Brighton & Hove
City Council


# Air Quality Detailed Assessment for

# Rottingdean Village
# Preston Road and The Drove

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# Executive Summary

In 2008 Brighton and Hove City Council (BHCC unitary authority) declared a centralised Air Quality Management Area (AQMA) for none compliance of nitrogen dioxide (EU and English legal limits - hourly and annual). This report considers if areas outside of the existing AQMA are compliant with nitrogen dioxide limits for the protection of human health.

In 2008/09 Defra (Department of Environment Food And Rural Affairs) requested that the city council carry out roadside nitrogen dioxide monitoring outside of the cities 2008-AQMA. This commenced in January-2009 with further sties added in 2010 including diffusion tube monitors in three new areas; Portslade Old Village, Preston Road Preston Drove junction and Rottingdean Village. As a complementary line of enquiry the 2010 further assessment extended detailed dispersion modelling to a number of areas adjacent to the existing AQMA.

Work over the past four years; has established that nitrogen dioxide is likely to be compliant in the following areas:

- Falmer and the A27 corridor - considered with screening tool assessment methods
- Five Dials Junction - assessed with ADMS-urban modelling as a part of the 2010 further assessment, nitrogen dioxide concentrations deemed to be well below objectives levels
- Portslade Old Village - the monitor adjacent to South Street demonstrated much lower concentrations than the objective and this was backed up by detailed dispersion modelling carried out for the last further assessment.

These areas have all ready been considered as part of the Local Air Quality Management (LAQM) process and do not require further air quality assessment at this time. In contrast nitrogen dioxide monitoring suggests concentrations continue to exceed the annual mean objective in or near to:

- Preston Road Preston Drove Junction and The Drove
- Rottigndean Village

Therefore defra agreed that there is a need to carry out detailed air quality assessments for these two general areas in accordance with the best available technical guidance.  For simplicity the two separate assessment areas for nitrogen dioxide are included in this one report.

The Updating Screening Assessment and these detailed assessments 2012 conclude that the existing AQMA requires a review. The Preston Road and Rottingdean areas should be included in a new AQMA.  It is recommended that the cities air quality model be updated and a new AQMA map produced.  The new 2013 quality action plan will target the new AQMA with recommendations justified by evidence presented in the most up to date technical investigations.

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## Glossary

| | |
|---|---|
| $\mu g/m^3$ | Concentration micrograms per cubic metre |
| 2WP | Two Wheel Powered Vehicles - motorbikes, mopeds and scooters |
| ADMS | Atmospheric Dispersion Model System from CERC |
| AHGV | Articulated Heavy Goods Vehicle |
| AQMA | Air Quality Management Area |
| AURN | Automatic Urban Rural air monitoring Network (UK) |
| BH9 | Brighton and Hove 9 monitor |
| BHCC | Brighton and Hove City Council |
| CAPP | Continuous Analyser Preston Park AURN |
| CERC | Cambridge Environmental Research Consultants |
| Defra | Department of the Environment Food and Rural Affairs |
| EMIT | Emission Inventory Tool from CERC |
| HGV | Heavy Goods Vehicle |
| LAQM | Local Air Quality Management Area |
| LGV | Light Goods Vehicle |
| m/sec | velocity metres per second |
| $NO_2$ | Nitrogen Dioxide |
| PD | Preston Drove Preston Road area |
| PSV | Passenger Service Vehicles - coaches and buses |
| RHGV | Rigid Heavy Goods Vehicle |
| RR | Rottingdean Receptors |

