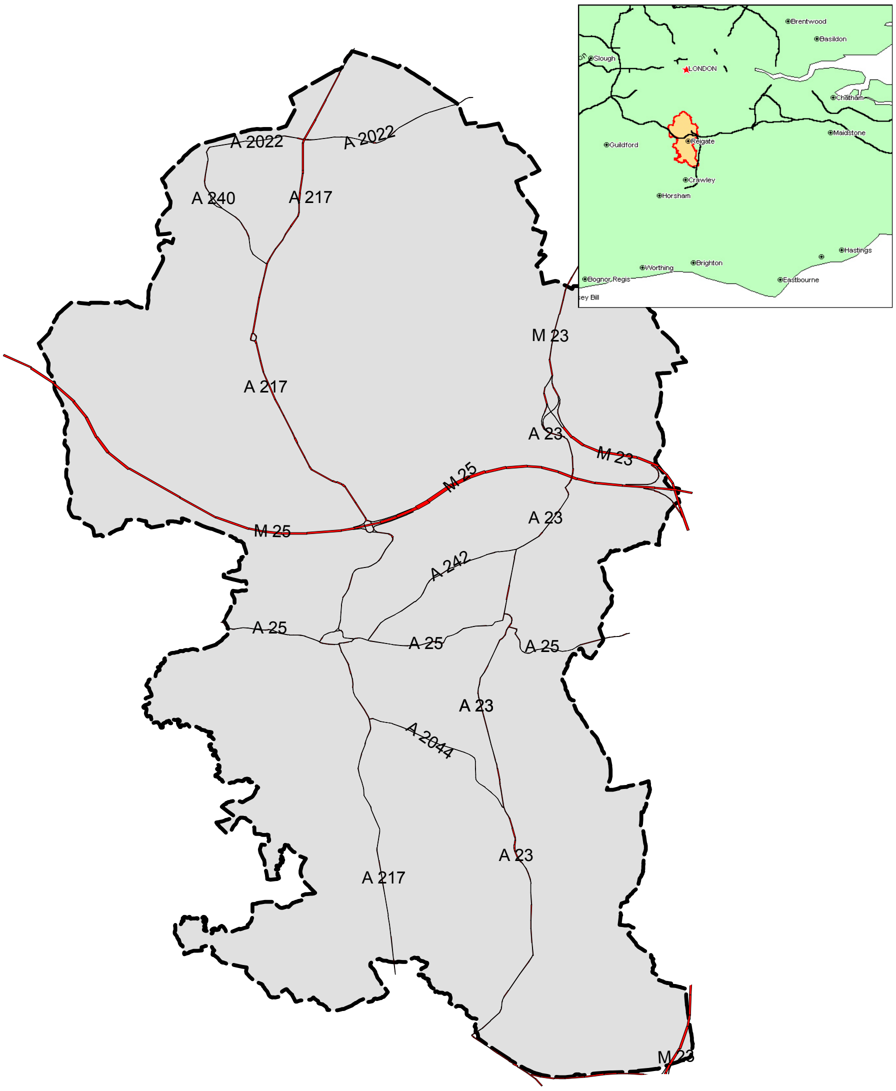
Stanger
Science and Environment

AQC
Air Quality Consultants

Final Report

Stage 3 Local Air Quality Review and Assessment NO_2 and PM_{10}



Reigate and Banstead Borough Council

July 2001

Report Ref: A35870100/yb/1743/Final

Final Report

Stage 3 Local Air Quality Review and Assessment NO_2 and PM_{10}

Prepared for Reigate and Banstead Borough Council

Town Hall
Castlefield Road
Reigate
Surrey
RH2 0SH

Prepared by Stephen Moorcroft (SSE)
Yvonne Brown (SSE)
Sunita Purushottom (SSE)
Duncan Laxen (AQC)

Stanger Science and Environment (SSE)
Great Guildford House
30 Great Guildford Street
London
SE1 OES

Air Quality Consultants (AQC)
12 St. Oswald's Road
Bristol
BS6 7HT

July 2001

Report Ref: A35870100/yb/1743/Final

Contents

1. Introduction

Air Quality Consultants (AQC) and Stanger Science and Environment (SSE) have been commissioned by Reigate and Banstead Borough Council's Environmental Services Division to undertake detailed modelling emissions in support of the Third Stage Review and Assessment report. This report is structured to cover the legislative requirements surrounding the current work, previous reports on local air quality within the Borough's area, and the results of the current assessment. Details of the methodologies used in the current work are given along with any assumptions made.

1.1. Project background

The scope of the study was to carry out a detailed assessment of nitrogen dioxide (NO_2) and particulate matter (PM_{10}) concentrations arising from road traffic sources and from Gatwick Airport. These pollutants were highlighted as requiring further assessment in the Council's Stage 2 report[1]. The Stage 2 report also recommended that further consideration be given to carbon monoxide (CO) at one location, the junction of the A217 and B3032 at Kingswood. This location has been examined, and there is no relevant exposure within 30 m of the road. The nearest properties are to the west of the junction, which is a large roundabout. The southbound carriageway of the A217 is over 100 m from these properties. There is thus no likelihood of the CO objective being exceeded at relevant locations, and this pollutant is thus not considered further.

1.2. Legislative Background

Part IV of the Environment Act 1995 placed a requirement on local authorities to periodically review air quality in their area. This involves consideration of present and likely future air quality against air quality objectives detailed in the Air Quality Regulations first laid down in 1997 and recently updated in 2000.

The Government has recommended a phased approach to air quality Review and Assessment, involving **three stages** with each subsequent stage increasing in its scope and detail in order to more accurately assess local air quality.

The First Stage Review and Assessment should be completed by all local authorities. This is essentially a screening exercise of all pollution sources that could have a significant impact within the authority's area, and a collation of all existing data. The results of this First Stage will determine whether the authority needs to proceed to a Second and/or Third Stage review and assessment. The Second Stage review and assessment allows a further screening of pollutant concentrations, and focuses upon those locations where the highest concentrations of each pollutant are likely to occur. Where these initial stages of review and assessment indicate that there is a significant risk of the air quality objectives not being met then a Third Stage review and assessment is required. This report needs to

[1] Report on the 2nd Stage Air Quality Review and Assessment.

include an accurate and detailed review and assessment of current and future air quality, and is likely to be based on sophisticated modelling and monitoring techniques.

Guidance has been issued by Government to assist local authorities in their duties. Specifically, the Technical Guidance Note LAQM.TG4(00) 'Pollutant Specific Guidance'[2] provides guidance on each stage of the review and assessment process for each regulated pollutant.

If, after completion of the detailed Stage Three review and assessment, the results still indicate that the air quality objectives are likely to be exceeded in certain areas the local authority has a duty to declare an Air Quality Management Area (AQMA). The authority will then be required to draw up an Action Plan in pursuit of bringing in line with the relevant air quality criteria, the pollutant concentrations in the designated area.

1.3. Air Quality Strategy (AQS)

The Air Quality Strategy for England, Scotland, Wales and Northern Ireland[3] (AQS) was published in January 2000. It supersedes the earlier National Air Quality Strategy[4] (NAQS) published in March 1997, and provides a revised framework for reducing air pollution at national and local levels from a wide range of emission sources.

Central to the Strategy are health-based standards for the eight local air pollutants of current greatest concern. These standards are based on recommendations made by the Government's Expert Panel on Air Quality Standards (EPAQS). From these standards, air quality objectives have been derived, which take account of the costs and benefits, as well as of the feasibility and practicality, of moving towards the standards. The relevant dates for achieving each of the objectives range from 2003 to 2005.

Table 1.1 sets out the air quality objectives in the AQS that are relevant to the Review and Assessment of air quality in Reigate Borough for the current assessment.

[2] LAQM TG4(98). Review and Assessment: Pollutant Specific Guidance. Department of the Environment, Transport and the Regions.

[3] DETR (2000) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland - Working together for Clean Air"

[4] DoE (1997) The United Kingdom National Air Quality Strategy

Table 1.1 Summary of Relevant Air Quality Objectives

Pollutant	AQS Objective (2000)
Nitrogen dioxide (NO_2)*	200 µg/m³ measured as a 1-hour average (short-term) to be achieved by 31.12.2005 (maximum of 18 exceedances) 40 µg/m³ measured as an annual mean (long-term) to be achieved by 31.12.2005
Particulate Matter (PM_{10})	50 µg/m³ (gravimetric) measured as 24-hour mean to be achieved by 31.12.2004 (maximum of 35 exceedances) 40 µg/m³ (gravimetric) measured as an annual mean (long-term) to be achieved by 31.12.2004

µg/m³ = micrograms per cubic metre;
* Nitrogen dioxide objectives are provisional

1.4. Previous Air Quality Assessments

The Second Stage review and assessment completed by Reigate and Banstead Borough Council indicated a risk of exceeding the annual mean (average) objective for nitrogen dioxide at a number of major roads in the area *viz* M25, M23, A217, A23, A2044, B2221 and the A25. A risk of exceeding the 24-hour PM_{10} objective was also identified along the M25, M23, A217, A23 and A25.

In addition, the south-west corner of the authority's area lies immediately adjacent to Gatwick Airport. Whilst the Airport does not lie within the Reigate and Banstead BC, there is a potential for emissions to impact upon the authority, particularly as it is within the predominant downwind direction. Studies carried out by BAA Gatwick have indicated both current and future exceedances of the annual average nitrogen dioxide objective within Horley, on the southern fringe of the Borough[5].

1.5. Report Structure

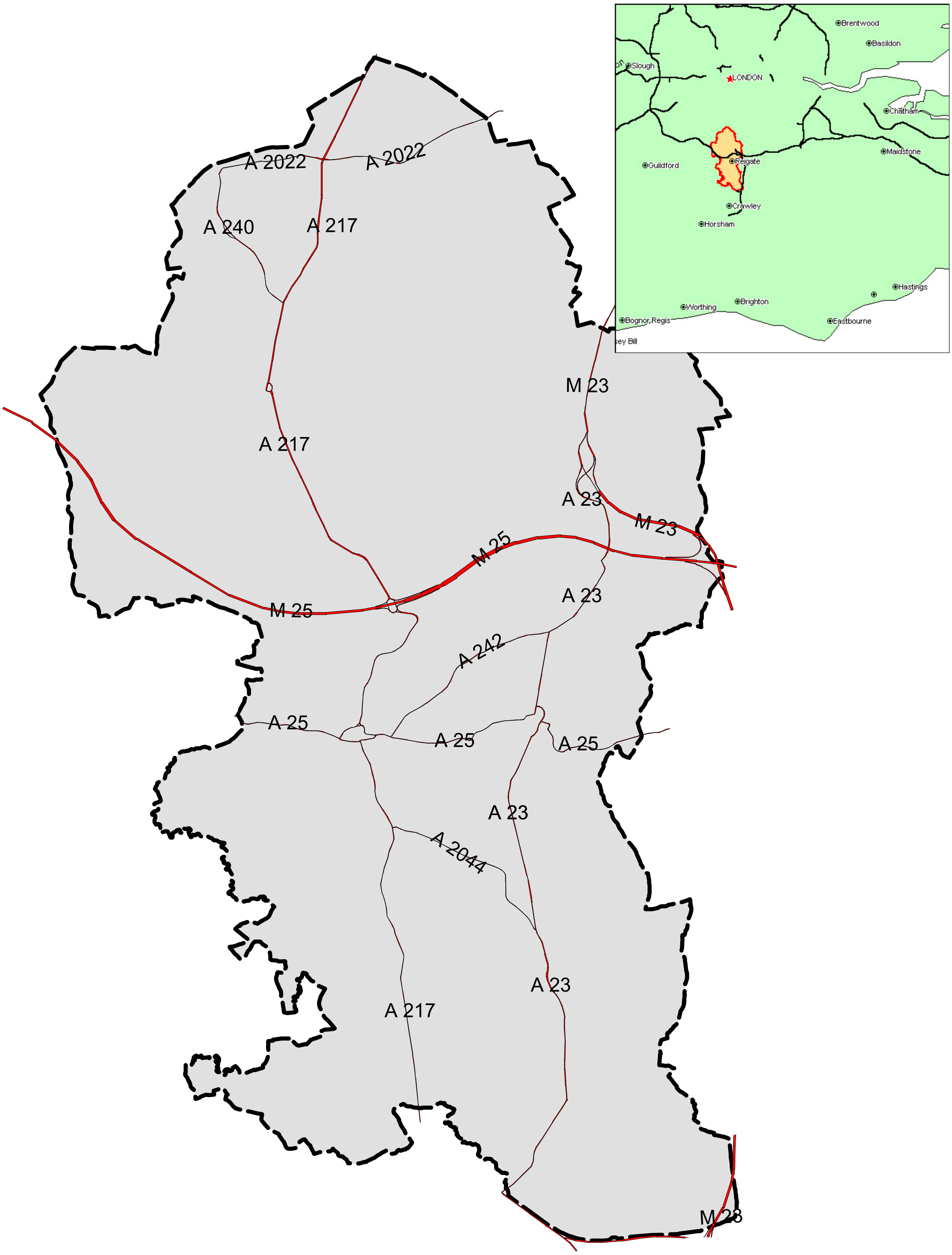
The report is divided into 4 main sections:

- a review of monitoring data used throughout the modelling assessment,
- modelling methodology,
- results, and
- conclusions and recommendations.