# 1 Introduction

## 1.1 *Brighton and Hove City Council*

Brighton and Hove City Council (BHCC) is the majority constituent of the Brighton-Worthing-Littlehampton agglomeration in Sussex on the South Coast of England. The 2011 census indicates that the cities population rose by more than 10% since the previous census in 2001, to 273,400 residents early 2011[1]. At a similar rate of increase the population is expected to be approximately 287,000 by the end of 2015. The urban area between the South Downs National Park and the English Channel has a population density similar to many London Boroughs. It is estimated that approaching half a million inhabitants live across four Sussex authorities between Peacehaven in the east and Littlehampton in the west. A reasonable assumption for vehicle ownership is one vehicle for every two people. Therefore we estimate there are approximately 240,000 vehicles in the Brighton-Worthing-Littlehampton conurbation. In contrast much of the council area is part of the South Downs National Park where population densities are amongst the lowest in South East England. Under Part IV of the Environment Act 1995 BHCC declared an Air Quality Management Area AQMA (in 2008) of 1,060 hectares (2,600 acres) for none compliance of Nitrogen Dioxide ($NO_2$) objectives (annual mean and hourly).

### 1.1.1 The Existing AQMA

Brighton and Hove's second AQMA was declared in 2008 for both nitrogen dioxide hourly and annual mean objectives. The 2008-AQMA declared under Part IV of the Environment Act 1995 extends from Arundel Road in the east to Adur District Council in the west, up to but not including Preston Park and the Old Shoreham Road to the north and to the English Channel in the south. The AQMA is approximately 12 % of BHCC's administrative area as Figure 1-1. The 2008 AQMA does not include the South Downs National Park (green) or substantial residential areas to the north and east of the city centre. The zone that actually exceeds the $NO_2$ annual mean objective is typically within ten metres (potentially fifteen in exceptional cases) of certain narrow or confined road

[1] Reference to the 2011 Census Results http://www.brightonbusiness.co.uk/htm/ni20120717.660827.htm

carriageways and is actually considerably less than the broader AQMA envelope. The map below also depicts the position of the two detailed assessment areas adjacent to the existing AQMA.

**Figure 1-1 Brighton and Hove AQMA and Green Space (2008-2012) and 2012 Detailed Assessment Areas**


### 1.1.2 Rottingdean

Rottingdean is a coastal village to the east of Brighton. It is within Brighton and Hove City council's administrative area with its own parish council. The village has a population of around 2,900 approximately 1% of the unitary authority. The South Downs National Park surrounds the village and separates it from The Marina and Brighton's urban centre to the west. Many of the buildings flanking Rottingdean High Street and adjoining Vicarage Lane were built centuries before motorised traffic started to become popular in the 1920s. Street pavements are narrow and some residential facades are 45 cm (16 inches) from the road carriageway. The B2123 runs through the centre of Rottingdean village and typically carries around 14,000 vehicles a day. Rottingdean is outside of Brighton's 2008 AQMA. Passive diffusion tube nitrogen dioxide monitoring has been located in the village since January-2009. A Detailed assessment including advanced dispersion modelling for air quality has been carried out for the village and is presented in this report.

### 1.1.3 Preston Road-Preston Road junction and South Road to the Drove

This area is to the north of Brighton and north west of Preston Park. The closest commercial and domestic properties are two metres from the kerb of Preston Road (A23) which carries around 21,000 vehicles a day. South Road adjoins near by and is one of the few crossing places under the main railway. When the Brighton to Norwood railway was built in 1841 there was no need to provide a wide bridge for passing travellers and farmers under the railway north of the town. As the city had continued to expand South Road to The Drove has become an important link from the east to the west across the urban area. The road under the railway is narrow and steep. The Drove typically carries 12,750 vehicles a day with a commercial and residential facade two metres from the kerb. Vans and wider cars have to check their run on the hill climb and give way to oncoming traffic. Preston Road and the Drove are not included in the 2008 AQMA. Nitrogen dioxide has been monitored on this part of Preston Road since January 2009 and on the Drove since January 2012. A Detailed assessment for air quality including an advanced dispersion for air quality has been carried out in this area and the findings are presented in this report.