Figure 1.1 shows the general location of Reigate and Banstead Borough Council.

[5] London BAA Gatwick, Gatwick Airport Sustainable Development Strategy, Appendices –Part 4, July 2000

Figure 1.1 Location of Reigate and Banstead Borough Council



2. Monitoring Programmes in Reigate Borough

2.1. Introduction

Nitrogen dioxide and PM_{10} concentrations are currently monitored within the authority's area using both a continuous (chemiluminescent) sampler and a TEOM. In addition, a number of sites are operated using passive diffusion tube samplers for nitrogen dioxide. These data provide both a valuable insight into current pollutant concentrations across the authority's area, and also allow the results from the dispersion modelling exercise to be validated.

2.2. Continuous Air Quality Monitoring

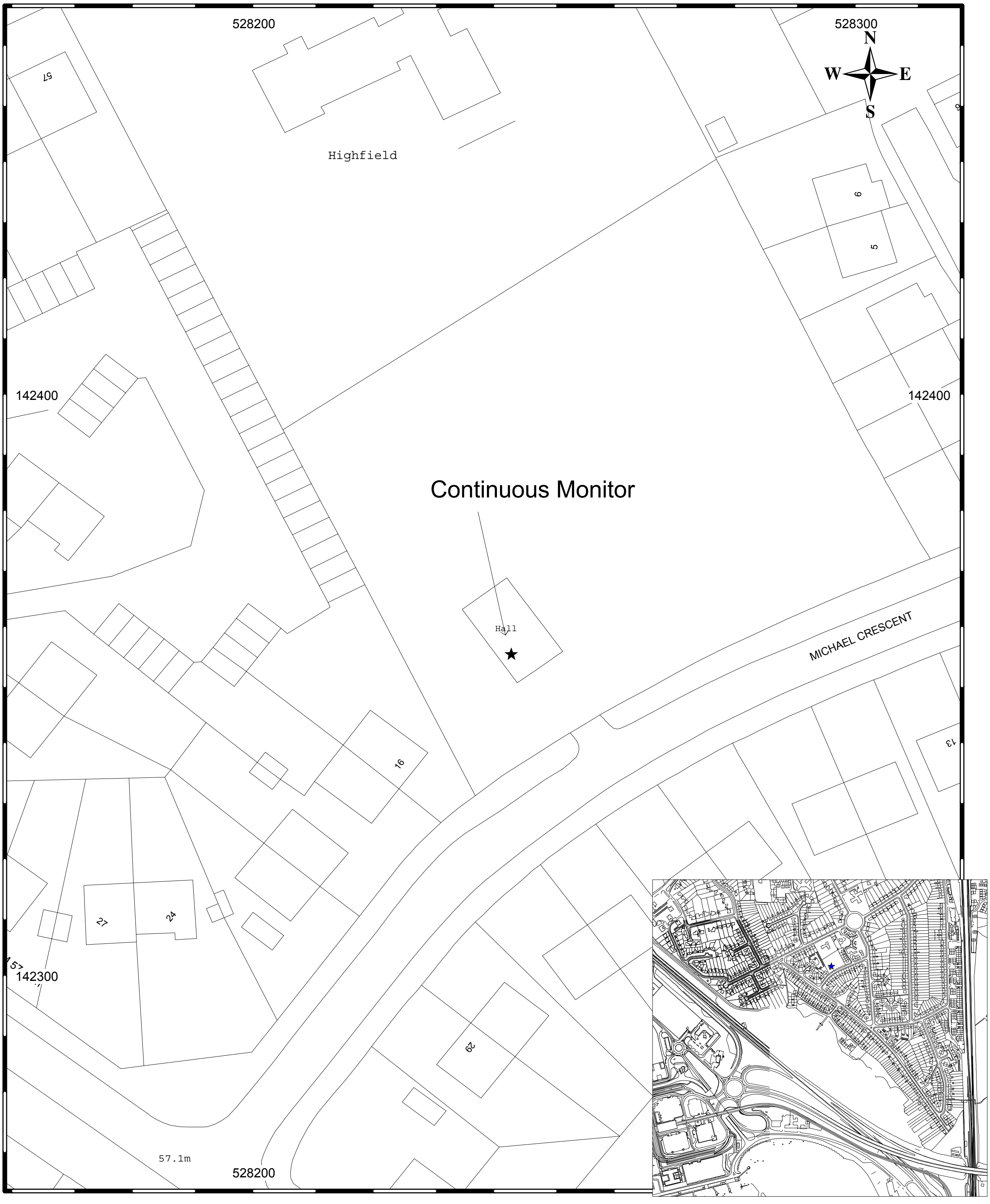
Continuous monitoring of NO_x/NO_2 and PM_{10} has been undertaken at a background location in Horley. The location of the monitoring station is shown in Fig 2.1. The site is at a background location at the Scout Hut in St Michaels Crescent, Horley. It is adjacent to a small local road and is 300m from a dual carriageway. The site is also about 400m to the north-east of Gatwick Airport. The monitoring station contains a chemiluminesence NO_x analyser and TEOM PM_{10} monitor, both of which have been supplied by ETI. Data handling and QA/QC are carried out by SEIPH-ERG. The TEOM data have all been multiplied by 1.3, the factor recommended in guidance to estimate gravimetric equivalent concentrations from TEOM monitoring.

The operation of the continuous monitoring station is ongoing, and will continue to provide useful data. For the purpose of model validation in this assessment, the data which have been ratified for the period 18th July 2000 to 30th November 2000 have been used. These data are shown summarised in Table 2.1 for NO_x/NO_2 and PM_{10}. Unvalidated data are also available for the period December 2000 to March 2001. The averages for the whole monitoring period, including the unvalidated data, are 66.2 µg/m^3 NO_x, 36.4 µg/m^3 NO_2 and 22.0 µg/m^3 PM_{10}, very slightly higher than the values used in the validation.

Table 2.1 Summary Statistics for NO_x/NO_2 and PM_{10}, Horley (July-2000 to Nov-2000)

Statistic	**NO_x**	**NO_2**	**PM_{10} (gravimetric)**
Minimum (µg/m^3)	5.4	5.1	0.4
Maximum (µg/m^3)	734	98.9	255
Average (µg/m^3)	60.6	35.2	20.6
%ile (µg/m^3)		91.5 (99.8th)	30.8 (90th)
Data Capture (%)	81	81	98

Figure 2.1 Location of Continuous Background Monitor in Horley



These data are also illustrated in Figure 2.2 (monitored NO_x concentrations) and Figure 2.3 (NO_2 concentrations).

Figure 2.2 Hourly Average NO_x ($\mu g/m^3$) monitored at Horley (July-2000 to Nov-2000)

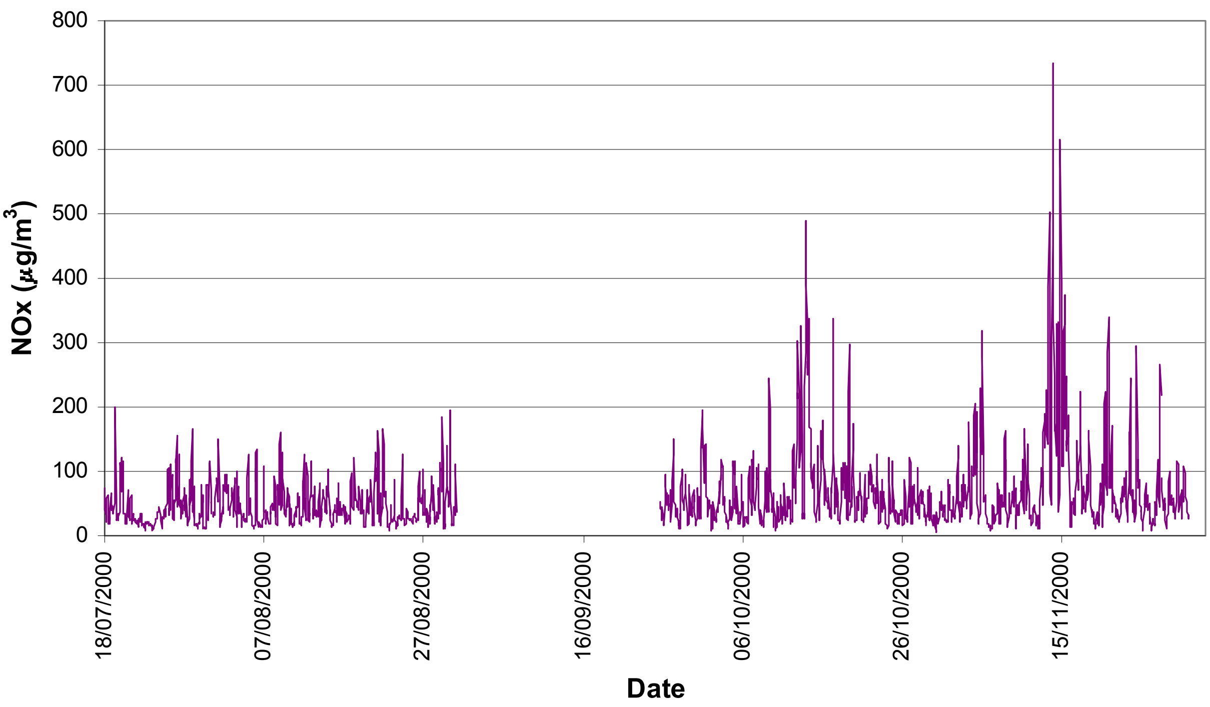
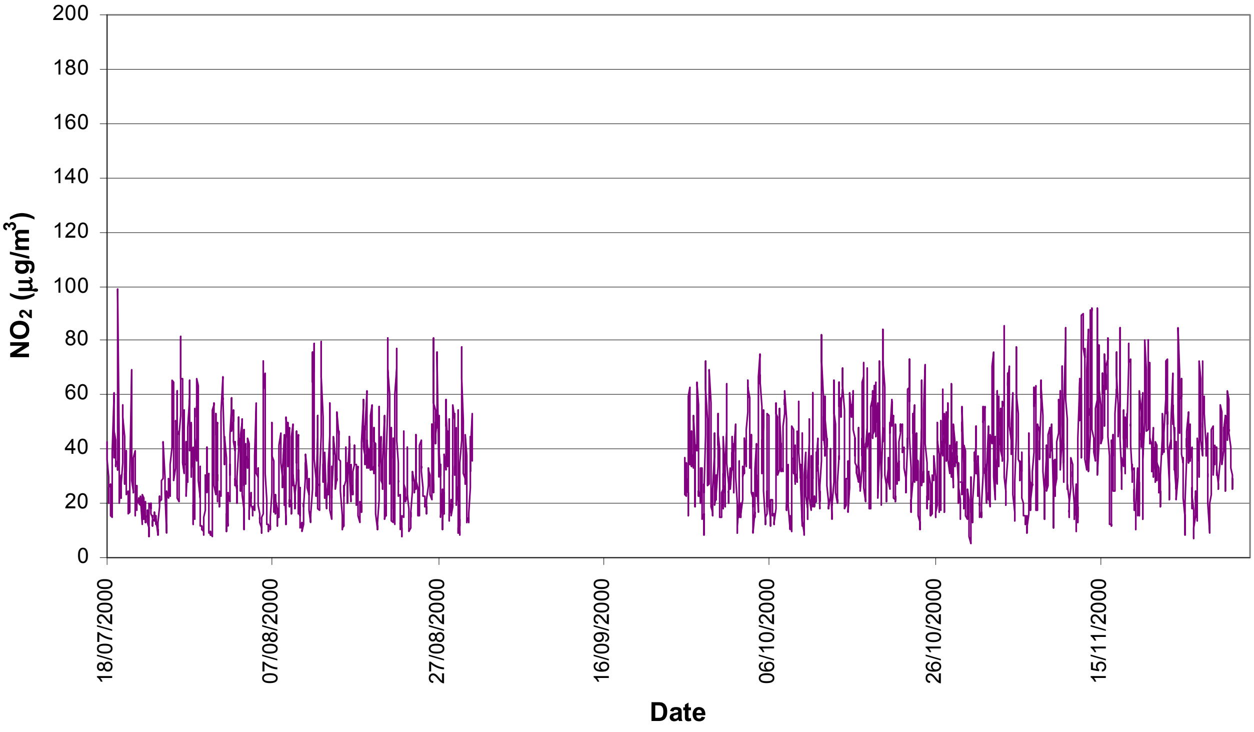


Figure 2.3 Hourly Average NO_2 (µg/m^3) monitored at Horley, (July-2000 to Nov-2000)



2.3. Passive Monitoring - Nitrogen Dioxide

Diffusion tube samplers provide an average nitrogen dioxide concentration over the exposure period (usually 4 weeks) and provide useful data for baseline and screening studies. Diffusion tubes represent a cost-effective approach to air pollution monitoring whilst enabling wide geographical coverage.