## 1.2 *Purpose of Local Air Quality Management*

This report fulfils the requirements of the Local Air Quality Management process as set out in Part IV of the Environment Act (1995), the Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007 and the relevant Policy and Technical Guidance documents. The LAQM process[2] places an obligation on all local authorities to regularly review and assess air quality in their areas, and to determine whether or not the air quality objectives are likely to be achieved. Where concentrations are likely to exceed, the local authority must declare an Air Quality Management Area (AQMA) and prepare an Air Quality Action Plan

[2] Currently under consultation so onus and quantity of duties falling on Local Authorities can be reduced and focus be directed towards further assessment and action planning rather than constant progress reporting

(AQAP) setting out the measures it intends to put in place in pursuit of the objectives.

### 1.2.1 Reason for Detailed Assessments

The objective of this Detailed Assessment is to identify any areas that are outside of the existing AQMA that are likely to have concentrations of nitrogen dioxide above objective levels as stipulated in the air quality regulations, Table 1-1. The previous Updating Screening Assessment report concluded that a detailed air quality assessment for air quality was a statutory requirement for the areas covered by this report. Given that monitoring and model methods are the same; for simplicity the two separate detailed assessment areas have been included within one report.

## 1.3 *Air Quality Objectives*

The air quality objectives applicable to LAQM **in England** are set out in the Air Quality (England) Regulations 2000 (SI 928), The Air Quality (England) (Amendment) Regulations 2002 (SI 3043), and are shown in Table 1.1. For nitrogen dioxide the EU and English target concentrations are the same.

**Table 1-1 Nitrogen Dioxide Air Quality Objectives Included in Regulations for the purpose of LAQM in England**

| **Pollutant** | **Air Quality Objective** | |
|---|---|---|
| | Concentration | Averaging Period |
| **Nitrogen dioxide** | 200 $\mu g/m^3$ not to be exceeded more than 18 times a year | 1-hour mean |
| | 40 $\mu g/m^3$ | Annual mean |

### 1.3.1 Discussion about Nitrogen Dioxide objectives

It is unlikely that the short term objective of 200 $\mu g/m^3$ will be exceeded where the annual mean is less than 60 $\mu g/m^3$. The annual mean is a more stringent objective that is more difficult to comply with. This detailed assessment considers both objectives however the annual mean is likely to be the primary consideration for permanent residential locations. Where a larger geographical area fails the annual mean more people are likely to be effected. The amount of inhalation dose and exposure to a mixture of pollutants are important when considering impacts on cardio-pulmonary health. Pedestrians crossing the road, cyclists and motorists using the road are not likely to be exposed to airborne pollution for the same frequency and durations as a resident living adjacent to it.