Nitrogen dioxide concentrations in Reigate have been monitored using diffusion tubes at a number of locations. Some of these sites are included in the UK Nitrogen Dioxide Diffusion Tube Survey, which is subjected to scrutiny through quality assurance procedures and inter-comparison exercises. The locations and descriptions of diffusion tubes as used in this assessment are shown in Table 2.2.

Table 2.2 NO_2 Diffusion Tube Monitoring Sites in Reigate Borough Council in Areas Under Investigation for the Stage 3 Review & Assessment.

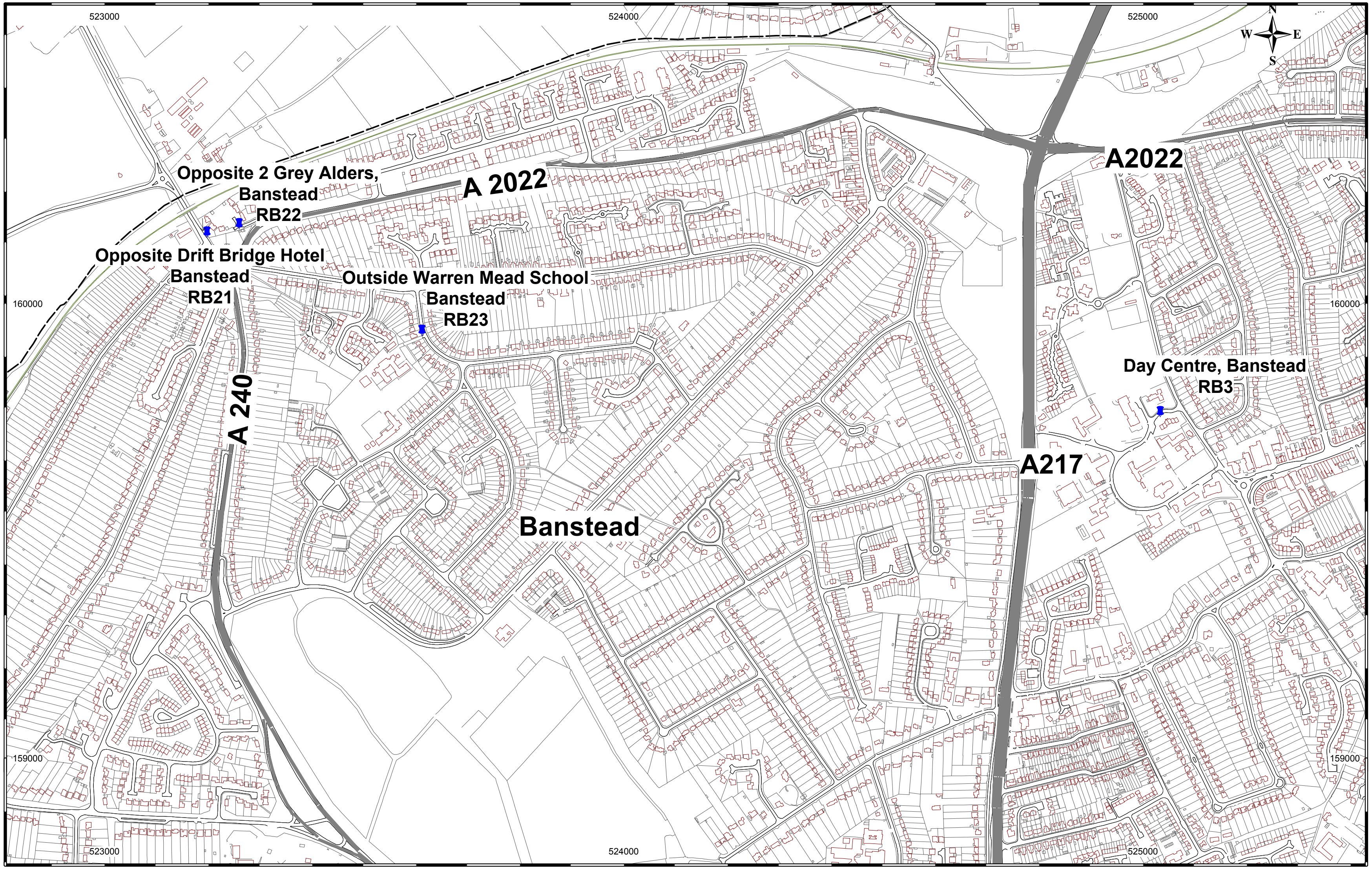
Location	Site Type	Grid Reference x	Grid Reference y
Boots, High Street, Reigate	R	525246	150252
Day Centre, Banstead	B	525034	159749
Day Centre, Horley	B	528471	143124
130 Radstock Way, Merstham	B	530118	153122
Rear of Boots, Reigate	I	525246	150286
63 St Mary's Road, Reigate	I	525750	149677
Rushworth Road, Reigate	B	525522	150628
Riverside Horley	Gatwick	528104	142226
Horley Police Station, Massetts Road, Horley	R	528424	142934
Public Car Park, Off Massetts Road Horley	I	528362	142983
11 Sylvan Way, Redhill	B	528511	149715
60, Brook Road, Merstham	B	529263	153156
Village Hall, Station Road, Merstham	I	529067	153375
Corner of London Road, Merstham	R	529026	153420
Opposite Drift Bridge Hotel, Banstead	R	523198	160095
Opposite 2 Grey Alders, Banstead	I	523260	160111
Outside Warren Mead School, Banstead	B	523612	159906

B (Background), I (Intermediate), R (Roadside)

The locations of the diffusion tubes are also shown in Figures 2.4 – 2.7.

Stanger
Science and Environment
AQC Air Quality Consultants

Figure 2.4 Diffusion Tube Locations in the Banstead area



Stanger
Science and Environment

AQC
Air Quality Consultants

Figure 2.5 Diffusion Tube Locations in the Merstham area

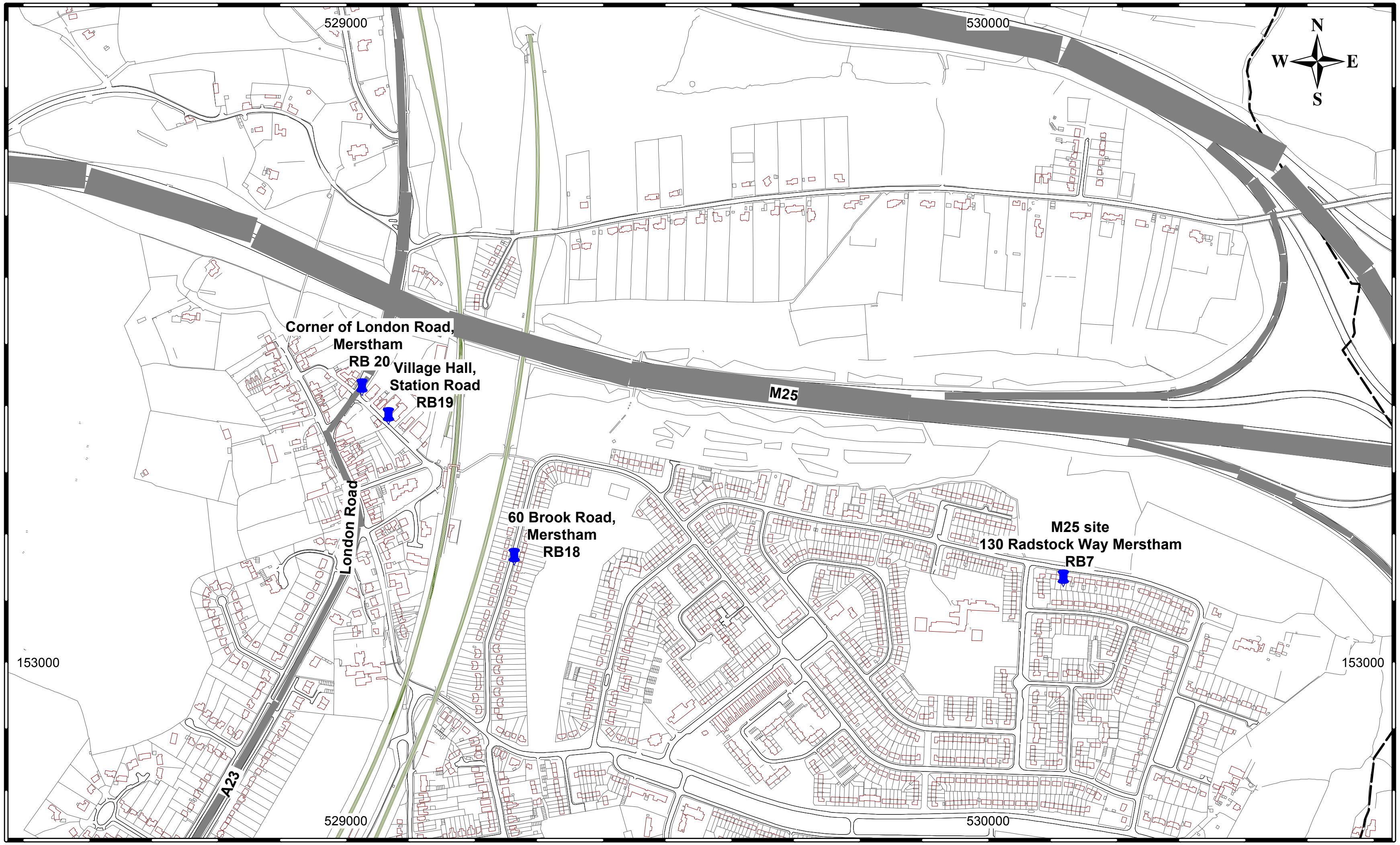


Figure 2.6 Diffusion Tube Locations in the Reigate and Redhill area

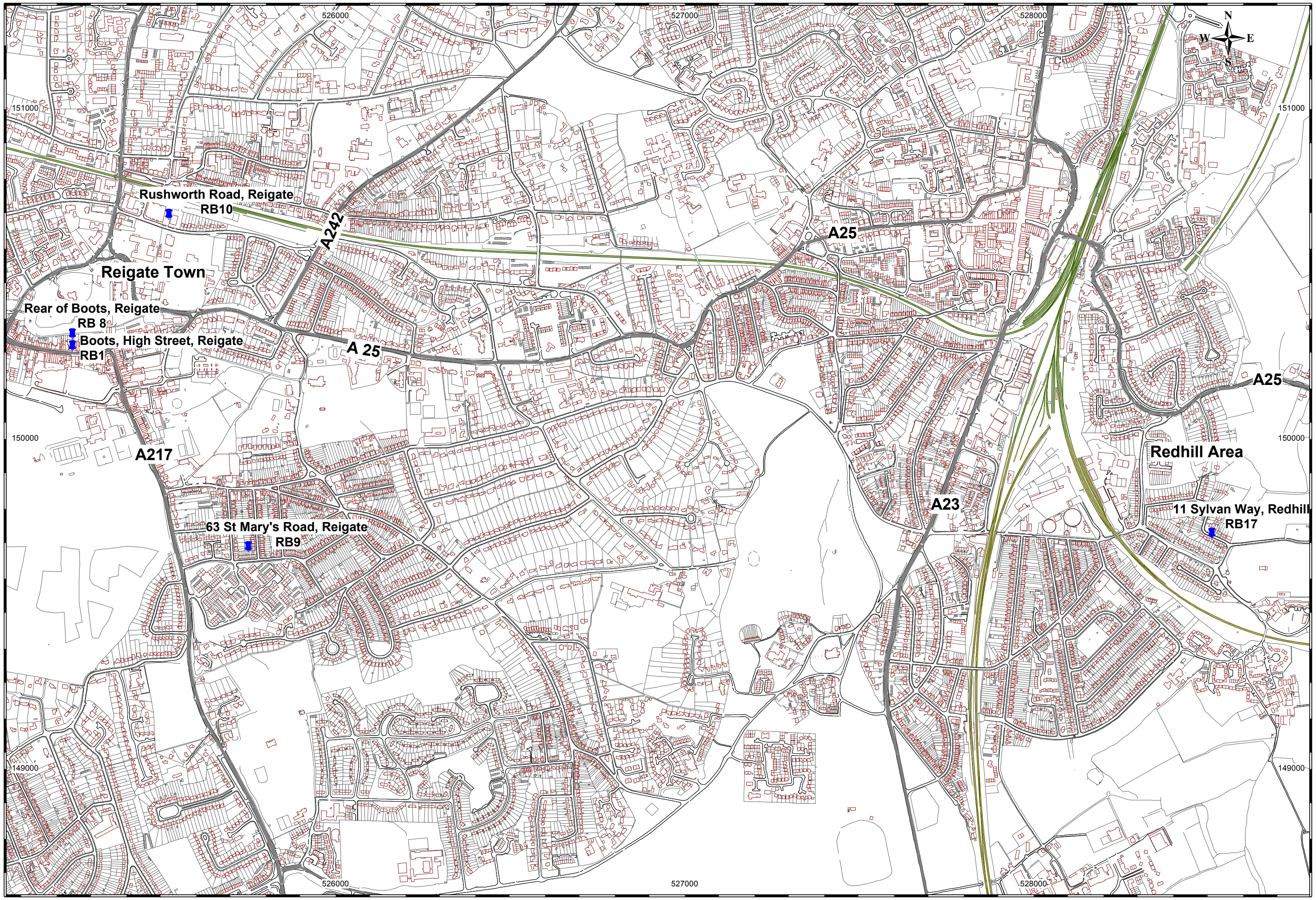
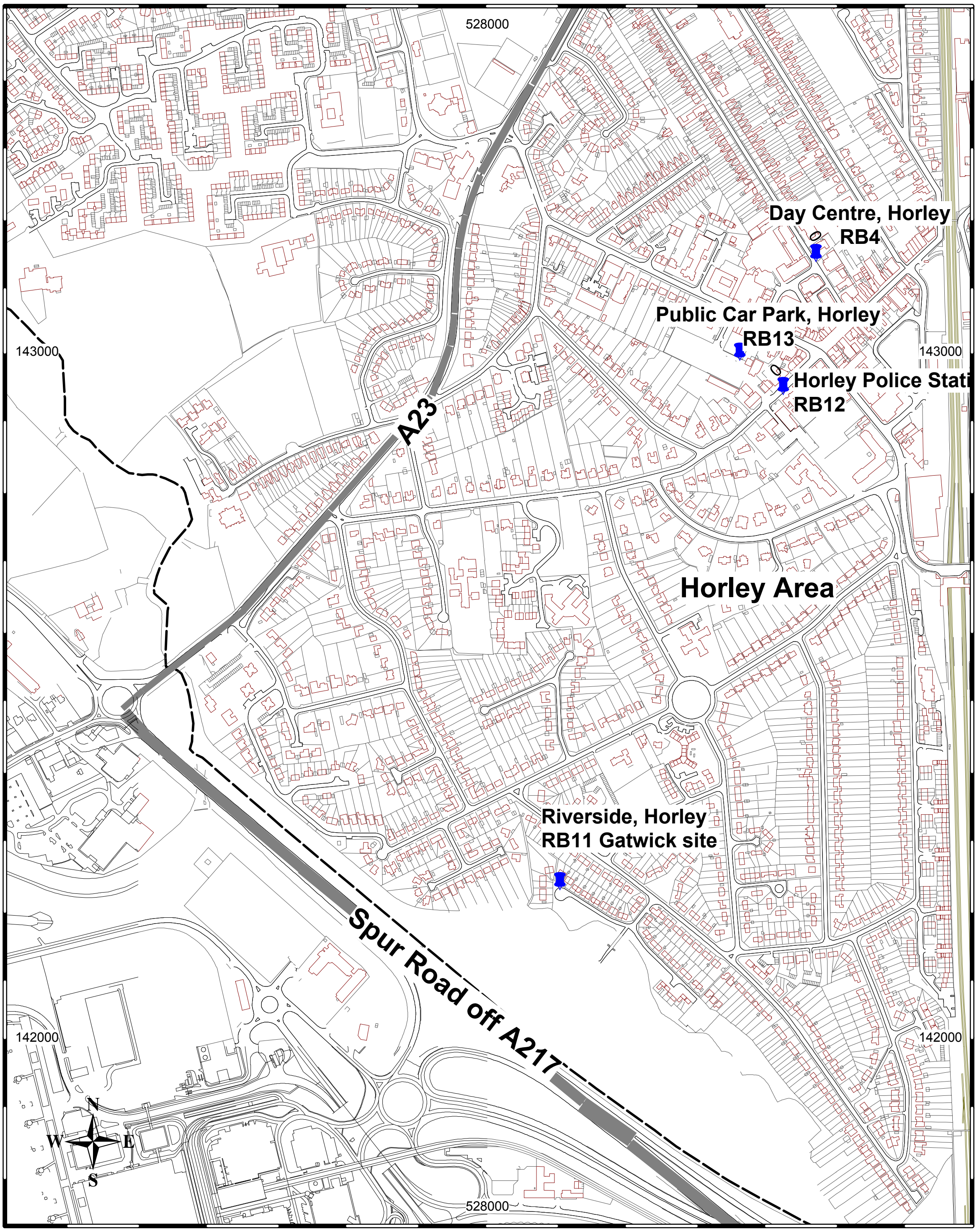


Figure 2.7 Diffusion Tube Locations in the Horley area



Results from the diffusion tube monitoring are summarised in Table 2.3 for the past 4 years (1997, 1998, 1999 and 2000). The estimated annual average concentrations are shown and the number of months of monitoring indicated in brackets.

Table 2.3 Reigate and Banstead NO2 Diffusion Tube Monitoring Results, 1997-2000

		Annual Average NO_2 ($\mu g/m^3$)			
Location	**Site Type**	**1997**	**1998**	**1999**	**2000**
Boots, High Street, Reigate	R	37.3(11)	34.7(11)	**43.4**(11)	34.5(11)
Day Centre, Banstead	B	25.6(11)	24.9(11)	25.5(12)	24.8(11)
Day Centre, Horley	B	28.7(11)	30.7(11)	33.5(11)	30.6(5)
130 Radstock Way, Merstham	B	21.3(11)	26.8(11)	25.0(9)	26.3(8)
Rear of Boots, Reigate	I	27.5(11)	22.8(11)	24.7(12)	24.7(7)
63 St Mary's Road, Reigate	I	23.5(11)	26.8(11)	22.9(12)	23.2(10)
Rushworth Road, Reigate	B	27.0(11)	25.2(11)	24.8(12)	23.9(8)
Riverside Horley	B	28.9(11)	34.2(11)	30.5(12)	29.5(11)
Horley Police Station, Massetts	R	33.3(11)	38.0(11)	39.8(10)	33.2(11)
Public Car Park, Off Massetts Road	I	27.1(11)	26.0(11)	28.7(12)	28.1(11)
11 Sylvan Way, Redhill	B	24.9(11)	26.3(11)	23.7(12)	22.2(10)
60, Brook Road, Merstham	B	29.4(11)	30.3(11)	30.2(12)	29.9(11)
Village Hall, Station Road,	I	29.8(11)	35.2(11)	34.5(12)	31.4(11)
Corner of London Road, Merstham	R	37.5(11)	37.4(11)	**40.6**(12)	38.6(11)
Opposite Drift Bridge Hotel,	R	**42.2**(11)	**42.6**(11)	36.8(12)	37.1(11)
Opposite 2 Grey Alders, Banstead	I	28.1(11)	25.6(11)	28.5(12)	25.7(11)
Outside Warren Mead School,	B	20.9(11)	20.6(11)	29.1(12)	23.0(10)

Concentrations greater than 40 $\mu g/m^3$ are shown in bold.

The results indicate that the annual average objective for NO_2 (40 $\mu g/m^3$) has been occasionally exceeded at a number of locations (shown in **bold**) in recent years; however no exceedances were measured in the year 2000 at any site.

Monthly concentrations from for all diffusion tube sites since 1997 are detailed in Table A1 in Appendix 1.

The performance of diffusion tubes is variable, and concentrations reported by different laboratories may under or over-read by 30% or more. Information on systematic bias comes from comparison of tubes collocated with continuous monitors. There is a national intercomparison exercise carried out each year by AEA Technology. The tubes used by Reigate and Banstead BC are supplied by Lambeth Scientific Services. They have indicated that the result of the published national intercomparison for 1999 is unreliable. Information was therefore sought from other authorities that have carried out their own intercomparisons using Lambeth Scientific Services tubes. A comparison carried out by the London Borough of Lambeth for a roadside site showed the tubes to be over-reading by +4.7% for 1999, while a comparison carried out by North Hertfordshire District Council showed tubes under-reading by -5.2%, also for 1999. On this basis it is reasonable to assume that the tubes provide results with no bias. It should however, be noted that the results for the background tubes in Horley in 2000 were around 30 $\mu g/m^3$, in 2000 (Table 2.3), while the continuous monitor gave a result of around 35-36 $\mu g/m^3$. Which suggests there may be an under-reading of tubes at background locations of around 15%.

3. Dispersion Modelling Methodology

3.1. Introduction

The assessment has been based on a 'layered' approach, in which the contributions from different sources have been combined to produce a total predicted concentration for the future relevant year. The 3 main inputs have been:
- Road traffic emissions from the general road network;
- Emissions arising from Gatwick Airport;
- Background pollutant concentrations.

Each of these elements is considered in turn.

Predictive modelling has been undertaken in the current study to assess air quality on a wider scale than monitoring methodologies would otherwise permit. For the current assessment, Stanger's bespoke version of a commercially available model, Breeze Roads[6], has been used to assess the individual impacts of road traffic emissions. Further details regarding the use of the model are given below. In addition to road traffic emissions, the contribution of Gatwick Airport has also been assessed.

3.2. Roads Modelling

Emissions arising from the local road network have been assessed using Stanger's bespoke version of a commercially available model, Breeze Roads[7]. The model has been used to predict the concentrations from road traffic sources throughout the Borough at previously identified locations where the potential to exceed relevant air quality objectives have been shown. Breeze Roads is a complete modelling package that is an enhanced version of previously released CAL3QHCR, CALINE4 and CAL3QHC models. It is a software package designed to predict air quality impacts of CO, NO_2 and particulate matter.

The approach to the assessment for road traffic sources has been to predict concentrations at specific receptors representing the facades of buildings, in order to assess the likelihood of exceedances of the relevant air quality objectives. Where exceedances of the annual objective are predicted to occur, concentrations have been predicted over a regularly spaced grid to enable contouring of results to be undertaken. The modelling has been carried out for the current year (2000) and the future year of the relevant objective (2005 for NO_2 and 2004 for PM_{10}) at roadside locations of both trunk roads, and smaller more congested roads (e.g. within Reigate town centre).

Further information concerning the inputs into the models and the levels of accuracy surrounding the predicted concentrations are given below.

[6] Trinity Consultants: www.trinity-consultants.com

[7] Trinity Consultants: www.trinity-consultants.com

Figure 3.1 Locations of roads in the Reigate and Banstead Borough Council

3.2.1. Input Data

Specific input data have been provided by the authority for this assessment. These include:

- Digital maps[8] covering the relevant road links to be included in the assessment.

[8] As provided under license agreement LA077054 Reigate and Banstead Borough Council

- Traffic flow data for relevant road links for the current year and for the years 2004 and 2005
- Percentage split between Heavy Duty Vehicles (HDV) and Light Duty Vehicles (LDV) types
- Average speed of vehicles on relevant road links

Where specific information was unavailable, Stanger Science and Environment have liased with the Environmental Services Division of Reigate Borough Council and the Traffic Department of Surrey County Council, in order to make reasonable assumptions regarding traffic flows and speeds.

The following roads have been included in the modelling assessment:

- A217 Extending from Kingswood to Banstead area in the northern part of the Borough;
- M25 Motorway extending across east to west of the Borough;
- M23 Motorway extending from north to south on the eastern side of the Borough;
- A2044 links between A23 and A217 in the Earlswood Common area to the south of the Reigate area;
- A242 between the Reigate area to Merstham in the north east;
- A25 between Reigate and Redhill;
- A23 linking London and Brighton passing through Redhill;
- A240 in Banstead area;
- A2022 to north of Banstead.

Figure 3.1 shows the relevant locations of each of the roads listed above, as used throughout this assessment. Annual average daily traffic (AADT) flows and proportions of HDVs (Heavy Duty Vehicles) have been based on the data provided by Surrey County Council Traffic Department. Traffic flows, speeds, and HDV percentage for the current year (2000) and for year of the objectives (2004 and 2005) are shown in Table A2 in Appendix 1.

These traffic flow parameters were used to calculate the emissions from the vehicles on each section of road. There are a number of published sources for vehicle emission factors; in this study the Design Manual for Roads and Bridges (DMRB), Volume 11 (Air Quality Annex, May 1999) emission factors were used for each road link in the current assessment.