# 2 Methodology

## 2.1 *Monitoring Method*

### 2.1.1 Diffusion Tubes

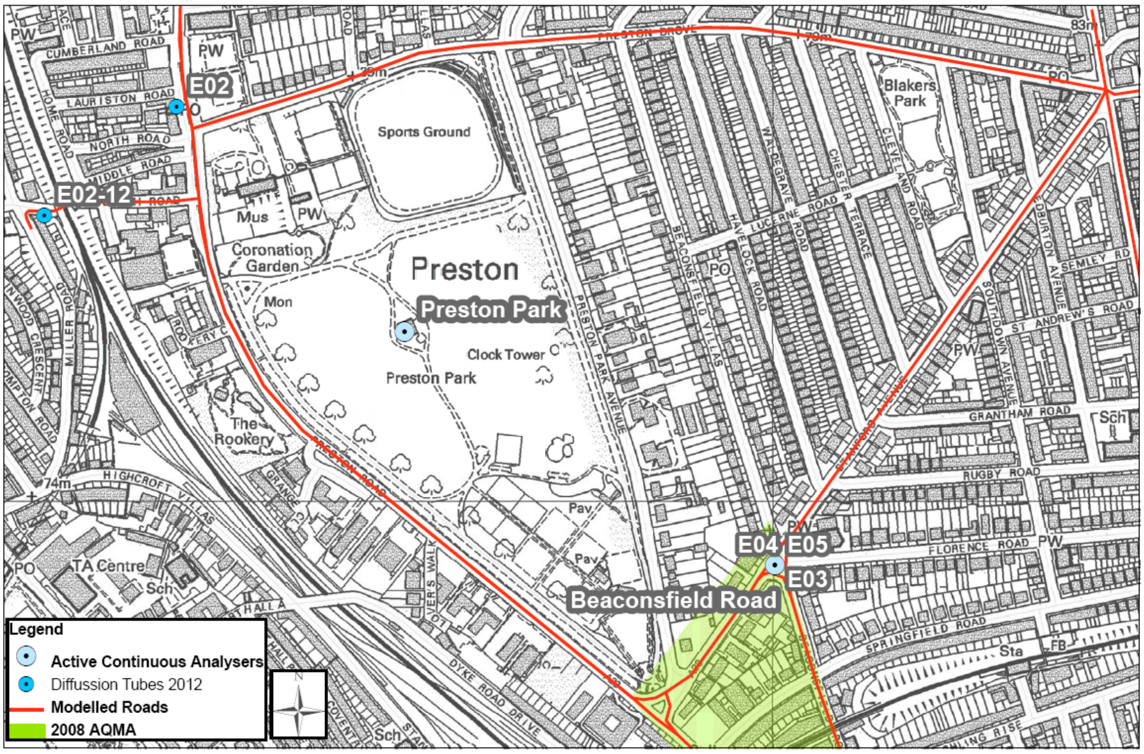
Nitrogen dioxide passive diffusion tubes have been placed on the façade of buildings within five metres of the kerb. The sample tubes located in the detailed assessment areas are part of a larger survey throughout Brighton and Hove. Triplicate tubes are co-located with the continuous analyser (BH9) on Beaconsfield Road. In accordance with the latest technical guidance any difference in the reading of the continuous analyser and the co-located tubes is used to apply an adjustment referred to as a bias correction factor for all the tubes in the area.

**Table 1.2 Nitrogen Dioxide tube Bias correction factors in recent years**

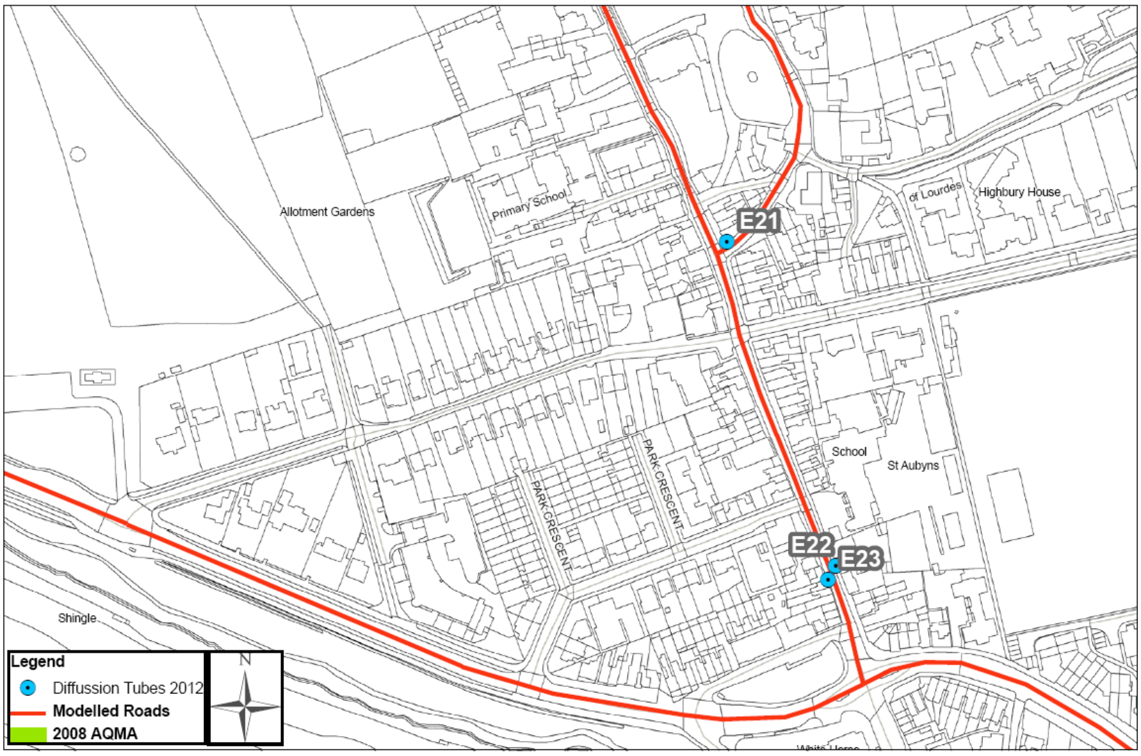
| 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|
| 0.72 | 0.72 | 0.84 | 0.85 | 0.82 |