The DMRB emission factors allow estimated changes in vehicle speeds and composition on the roads to be taken into account. Emission rate graphs for light-duty and heavy-duty vehicles are given. These show changing vehicular emission rates over future years and take account of changes in the fleet composition such as vehicle type and engine size, and the introduction of new vehicular emissions technologies. A number of tables provide correction factors for vehicle speeds other than the reference value of 100 km/hr for both light-duty and heavy-duty vehicles. The use of both graphs and tables results in an emission rate for a given vehicle type in a given year, travelling at a given speed.

These emission factors (expressed as grams per vehicle-mile) have been imported from an Excel spreadsheet format, along with the hourly traffic flow, the road geometries, receptor locations and meteorological data into the model for processing. The detailed emissions for each section of road are provided in Table A3 in Appendix 1.

3.3. Gatwick Airport Modelling

The assessment of emissions arising from an airport of the magnitude of Gatwick is an extremely complex task. In order to assemble the inventory it is necessary to compile detailed information on the number of aircraft movements, aircraft types and engine configurations, aircraft operating conditions (including times-in-mode, taxiing patterns), APU usage, together with airside/landside traffic emissions and stationery sources. Such details are required for both the current year, and the future years of the assessment.

BAA Gatwick (BAAG) has recently published its Sustainable Development Strategy , which contains details of an emissions inventory compiled for 1996/97 and for 2008 (taking into account planned airport expansion to 40 mppa). A detailed modelling exercise based on these data was also carried out by AEA Technology using the LPAM model. Due to the detailed knowledge of airport operations that is required, it was considered unlikely that the authority would be able to improve upon the emissions inventory and dispersion modelling work that had already been carried out. BAAG therefore kindly provided the results of their modelling assessment, which were incorporated into this study.

Data were provided by AEA Technology in the form of receptor grid matrices for 2008. A number of matrices were provided for both NO_x and PM_{10}, representing the different source contributions from the airport. To avoid the possibility of 'double counting' emissions were limited to those sources within the airport perimeter, with the exception of the 'off-airport' car parks. Traffic on the roads surrounding the airport has already been considered in the information provided by Surrey County Council. The predicted concentrations of NO_x and PM_{10} at each receptor in the grid were made up of the contribution from four main types of sources. These are:

- Aircraft emissions: includes aircraft takeoff, landing and climbout, engine testing, idle and taxi. NOTE - emissions associated with 100% thrust on take-off were assumed;
- Stationary Sources: includes boiler houses;
- Mobile Sources (Airside): includes the BA, GAL and other support vehicles, such as baggage and passenger transport, tugs, conveyors etc;
- Mobile Sources (Landside within airport perimeter): including buses, freight, on-airport car parks, staff, taxis etc.

The prediction matrices provided by AEAT were for the year 2008 and therefore need to be adjusted for the relevant years in this study (i.e. 2000 and 2004/2005). Correction factors have been derived from the disaggregated emission inventories for 1996/1997 and 2008, assuming linear change (increase or reduction) between these two years. Specific factors have been derived for NO_x and PM_{10}, for Aircraft emissions, Stationary sources, Mobile sources (airside) and Mobile sources (Landside). These are shown in Table 3.1 and have been applied to the relevant LAPM output files provided by AEAT.

Table 3.1 Correction Factors Applied to 2008 Gatwick Predictions

Type of Source	NO_x 2000	NO_x 2005	PM_{10} 2004
Aircraft Emissions	0.65	0.867	0.991
Stationary Sources	1.00	1.00	1.00
Mobile Source(airside)	1.15	1.055	1.349
Mobile Source(Landside)	1.77	1.287	1.295

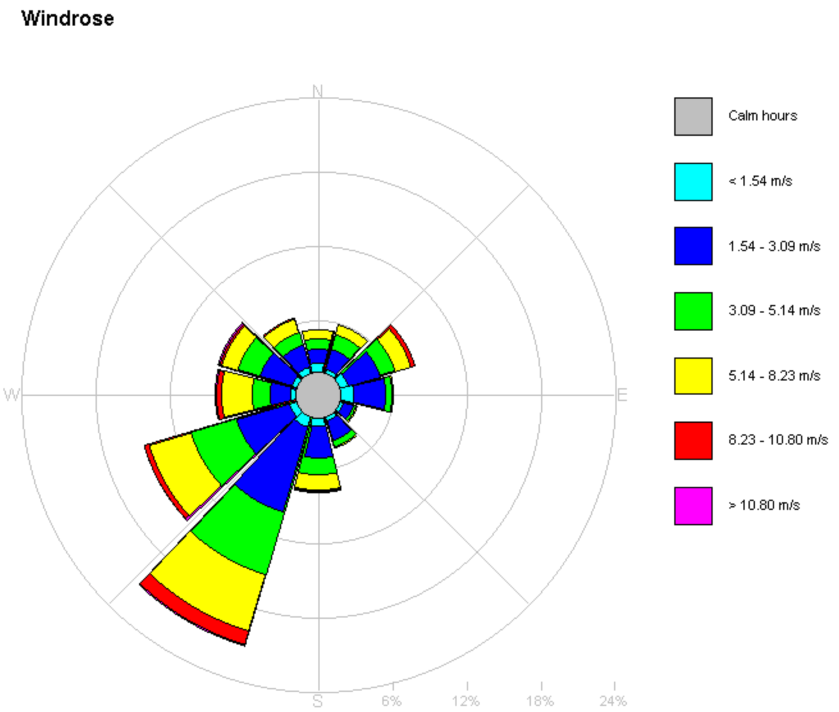
It can be seen from Table 3.1 that aircraft emissions decrease for the years 2004/2005 and 2000 as compared to the year 2008, as there are greater expected air traffic movements in 2008, and improvements in terms of aircraft emissions technology are unlikely in these timescales. Mobile source emissions are higher in the years 2004/2005 and 2000 as compared to 2008 as, despite lower traffic volumes, improved vehicular emissions technologies are expected to reduce emissions in future years. The change in airside mobile source emissions is less dramatic, as in-service periods for these vehicles are much longer.

The above correction factors have been applied to each matrix. Total NO_x and PM_{10} concentrations (arising from Gatwick Airport) for each year was then calculated by re-combining the contributions from each source type. Concentration contours for NO_x and PM_{10} were then derived by interpolation between each receptor point. The interpolated contributions extend from Gatwick Airport to cover the whole of Horley in the south of the Borough.

3.4. Meteorological Data

Hourly sequential meteorological data from the observing station at Gatwick Airport for 1999 has been used in the assessment. This is the closest recording meteorological observing station to the areas providing the required information for the dispersion models and is situated to the south of the authority area. Figure 3.2 shows the windrose recorded at Gatwick Airport for 1999.

Figure 3.2 Windrose for Gatwick meteorological station, 1999



Long-period meteorological records of wind speed, direction and stability parameters are required to predict the pollutant concentrations that could occur under different weather conditions. When the atmosphere is said to be 'stable', there is little turbulence and vertical movement of air. These conditions are mostly confined to the hours between sunset and sunrise, and require light winds.

'Unstable' atmospheric conditions are generally confined to the daytime when, primarily, due to surface heating, there is considerable turbulence and rapid vertical movement, thus dissipating the pollutant fairly rapidly resulting in decreased pollutant concentrations away from the source. Unstable conditions favour light winds and strong to moderate levels of sunshine.

'Neutral' stability is by far the most frequent, and occurs under cloudier weather conditions and is biased towards higher wind speeds. A neutral atmosphere can persist during the day or night, but are mostly likely to occur during storm conditions.

3.5. Background Concentrations

Predicted concentrations from the Breeze Roads model and Gatwick Airport account only for those sources that have been input to the model. In order to determine the total concentration of each pollutant, appropriate 'background' concentrations must also be taken into consideration. For this assessment, background concentrations have been derived from the National Air Quality Archive[9]. The Archive contains mapped background concentrations for 2004/2005, which have been prepared by NETCEN on a $1x1km^2$ basis across the UK,

3.5.1. Annual Average Concentrations : NO_x

Background values for NO_x for the year 2005 have been identified for different areas within the authority boundary. In each case care has been taken to avoid double counting of emissions (by avoiding grid squares containing sources included in the models). Background concentrations for the year 2000 have been 'corrected' using factors described in LAQM.TG4 (00)[10]. The background concentrations assumed for different areas are shown in Table 3.2 below.

These background NO_x concentrations have been added to the predicted contributions from road traffic, and from Gatwick Airport. The detailed methodology is described in full in Section 3.6.

---

[9] Internet address: http://www.aeat.co.uk/netcen/airqual/

[10] Review and Assessment: Pollutant Specific Guidance. Part IV The Environment Act 1995 Local Air Quality Management LAQM.TG4 May 2000.

Table 3.2 Background Concentrations of NO_x ($\mu g/m^3$)

Site	Annual Average NO_x ($\mu g/m^3$)	
	2000	**2005**
A217Banstead area(Northern part of the Borough)	30.0	23.1
A217(Kingswood towards M25, Reigate and Redhill area, Areas near M25/M23	40.0	30.7
Earlswood(Southern edge of Reigate)	30.0	23.1
A217 South of Reigate and towards Horley	26.0	19.9
A23 south of Redhill towards Gatwick (and area surrounding Gatwick)	34.0	26.1
A23/M23 junction area	35.0	26.9
A23 north towards Purley	30.0	23.1

Background NO_x concentrations are added to the predicted contributions from road traffic, and from Gatwick airport. The detailed methodology is described in full in Section 3.6.

3.5.2. Annual Average Concentrations : PM_{10}

A similar approach to that described above has been used to obtain the annual average PM_{10} background concentrations. A concentration of 25.4 $\mu g/m^3$ gravimetric for 2000, and 24.0 $\mu g/m^3$ gravimetric for 2004 has been used for the whole area.

3.6. Validation of Predicted Concentrations

Validation of the predicted concentrations has been undertaken for both road traffic and Gatwick Airport emission. A systematic error for each part the modelling is derived by comparing modelled results with available monitored data.

In order to derive the systematic errors for the road traffic predictions, concentrations of NO_x/NO_2 have been predicted at the locations of the Roadside diffusion tubes included in the assessment. Predicted concentrations at these locations were then compared to the measured values at the roadside in order to derive the estimate of error of the model.

The impact of Gatwick Airport has been predicted mainly in the Horley area to the south of the Borough. In order to derive the systematic error for the Gatwick Airport emissions the concentrations of NO_x/NO_2 and PM_{10} were predicted at the location of the continuous background-monitoring site in Horley.

Validation of both Gatwick Airport predictions and road traffic have been undertaken in the Horley area, whereas the remaining part of the Borough has included only validation of road traffic modelling.

3.6.1. Road Traffic Validation : Predicted concentrations - Annual Average NO_2

Predicted annual average NO_x concentrations arising from road traffic emissions in 2000 has been carried out using Breeze Roads. Subsequent corrections based on measured NO_x concentrations, the addition of relevant background concentrations, and conversion of NO_x to NO_2, has then been carried out. This provides a transparent way of viewing the process of deriving the final validated results.

There are a total of 17 diffusion tube monitoring sites in the Borough. Of these, 4 sites in the south of the Borough are expected to be influenced by emissions from Gatwick Airport. A further 7 sites are at background locations and would not represent concentrations directly from local road traffic. These sites were not used in the validation of road traffic predictions. A total of 6 sites near roads have been identified for use in the validation of the Breeze Roads modelling. Table 3.3 shows the classification of the diffusion tube sites as used in the validation. No roadside continuous monitoring of NO_2 is available in the Borough.

Table 3.3 Classification of Diffusion Tube Monitoring Sites for Validation

Site Location	Reference	Classification for Sites
Day Centre, Horley	RB4	Possible Gatwick influence due to proximity to Gatwick Airport
Riverside, Horley	RB11	
Horley Police Station, Massetts Road, Horley	RB12	
Public Car Park, off Massetts Road, Horley	RB13	
Day Centre, Banstead	RB3	Background Sites
130 Radstock Way, Merstham	RB7	
63 St Mary's Road, Reigate	RB9	
Rushworth Road, Reigate	RB10	
11 Sylvan Way, Redhill	RB17	
60 Brook Road, Merstham	RB18	
Outside Warren Mead School, Roundawood Way, Banstead	RB23	
Boots, High Street, Reigate	RB1	Sites near roadside or intermediate : Considered for Validation
Rear of Boots, Reigate	RB8	
Village Hall, Station Road, Merstham	RB19	
Corner of London Road, Merstham	RB20	
Opposite Drift Bridge Hotel, Banstead	RB21*	
Opposite 2 Grey Alders, Banstead	RB22	

* Classified as Roadside Site but near a road not included in modelling.

Whilst diffusion tube RB21 is at a roadside location, this is a residential road for which traffic data were not available. The site has therefore been excluded from the validation exercise.

Roadside diffusion tubes provide estimates of the annual average NO_2 concentrations that include both contributions from background sources and road traffic sources directly. In order to use diffusion tube results to determine the accuracy of the Breeze Roads predictions of NO_x, the diffusion tube NO2 results need to be converted back to NO_x.

Conversion of NO_x to NO_2 has been undertaken using the following equation as derived from long-term monitoring relationships throughout the UK, and detailed in LAQM.TG4(00).

$$\text{Total } NO_2\ (\mu g/m^3) = 3.3931 \times (\text{Total annual average } NO_x\ (\mu g/m^3))^{0.5278}$$

The contribution of vehicle emissions to measured roadside NO_x (i.e. NO_x due to road traffic alone) was derived from the estimated annual average measured NO_x minus the relevant average background NO_x as described above:

$$\text{Roadside Contribution of } NO_x = \text{Diffusion Tube } NO_x - \text{Background } NO_x$$

Table 3.4 below shows the total 2000 annual average NO_2 concentration at each diffusion tube location, the converted NO_x average, the estimate background NO_x, and derived roadside NO_x concentration.

Table 3.4: Diffusion Tube Total NO_2 and NO_x ($\mu g/m^3$)

Diffusion Tube Reference	Annual Average NO_2 Year 2000	Converted Annual Average NO_x Year 2000	Estimated Background NO_x Year 2000	Estimated monitored Roadside NO_x (Total Diffusion Tube NO_x – Background NO_x)
RB1	34.5	81.0	40	40.97
RB8	24.7	43.0	40	2.99
RB19	31.4	67.7	40	27.74
RB20	38.6	100.2	40	60.17
RB22	25.7	46.3	30	16.35

The estimated roadside contribution of NO_x may then be directly compared to the modelled value of roadside NO_x and an average 'correction factor' derived to account for the systematic error of the model. Table 3.5 shows the method for determination of the correction factor for modelled roadside NO_x.

Table 3.5 Estimation of Systematic Error of Modelled Roadside NO_x

Diffusion Tube Reference	Estimated monitored Roadside NOx Year 2000	Modelled Roadside NO_x (from Breeze Roads) Year 2000	Roadside NO_x Correction Factor (Monitored/Modelled)
RB1	40.97	16.88	2.4
RB8	2.99	7.96	0.4
RB19	27.74	18.76	1.5
RB20	60.17	26.85	2.2
RB22	16.35	2.66	6.2
Monitored NO_X (roadside contribution) = Modelled NO_X (road contribution) x systematic error(factor)			
Average Correction Factor = 2.5			

It is therefore assumed that the model is underpredicting the roadside contribution to NO_x concentrations by a factor of 2.5. It is clear though, that there is considerable uncertainty in this adjustment factor.

The Breeze Roads model was then used to predict annual average NO_x concentrations from road traffic at each of the 17 diffusion tube sites, and the correction factor of 2.5 applied. The assumed background NO_x was then added, to give the total concentration at each diffusion tube site as NO_X ($\mu g/m^3$), and then converted to NO_2 using the LAQM.TG4(00) equation (as described above). The final NO_2 concentration predicted at each diffusion tube may then be compared to the measured diffusion tube NO_2 concentration. Table 3.6 shows the monitored diffusion tube annual average NO_2 concentrations and the corresponding modelled NO_2 concentrations.

Table 3.6 Comparison of Modelled and Monitored NO_2 Concentrations at Diffusion Tube Locations in Reigate Borough (μg/m^3)

Location	Site Type	Ref	Total Monitored NO_2	Total Modelled NO_2 (Corrected Roads + Background)	Difference (modelled – monitored)	
					μg/m^3	%
Boots, High Street, Reigate	R	RB1	34.5	34.8	0.32	0.9%
Day Centre, Banstead	B	RB3	24.8	22.5	-2.32	-9.3%
Day Centre, Horley	B	RB4	30.6	23.3	-7.29	-23.9%
130 Radstock Way, Merstham	B	RB7	26.3	35.8	9.56	36.1%
Rear of Boots, Reigate	I	RB8	24.7	29.4	4.71	19.0%
63 St Mary's Road, Reigate	I	RB9	23.2	25.1	1.92	8.2%
Rushworth Road, Reigate	B	RB10	23.9	28.1	4.23	17.6%
Riverside Horley	B	RB11	29.5	27.7	-1.89	-6.1%
Horley Police Station, Massetts Road, Horley	R	RB12	33.2	23.5	-9.65	-29.2%
Public Car Park, Off Massetts Road Horley	I	RB13	28.1	23.6	-4.52	-16.0%
11 Sylvan Way, Redhill	B	RB17	22.2	24.3	2.14	9.5%
60, Brook Road, Merstham	B	RB18	29.9	31.9	1.97	6.7%
Village Hall, Station Road, Merstham	I	RB19	31.4	35.8	4.45	14.0%
Corner of London Road, Merstham	R	RB20	38.6	40.0	1.44	3.6%
Opposite Drift Bridge Hotel, Banstead	R	RB21*	37.1	21.6	-15.49	-41.8%
Opposite 2 Grey Alders, Banstead	I	RB22	25.7	22.7	-3.02	-11.7%
Outside Warren Mead School, Banstead	B	RB23	23.0	21.5	-1.48	-6.5%

* The model for this location did not include the road on which the tube is sited.

Comparison of the predicted annual average NO_2 concentrations against the monitored diffusion tube concentrations reveals a different behaviour for the model in Horley, in the vicinity of Gatwick Airport, to the rest of the Borough. Through most of the Borough model produces an average over-prediction of +7.3% excluding the four Horley sites (and RB21), and a +5.2% over-prediction for the roadside site used to develop the correction. To remain conservative no further adjustment will be made for this apparent over-estimation of the model. In the area near to Gatwick Airport the model under-predicts by an average of -18.8%. This will be due to the need to include NO_x from the airport in the model. The next section describes the methodology used to incorporate the contribution of Gatwick NO_x into the model.

3.6.2. Gatwick Validation : Predicted concentrations - Annual Average NO_2

Analysis of diffusion tube data in the South of Reigate Borough indicates that modelled NO_2 is underpredicted by the Breeze Roads model. This may (in part) be attributed to the influence of Gatwick Airport that lies directly to the south of Horley. Hence a separate validation was undertaken for this area in order to determine the contributions from airport-related activities.

The monitoring data provided from a continuous monitoring site have been used to validate modelling results (for NO_x and NO_2) and assist in determining the potential errors associated with assessment of impacts from sources in and around Gatwick Airport.

Predicted NO_x concentrations arising from Gatwick Airport for 2000 have been carried out as described in the section above. The contribution from each of the 4 source types, and the total NO_x concentration at 4 diffusion tubes sites, are shown in table 3.7 below.

Table 3.7 Modelled Gatwick NO_x Contribution for Year 2000 at Monitoring Locations ($\mu g/m^3$)

Site Location	Reference	Aircraft 2000	Stationary 2000	Mobile Landside 2000	Mobile Airside 2000	Total NO_x due to Gatwick 2000
Day Centre, Horley	RB4	37.15	0.44	6.68	2.80	47.06
Riverside, Horley	RB11	68.00	0.56	14.48	7.71	90.75
Horley Police Station, Massetts Road, Horley	RB12	39.62	0.45	7.27	3.56	50.90
Public Car Park, off Massetts Road, Horley	RB13	37.59	0.45	7.25	3.17	48.46
Scout Hut, Michael Crescent Horley (Continuous Monitor)	CML	67.91	0.56	11.22	6.87	86.57

A background NO_x concentration of 34 µg/m^3 in 2000 has been assumed, as explained in section 3.5.1. The total NO_x at each monitoring location was obtained as the sum of:

- Modelled Gatwick NO_x (as shown in Table 3.7) plus
- Corrected Breeze Roads modelled NO_x plus
- Background NO_x.

The total NO_x has then been converted to NO_2 using the equation detailed in LAQM.TG4(00) given in section 3.6.1. Table 3.8 shows the comparison between monitored and modelled NO_2 (after conversion from NO_x) concentrations.

Table 3.8 Comparison of Modelled and Monitored NO_2 Concentrations in Horley (µg/m^3)

Site Location	Reference	Modelled NO_2 (Gatwick+Roads+Background)	Monitored NO_2	Difference NO_2 (Modelled - Monitored)	
Day Centre, Horley	RB4	35.52	30.6	+4.92	+16.1%
Riverside, Horley	RB11	46.75	29.5	+17.21	+58.3%
Horley Police Station, Massetts Road, Horley	RB12	36.50	33.2	+3.32	+10%
Public Car Park, off Massetts Road, Horley	RB13	36.00	28.1	+7.91	+28.1%
Scout Hut, Michael Crescent Horley(Continuous Monitor)	CML	44.83	35.2	+9.63	+27.4%
Average over-prediction = +8.6 (+28%)					

The average over-prediction of NO_2 is determined to be 8.6 µg/m^3 or +28% when the Gatwick contribution of NO_x, as calculated using the AEA Technology model output, is considered. Table 3.7 indicates that the largest contribution of NO_x due to Gatwick sources is from aircraft emissions. The monitored NO_2 at both diffusion tube and continuous monitoring sites indicates a large overestimation of total NO_2 concentrations. The over-prediction leads to predicted NO_2 concentrations in 2000 approaching, or well above the level of 40 µg/m^3 NO_2. In contrast, the monitoring data indicates that exceedances of the objective are unlikely to occur at these locations. Some further consideration of the methodology for the inclusion of Gatwick Airport is required.

To further validate the Gatwick modelling results (based on AEAT original data), the monitored NO_x from the continuous monitoring location at Horley has been used. Since this is a background site, a negligible local road traffic contribution has been assumed.

The following can be derived:

Monitored NO_x (including background) = 60.6 $\mu g/m^3$

Estimated monitored NO_x due to Gatwick contribution (total monitored NO_x – estimated background of 34 $\mu g/m^3$) = 26.6 $\mu g/m^3$

Modelled Gatwick NO_x (estimated from AEAT original data)) =86.6 $\mu g/m^3$

Factor Monitored NO_x : Modelled NO_x =3.25

The comparison of modelled and monitored NO_x indicated that there may be an over-prediction of the Gatwick contribution to NO_x by a factor of 3.25, i.e. the Gatwick NO_x predictions should be divided by 3.25 (It should be noted that if the longer period NO_x concentration of 66.2 $\mu g/m^3$ is used (Section 2.2), then the correction factor becomes 2.69, and Gatwick NO_x contributions would be higher by 21% than the 'corrected' values used). This 3.25 'correction factor' has been applied to the estimated Gatwick NO_x contribution at each of the diffusion tube sites and the continuous background site in Horley. Once again, the total NO_x (corrected Gatwick contribution, Breeze Roads contribution and background) has been converted to NO_2 using the LAQM.TG4(00) equation. A comparison of the modelled corrected NO_2 and monitored NO_2 is shown in Table 3.9. NB: Breeze Roads predictions have been corrected using the factor identified in section 3.6.1.

Table 3.9 Comparison of Corrected Modelled and Monitored NO_2 concentrations in Horley ($\mu g/m^3$)

Site Location	Diffusion Tube Reference	Final Modelled NO_2 (Corrected Gatwick +Roads+Background)	Monitored NO_2	Difference NO_2 (Final Modelled - Monitored)	
Day Centre, Horley	RB4	27.59	30.60	-3.01	-9.8%
Riverside, Horley	RB11	34.55	29.55	5.00	+16.9%
Horley Police Station, Massetts Road, Horley	RB12	28.10	33.18	-5.08	-15.3%
Public Car Park, off Massetts Road, Horley	RB13	27.92	28.09	-0.17	-0.6%
Scout Hut, Michael Crescent Horley(Continuous Monitor)	CML	32.68	35.20	-2.52	-7.2%
Average under-prediction = -1.16 $\mu g/m^3$ (-3.2%)					

There is then an average under-prediction -1.16 $\mu g/m^3$ or -3.2% of total modelled NO_2, if the correction factor of 3.25 is applied to the Gatwick NO_x contribution. This slight under-prediction has not been allowed for, but should be borne in mind when considering the results for the Horley area. Where Gatwick Airport contributions have been considered in the results section of this assessment, NO_2 concentrations have been derived using the corrected Gatwick NO_x concentrations.