Between 2007 and 2011 raw diffusion tube results have been on the high side compared to local continuous analysers. The bias correction factor takes account of this. The nitrogen dioxide diffusion locations in the two detailed assessment area are included in Figure 2-1 and summarised in detail in Table 8-1. The dispersion model has been set up to predict in space (but not the future) concentrations at precisely the same location as the monitors. The comparison between monitoring results and modelling estimations is used to verify the dispersion model predictions. The model predictions are reported at virtual receptors at roadside residential facades and as contour maps throughout the two assessment areas.

**Figure 2-1 Nitrogen Dioxide Monitoring in or adjacent to the Detailed Assessment Areas**





### 2.1.2 Model Assessment Methodology

The impact of all emissions sources on local air quality in Rottingdean and near to the Preston Drove Preston Road junction has been predicted using the ADMS-urban (atmospheric dispersion model system). ADMS is used by the Environment Agency and a number of larger local authorities to assess emissions from traffic, commercial and domestic and industrial sources and their combined impacts on local air quality. It is validated for the prediction of airborne pollution dispersion. The model is developed and validated by CERC (Cambridge Environmental Research Consultants)[3]. The ADMS model is set up to depict real local conditions as closely as possible reflecting emissions to ambient air arising from traffic and none traffic sources. The atmospheric emissions inventory toolkit (EMIT also written by CERC) has been used to determine emissions from commercial and domestic sources and different vehicle categories.

### 2.1.3 Model Approach - Year

2010 has been modelled to represent the current situation, not because this is the most recent full year, but because monitoring throughout the city strongly suggest 2010 was a worse-case year for nitrogen dioxide concentrations during the past decade. There has been little improvement in diesel emissions between Euro-I and Euro V vehicles most especially in urban stop-start driving environments[4]. It is recognised that some apparently rural villages for short distances have driving conditions that might be described by the motor industry as *ultra-urban*. Emissions are harder to predict in this scenario because internal combustion engine performance is compromised by cold starts, idling, acceleration and breaking. In recent years there has been a national and local shift towards greater use of diesel vehicles that have higher emissions of $NO_x$ and particulate compared with alternative modes of propulsion; including petrol[5]. Therefore it is reasonable to assume as a worse case approach that similar roadside concentrations to the 2010 scenario will be repeated during current and future years up to and including 2015.