4. Predicted Concentrations

4.1. Introduction

Predictions of NO_x/NO_2 and PM_{10} based on emissions from road traffic were undertaken at the facades of buildings. The locations of the receptors are shown in Maps 4.1A-4.1 M. Predictions were undertaken along the following major roads included in the modelling assessment:

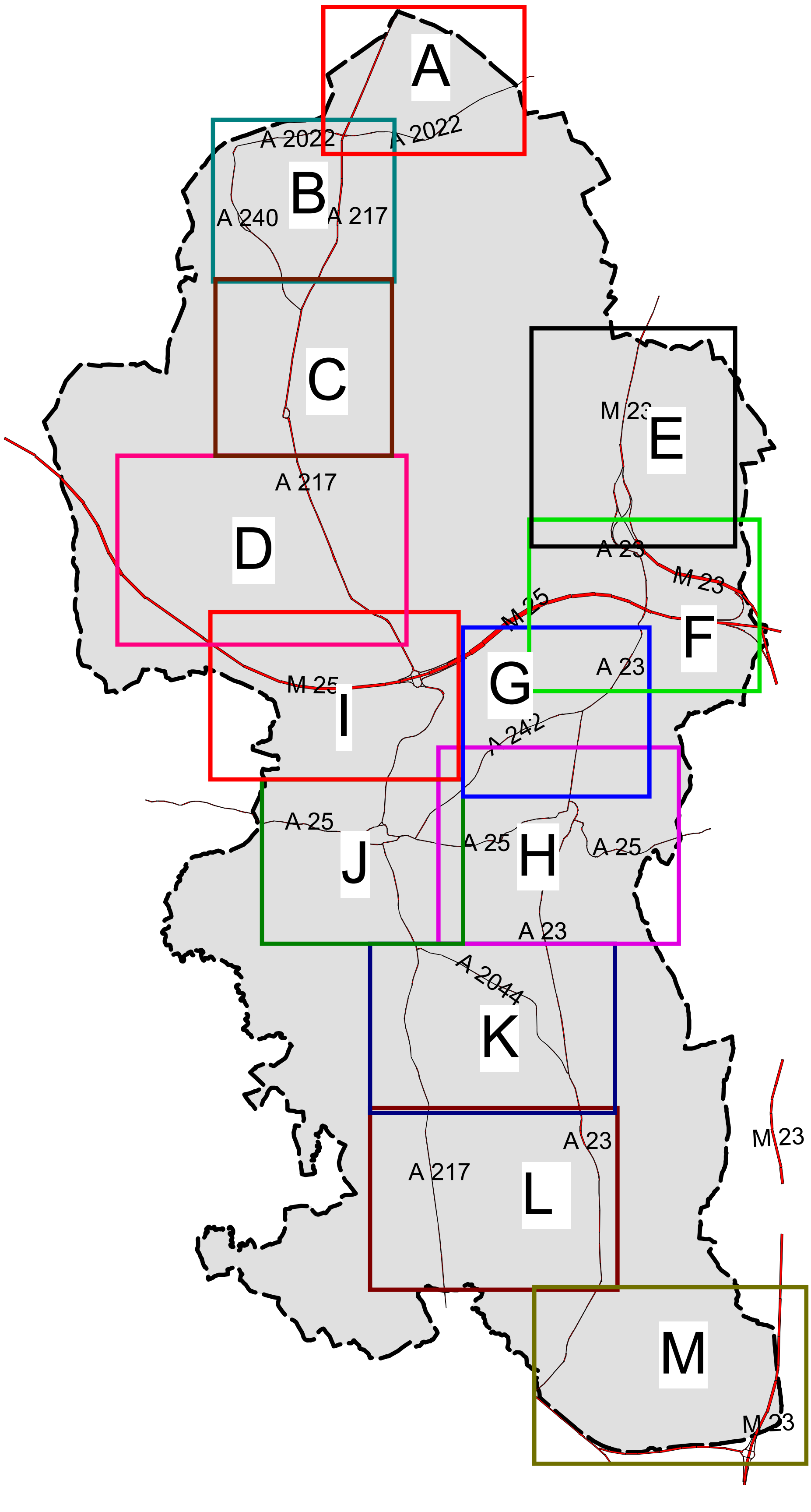
- A217 Extending from Kingswood to Banstead area in the northern part of the Borough
- M25 Motorway extending across east to west of the Borough
- M23 Motorway extending from north to south on the eastern side of the Borough
- A2044 links between A23 and A217 in the Earlswood Common area to the south of the Reigate area
- A242 between the Reigate area to Merstham in the north east.)
- A25 between Reigate and Redhill
- A23 linking London and Brighton passing through Redhill
- A240 in Banstead area
- A2022 to north of Banstead

Predictions of annual average concentrations have been undertaken for the years 2000 and 2005 for NO_x/NO_2 and 2004 for PM_{10}. The methods for validation of the annual average NO_2 concentrations have been described in detail in section 3.6. No validation could be undertaken for PM_{10} due to a lack of appropriate roadside PM_{10} monitoring data.

Where exceedances of the annual average objective are predicted to occur at the façade of the building, a further detailed grid of equally spaced points has been modelled in order to allow concentration contours to be drawn. The contour plots allow the areas of predicted exceedances of an objective to be more clearly defined, and facilitate the declaration of Air Quality Management Areas (AQMAs).

The Borough has been divided into 13 areas in order to display the predicted results with sufficient resolution. These areas (A – M) are shown in Figure 4.1 and are referred to when presenting the predicted results.

Figure 4.1 Areas of Predicted Results



4.2. Results for Nitrogen Dioxide: Road Traffic

4.2.1. Annual Average NO_2 concentrations: Year 2000

Predictions of annual average NO_2 were undertaken at a total of 3820 receptors locations, at the façade of properties included in the modelling assessment.

Table 4.2a shows the minimum, maximum and range of validated concentrations of NO_2 predicted at all receptor locations for the year 2000.

Table 4.2a Annual Average NO_2 Predictions at Building Facades (2000)

Parameter	**Annual Average NO_2 concentrations ($\mu g/m^3$)**
	Year 2000
Minimum	20.3
Maximum	95.0
Range	74.7

Maps 4.2 A – 4.2 M show the predicted annual average NO_2 concentrations at each receptor for the year 2000. The maps indicate that there are a number of exceedances of 40 $\mu g/m^3$ along various sections along M25, A217 and M23. The maximum concentrations are predicted at buildings within a few metres of the motorway edge and are uncharacteristically high. These extreme levels are likely to result from difficulties in predicting concentrations near to motorways in the absence of detailed monitoring at these locations.

In total, annual average concentrations greater than 40 $\mu g/m^3$ were predicted at 141 locations in 2000. These locations are mainly near the M25 and A217 roads. The results of future predictions (year 2005) are discussed in section 4.2.2 below.

4.2.2. Annual Average NO_2 concentrations: Year 2005

The range of predictions for annual average NO_2 in 2005 at 3820 receptor locations Reigate Borough is shown in Table 4.2b. Maps 4.3 A- 4.3 M show the annual average NO_2 concentrations predicted at each individual location for the year 2005.

Table 4.2b Annual Average NO_2 Predictions at Building Facades (2005)

Parameter	**Annual Average NO_2 Concentrations ($\mu g/m^3$)**
	Year 2005
Minimum	15.6
Maximum	78.0
Range	62.5

Concentrations greater than 40 µg/m^3 in 2005 have been predicted at a total of 38 locations as shown in Table 4.2c. These are not necessarily relevant locations in terms of public exposure over the averaging period of the objective. This is discussed in Section 4.4.

Table 4.2c Locations of Predicted Exceedances of Annual Average NO_2 Concentrations (µg/m^3), 2005

Location	Concentration Range	Map Reference
Depot at the intersection of M25 and A23	46-50	Map 4.3 F
Electrical Sub Station near M25	46-50	Map 4.3 D
Scrap Yard to the south east end of Reigate Borough near M23	38-46	Map 4.3 M
Dell House along M25 towards the east of the Borough	42-46	Map 4.3 F
Hunter's Lodge and farms along M25	60-95	Map 4.3 I
Rose Cottage and Magador End along M25	50-56	Map 4.3 I
White Lodge and cottages near Stuart Lane and Dorking Road along M25	56-95	Map 4.3 D
South Gable near M25	46-50	Map 4.3 I
Buildings near to AshoChase Road near the intersection of M25 and A23	50-60	Map 4.3 F
Cottages at the intersection of intersection of M25 and A23	46-50	Map 4.3 F
Cottages opposite Community Centre along the A23	38-42	Map 4.3 E
Cottage along A23 near Flying Scud (Earlswood)	38-42	Map 4.3 H
Cottage No 119 and 1 along A23 near Brighton Road	42-50	Map 4.3 E
Cottages along M23 (Shepherds Hill) Little House Cottage and Dilkhusha	42-50	Map 4.3 F
Yew Cottage and Highland along A217	38-42	Map 4.3 I
Glade House along M25	38-42	Map 4.3 F
Quarry Cottages 1-6 near M23	38-46	Map 4.3 F
Building No 16 along London Road (Reigate Town Centre)	38-42	Map 4.3 J
Moralee Cottage near M25	46-50	Map 4.3 I
Merrywood Cottage in Merrywood Grove near M25	60-95	Map 4.3 I
Trentham south east end of Reigate Borough near M23	38-54	Map 4.3 M

4.3. Results for Particulate Matter (PM_{10}): Road Traffic

Predictions of annual average PM_{10} were undertaken at the 3820 receptors at the facades of properties along the roads included in the modelling assessment. The 90th percentile of daily mean PM_{10} concentrations have been derived from the annual average PM_{10} concentrations. LAQM.TG4(00) provides a methodology based on long term continuous monitoring of PM_{10} that shows the 90th percentile of daily mean of PM_{10} concentrations can be estimated by multiplying the annual average PM_{10} by 1.79. This factor is obtained as worst case and is recognised as conservative approach.

$$\text{Annual average } PM_{10} = \text{Predicted } PM_{10} + \text{Background}$$

$$90^{th} \text{ percentile of daily mean of } PM_{10} = \text{Annual average } PM_{10} \times 1.79$$

Table 4.3a shows the minimum, maximum and range of validated concentrations of PM_{10} predicted at the facades of buildings for 2000 and 2004.

Table 4.3a PM_{10} Predictions at Building Facades

Parameter	PM_{10} concentrations ($\mu g/m^3$)			
	Year 2000		Year 2004	
	Annual Average	90^{th} %ile Daily Mean	Annual Average	90^{th} %ile Daily Mean
Minimum	25.4	45.5	24.0	43.0
Maximum	30.1	53.8	29.1	52.1
Range	5.7	8.3	5.1	9.1

Maps 4.5 A-M and 4.6 A-M show the predicted annual average PM_{10} concentration at each receptor for the years 2000 and 2004 respectively. Maps 4.7 A-M and 4.8 A-M show the predicted daily mean (90^{th} percentile) concentrations for 2000 and 2004.

The results indicate that exceedances of annual average objective for PM_{10} are unlikely to occur at any of the building facades in 2000 or 2004. However the daily mean PM_{10} objective is approached or exceeded at 5 locations in 2000 and 2004. The factor of 1.79 has been recognised as an overly conservative approach and a more realistic estimate of the 90^{th} percentile of daily means is obtained by using the factor of 1.68. Table 4.3b shows the daily mean PM_{10} concentrations obtained using both the factor 1.79 and 1.68 at the 5 receptor locations for the years 2000 and 2004.

Table 4.3b Comparison Daily Mean PM_{10} Concentrations Using Conservative and Realistic Estimation Factors

Parameter		PM_{10} concentrations($\mu g/m^3$)			
		90th %ile Daily Mean Year 2000		90th %ile Daily Mean Year 2004	
Receptor Location	Rec ID	factor 1.79	factor 1.68	factor 1.79	factor 1.68
Hunter's Lodge near M25	2803	50.89	47.76	48.77	45.77
Merry Wood Cottage along M25	3664	50.79	47.67	48.72	45.73
Linden Lea near M25	3707	50.21	47.12	48.13	45.18
Cottage Along M25	3708	50.83	47.71	48.82	45.82
White Lodge Along M25	3709	53.80	**50.49**	52.07	48.87

Using the more representative factor of 1.68 to derive the daily mean PM_{10} indicates that exceedances of the PM_{10} objective are unlikely to occur in the 2004.

4.4. Summary of Predictions from Road Traffic Only

A number of exceedances of the annual average NO_2 objective for 2005 have been predicted alongside the M25, A217, M23 for the year 2005.

The annual objective is relevant at a number of locations including background locations where members of the public might be regularly exposed, and at the building facades of residential properties, schools, hospitals, and other public buildings. The annual objective does not apply at the facades of offices, or other places of work where the public does not have regular access, or at gardens of residential properties and locations where public exposure is expected to be short term (such as kerbside locations).

With the above information in mind, the electrical sub station, scrap yard and the depot, identified in section 4.2.1 are commercial properties and other non-residential properties which are not required to have further assessment of the annual objective carried out because they do not meet the public exposure criteria.

For the remaining properties, the annual average NO_2 concentrations have again been predicted for the year 2005 over a 5 metre spaced receptor grid covering the properties. This enables concentration contours to be drawn and the extent of the predicted exceedances to be defined. The properties at which contouring has been carried out are listed below in Table 4.4a, along with the corresponding contour Map reference.

Table 4.4a Locations for Contouring Annual Average NO_2 Concentrations in 2005

Location	Map Reference
Dell House	4.4A
Hunter's Lodge farms along M25	4.4B
Rose Cottage and Magador End along M25	4.4C
White Lodge	4.4D
South Gable	4.4E
AshoChase Road	4.4F
Cottages at the intersection of M25 and A23	4.4G
Cottages opposite Community Centre along the A23	4.4H
Cottages along A23 near Flying Scud(Earlswood)	4.4I
Cottage No 119 along A23 near Brighton Road	4.4J
Cottage No 1 along A23 near Brighton Road	4.4K
Cottages along M23 (Shepherds Hill)	4.4L
Little House Cottage	4.4M
Yew Cottage and Highland along A217	4.4N
Glade House	4.4O
Quarry Cottages near M23	4.4P
Building No 16 (Reigate Town Centre)	4.4Q
Merrywood Cottage and Moralee	4.4R
Trentham (South East of Reigate Borough)	4.4S

The maps show that all potential exceedances occur within 30 metres of the roadside and that the concentrations rapidly reduce as the distance from the road increases. Very high concentrations are obtained in the vicinity of the M25 motorway. It is likely that the concentrations predicted at motorway locations are higher than would be expected to be observed. The predicted levels are as a result of difficulties with modelling at locations close motorways in the absence of monitoring at similar locations to validate the model. While the concentrations predicted close to the motorway are perhaps overestimated, it is reasonable to assume that exceedances would occur at these locations.

There are no predicted exceedances of the annual average or daily mean PM_{10} objectives in 2004.

4.5. Gatwick Airport Emissions

Due to the influence of Gatwick Airport emissions to the Horley area in the south of the Borough, an additional assessment of local NO_x/NO_2 and PM_{10} concentrations has been undertaken. As explained in Section 3.5 an area of dimension 1.5 km x 1.4 km encompassing Horley Predictions of NO_x and PM_{10} within an area of 1.5 km x 1.4 km centred on Horley has been carried out, using a 5m receptor grid spacing. The predictions have included Gatwick Airport emissions (based on corrected NO_x), corrected Breeze Roads modelled NO_x, and background NO_x.

The detailed results below are provided only for the relevant objective years (2005 and 2004). However, contributions for the year 2000 have been considered previously in section 3.6.2 in order to validate the modelling.

4.5.1. Results for Nitrogen Dioxide (2005)

In order to clarify the Gatwick Airport contribution to concentrations in the Horley area, three scenarios have been used to determine annual average NO_2 concentrations. These are listed below along with the relevant map reference for the predicted concentrations:

1. Breeze Roads traffic modelling, including background (section 3.4.1) but excluding Gatwick - Map 4.9A
2. Breeze Roads + Corrected Gatwick (section 3.6.2 on Gatwick NO_2 validation) + background - Map 4.9B
3. Breeze Roads + Uncorrected Gatwick + background - Map 4.9C

Map 4.9A shows that highest predicted concentrations are very close to the roadside, within 10 meters of the kerb and that the concentrations rapidly reduce as the distance from the road increases. There are no predicted exceedances of the annual average NO_2 objective based on modelling of the roads in the Horley area, when Gatwick emissions are excluded.

The map 4.9B shows the predicted NO_2 concentration contours for the Horley area which include road traffic modelling, Gatwick modelling (based on corrected NO_x) and background concentrations. Exceedances have been predicted at a number of properties in the south close to the junction of the A217 spur road and the A23. This area lies directly to the north of the boundary with Gatwick airport.

The modelling results presented, based on this scenario, provide the best fit to the monitored background concentrations in the area. As described in section 3.6, monitored concentrations at background locations in Horley indicate that exceedances are unlikely. The modelling, however, shows that exceedances may occur close to the properties near the Gatwick spur road.

The map 4.9C shows concentration contours based on uncorrected Gatwick modelling (based on original AEAT data), combined with road traffic modelled NO_x and background NO_x. This scenario shows a widespread influence of Gatwick Airport over a large area, with exceedances of the annual average NO_2 objective predicted over most of Horley, except for a small area in the north-west.

The use of either corrected Gatwick NO_x or uncorrected Gatwick NO_x has large ramifications for the likely area of exceedance of the annual average NO2 objective. Where the Gatwick NO_x contribution is not corrected, the resulting area of exceedance would be considerably larger.

The uncertainties associated with the modelling, and the implications for declaration of an AQMA, are considered further in Section 5.

4.5.2. Results for PM_{10} (2004)

Two separate scenarios have been modelled for the 90th percentile of daily mean PM_{10}. These are:

1. Breeze Roads traffic modelling, including background (section 3.4.2), but excluding Gatwick - Map 4.9D
2. Breeze Roads + Gatwick - Map 4.9E.

No correction factor has been estimated for Gatwick PM_{10} contributions. As described in section 3.6.2, available monitoring of PM_{10} concentrations in Horley suggests a lower concentration than that used for background concentrations in this assessment, therefore, as a more conservative approach, no corrections for PM_{10} have been used.

Map 4.9 D (road traffic only) shows that the highest predicted concentrations are very close to the roadside, within 10 meters of the kerb and that the concentrations rapidly reduce as the distance from the road increases. No exceedances of the daily mean PM_{10} objective are predicted to occur.

The map 4.9E shows concentration contours including Gatwick contributions. In the south close to the junction of the A217 spur road and the A23 the predicted PM_{10} values are close to the daily mean objective of 50 $\mu g/m^3$, however, there are no predicted exceedances for 2004.

5. Conclusions and Recommendations

This assessment reports on detailed modelling work carried out for areas previously highlighted in the Stage 2 Review and Assessment carried by Reigate Borough Council. It has included a detailed assessment of the annual average air quality objectives for NO_2 from road traffic emissions using the BREEZE Roads dispersion model. In the Horley area, near to Gatwick Airport, account has also been taken of the contribution from the airport.

The assessment has included a validation exercise for road traffic emissions, whereby predicted concentrations for the current year have been compared with monitored data obtained for roadside monitoring locations. A separate validation has been carried out for the Horley area, using the results of the automatic monitoring carried out by the Council, to allow for the contribution of Gatwick Airport emissions. Consideration is given to the uncertainties in the predictions, which are taken into consideration in the following sections.

5.1. Predicted Pollutant Concentrations

Results of the assessment for road traffic emissions have indicated likely exceedances of the annual average objective for NO_2 at a number of locations alongside the M25, A217 and M23 in the year 2005. These exceedances apply to residential properties within 30 m of the road.

Likely exceedances of the annual average objective for NO_2 are also predicted for properties in Horley close to both Gatwick Airport and the A217 and A23 roads.

No exceedances of the PM_{10} objectives are likely in any parts of the Borough, although concentrations are predicted to be close to the daily mean objective.

5.2. Uncertainties in Predictions

Uncertainty in the predictions of the models has been taken into consideration..

Systematic error (or bias) is an error relating to the consistent under- or over-prediction of pollutant concentrations and can be associated with various assumptions surrounding the input parameters of the model. For example, the number of vehicles on the local road network, the speed of vehicles, and the composition of the vehicle fleet (i.e. percentage of HGVs and LGVs) can all influence the outcome of the results. In addition, further errors are associated with estimates of emissions factors, driving patterns and the use of meteorological data obtained for a year other than that for which predictions are made. Moreover, where empirical relationships have been used to derive statistics from long-term trends, it is often the case that a conservative approach to the relationship is taken, thereby introducing further errors.

The influence of these systematic errors can best be examined by validation of modelled concentrations against monitoring results. This procedure has been applied in this case, and adjustments made to model results to allow for the identified systematic errors (Section 3.6).

The validation of the road traffic prediction model has identified that the model is under-predicting the nitrogen oxides concentrations by, on average, a factor of 2.5. This validation is however very limited, as it is against nitrogen oxides concentrations derived from diffusion tube measurements of nitrogen dioxide, as well as being for only a limited number of roadside monitoring sites. Nevertheless, once this factor of 2.5 is allowed for, the model shows reasonably good agreement with monitored nitrogen dioxide concentrations at both roadside and background locations. There is an average over-reading of around 7% (Section 3.6.1). This compensates for the potential under-reading of the diffusion tubes (Section 2.3), indicating a reasonable performance of the model for roadside locations.

It is important to note, however, that the model has not been specifically validated for locations near to motorways, where the exceedances are predicted. It is important, therefore, that monitoring be carried out at such locations.

In the case of the Horley area, it has been necessary to take account of the nitrogen oxides emissions from the airport. This has not proved straightforward. The best approach, given the limited information available on emissions from the airport, has been to extrapolate the modelled concentrations prepared by AEA Technology, on behalf of BAA Gatwick, to the years of interest for this Review & Assessment, 2000 and 2005, from the information provided for emissions at the airport in 1996/7 and 2008. This must introduce uncertainty into the values to be used, both for the 2000 validation, and for the 2005 predictions.

The model validation for 2000 has suggested that the AEA Technology model has been predicting nitrogen oxides concentrations too high by a factor of around 3. This could be for a variety of reasons, all of which could affect the values used for future year predictions. In other words, the factor of 3.25 adjustment applied to 2000 estimates may not be appropriate for 2005. This adds to the uncertainty in model predictions for the Horley area.

The model validation for the Horley area, indicates a slight under-prediction (using the adjusted Gatwick model) of around -3% against all monitoring results, and -7% against the higher quality chemiluminesence monitor (this becomes –10% when compared with the longer period average nitrogen dioxide concentration of 36.4 $\mu g/m^3$ (Section 2.3) which includes some unvalidated data). Thus when considering the results for the Horley area it should be recognised that there are additional uncertainties that may be underestimated.

In the case of PM_{10}, the model has not been specifically validated, as there are no suitable roadside PM_{10} data to allow this. However, the measured 90^{th} percentile of daily means at Horley was 30 $\mu g/m^3$ in 2000, which is considerably less than the values of around 45 $\mu g/m^3$ predicted for this location in 2004. This suggests that the model is over-predicting by a considerable margin. Even with this conservative approach to the modelling, there are no predicted exceedances in 2004.

The systematic errors are the most important to take into account in the Review & Assessment process. It is only by their elimination that an assessment can be made of the most likely outcome in the relevant year. There will nevertheless be residual or random errors remaining. It is generally considered that these are likely to be of the order of ±10% for nitrogen dioxide. It can be appropriate to consider these random errors when defining the boundaries for AQMAs, usually by taking the conservative (precautionary) approach of defining the AQMA to cover all locations in excess of the objective minus 10%.

5.3. Recommendations

It is recommended that Reigate Borough Council declare Air Quality Management Areas (AQMAs) on the basis of the likely exceedances of the annual average NO_2 objective highlighted in this report. Prior to defining the exact areas to declare, it is recommended that the Council confirm that there is relevant public exposure at each of the locations identified in Section 4.4.

In the case of the exceedances due solely to road traffic (specifically at motorways locations), it is recommended that the areas of likely exceedance in 2005 are taken to be those based on the 40 $\mu g/m^3$ contour. It is not considered necessary to add any further factor for uncertainty, as it is likely that the concentrations have been over-estimated at these types of locations.

In the case of the Horley area, where there is the added contribution of Gatwick Airport emissions, it is recommended that the areas of likely exceedance in 2005 be based on the 36 $\mu g/m^3$ contour. This is driven by concerns regarding the likely under estimation of the model in the area; the additional uncertainties in the modelling due to the assumptions used to deal with the Gatwick emission; and the fact that emissions of nitrogen oxides from the airport are likely to increase beyond 2005. As previously discussed, it is also appropriate to take into account random errors when defining the boundaries for AQMAs, as advised in guidance to local authorities. It is thus appropriate to adopt the conservative (precautionary) approach of defining the AQMA to cover all areas identified as likely to exceed the objective, i.e. using the 36 µg/m3 contour, together with the additional area based on a further 10% uncertainty. On this basis, the AQMA designation in the Horley area should be defined on the basis of the 32 µg/m3 contour.

It is not necessary to declare any Air Quality Management Areas for PM_{10}, or any of the other regulated pollutants.

The Stage 4 further assessment that will be required for the AQMAs, should be used to confirm the areas of likely exceedance using further monitoring. This should be based on the use of diffusion tubes distributed throughout the areas of likely exceedance. These tubes should be carefully validated against chemiluminesence monitors, both at roadside and background locations. A period of measurement using a chemiluminesence monitor should also be considered for locations both near to the M25 motorway, and in the residential area of Horley where the highest concentrations are predicted.

6. Report Statement

"We confirm that in preparing this report we have exercised all reasonable skill and care.

Unless specifically assigned or transferred within the terms of the agreement, the consultant asserts and retains all Copyright, and other Intellectual Property Rights, in and over the report and its contents".