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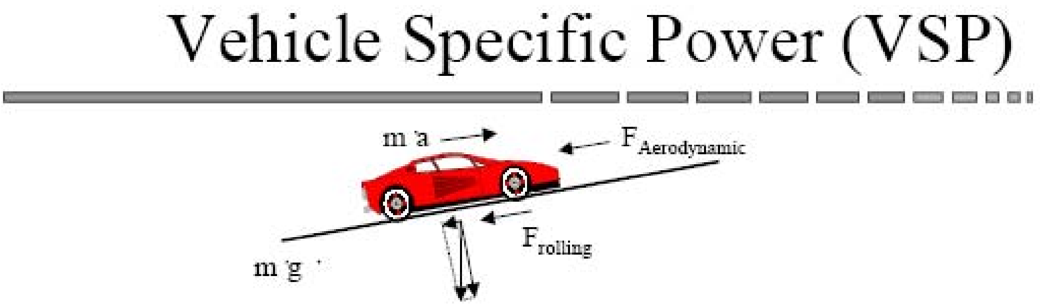
[3] Cambridge Environmental Research Consultants CERC http://www.cerc.co.uk/environmental-software.html

[4] Trends in $NO_x$ and $NO_2$ emissions and ambient measurements in the UK, March 2011
http://uk-air.defra.gov.uk/reports/cat05/1103041401_110303_Draft_NOx_NO2_trends_report.pdf

### 2.1.4 Model Approach Emission Calculation

Traffic emissions are one of the most important variables for local air quality. They and are influenced primarily by fuel type, vehicle mass and road gradient. Speed is used with EMIT to determine emissions for each road section and the slowest speeds represent the highest tail pipe releases of oxides of nitrogen $NO_x$. For internal combustion engines it is reasonable to assume the slowest speeds at around 5 to 10 kph (<10 mph) will produce the highest emissions. In reality emissions will be influenced by driving style, the degree to which the driver conserves momentum (kinetic energy) and the rate of acceleration. Fuel demand and emission rates relate to the actual forces a vehicles needs to overcome to propel forward, something that is best explained by Vehicle Specific Power (VSP)

**Figure 2-2 Vehicles Specific Power relates to emission rates**




$$VSP = \frac{Power}{Mass} = \frac{\frac{d}{dt}(E_{Kinetic} + E_{Potential}) + F_{Rolling} \cdot v + F_{Aerodynamic} \cdot v + F_{internal\ friction} \cdot v}{m} =$$

$$\approx v \cdot a \cdot (1 + \varepsilon_i) + g \cdot grade \cdot v + g \cdot C_R \cdot v + \frac{1}{2}\rho_a C_D \frac{A}{m}(v + v_w)^2 \cdot v + C_{if} \cdot v$$

Courtesy of David Carslaw, London Air Quality Network Seminar 2011.

### 2.1.5 Model Approach - after emission variables

Road width (kerb to kerb distance) and street canyon width (building-line façade to façade distance) strongly influence dilution and dispersion of emission and concentrations in the near field within fifteen metres of the traffic sources.

In close proximity to the traffic other variables are less influential on local air quality such as background concentrations that would prevail if the road was not

[5] Brighton and Hove City Council, 2012 Updating Screening and Assessment

there and the choice of meteorological data used to determine dispersion in the short distance between the tail-pipe and roadside i.e. residential (pathway). One argument is that meteorological conditions are more influential over longer pathways between source and receptor for example a plume emitted from a power station. In Brighton and Hove the $NO_2$ problem where people live and are present for longer durations is almost entirely within ten metres of a road kerb.

The model predicts nitrogen dioxide concentrations at building-line façades at monitoring locations and also at selected residential receptors closest to the road. The receptor details for the Preston Road area are given in and for Rottingdean in Figure 8-1 and Figure 8-2.

### 2.1.6 Traffic Data

Detailed traffic data has been obtained from continuous counters. The weight sensitive strips operate twenty-four hours a day, seven days a week and count five categories of vehicle as follows:

- Motorcycles or two wheel powered (2WP) vehicles
- Cars
- Light Goods Vehicles (LGV < 3.5 tonnes) – typically vans and minibuses
- Heavy Goods Vehicles (HGV rigid and articulated)
- Buses and Coaches

The traffic counters that provide evidence in support of the Rottingdean detailed assessment are:

- Site 23 A259 between Roadean and Greenways
- Site 614 A259 Marine Drive west of Chailey Av
- Site 617 B2123 Falmer Road, Woodingdean - Rottingdean

Information on the locations is given in the appendix, Figure 8-3. Similarly for Preston Drove-Preston Road and South Road data from one continuous counter and two 12-hour manual counters were used:

- Site 50 A23 Preston Road South of Preston Drove
- M4857 Preston Drove west of five ways
- A704 South Road between the A23 and the railway

An adjustment with an increase of 1 % for each year has been applied where available traffic counts refer to previous years prior to 2010. This approach is similar to past detailed assessments in Sussex and elsewhere. Whilst the model is set up to reflect the real world as closely as possible the approach is likely to represent a worse case. After a long term trend for increases in traffic since the Second World War some local road counters show that the traffic numbers peaked around 2007/08 time. Local fuel consumption statistics, point to a decline in personal vehicle use since 2008[5]. At the same time petrol consumption appears to be lower than a few years ago and diesel has a greater share of the private van and car market. The count of diesels is likely to be more influential on roadside air quality than the total tally of traffic.

Using knowledge of the local area the proportion of cars that are taxis for each road link has been estimated. The HGV component has been divided into six groups; three rigid and three articulated categories using the following percentile splits obtained from CERC.

**Rigid HGV:**

| | |
|---|---|
| 2 axle: | 56.2% |
| 3 axle: | 7.4% |
| 4 axle: | 9.4% |

**Articulated HGV:**

| | |
|---|---|
| 4 axle: | 5.0% |
| 5 axle: | 12.1% |
| 6 axle: | 9.9% |

This approach provides eleven vehicle categories each with their own emissions profiles. A full list of Traffic counts is given in Table 8-4 and Table 8-5.

### 2.1.7 Traffic Speed

Each road link in the two detailed assessment areas is assigned a representative speed (kph) that relates to the busiest hours in the day i.e. *modal* average when the majority of vehicles travel at peak hours. Low speeds are assumed in order to calculate realistic emission rates. This worse case approach helps the model achieve a closer agreement with recent roadside monitoring without the requirement for further adjustments. The physical parameters of each road link included in the two detailed assessment areas are tabulated in Table 8-6 and Table 8-7.

### 2.1.8 Road Width

As stated above road width can be a significant variable for localised air quality. Where relatively few internal combustion engines operate in narrow and confined spaces airborne pollution usually becomes more concentrated than the surrounding environment. The carriageway widths included in this model assessment vary from between 5 metres along the middle section of Rottingdean High Street, up to 18m on the A259 near St Dunstan's roundabout. South Street as it approaches The Drove under the railway is confided to less than 6 metres for east and westbound traffic. The narrow carriageways started as cart tracks and livestock drives, in contrast wider road widths where purpose built for monetised vehicles.

### 2.1.9 Road Gradient

The road links included have variable gradients and some sections have steep inclines. Steeper roads demand more fuel to shift a vehicle's mass on a climb and this scenario usually results in higher tail-pipe emissions. Higher ambient concentrations of pollutants close to the kerb are likely to arise where engines haul heavy vehicles on a hill climb. The effects of the climb may be compounded where the road link is enclosed by buildings adjacent to the slope.

Road slopes have been calculated using road spot heights on detailed OS maps to derive a ratio of so many metres up (Z) to so many along (X or Y). For example a 1:15 gradient on a busy road is likely to be influencing factor on air quality adjacent to the kerb. Road gradient is one of the variables computed with vehicle category, count and speed that have been used to derive emission rates for each road sections.

### 2.1.10 Emission Factors

Emissions have been calculated using EMIT for each of the road links in the two detailed assessment areas. The emission rates for each road section are set out from Table 8-8**.** Two methods for calculating emission were compared. The worse-case approach for oxides of nitrogen is to assume all diesel vehicles have Euro-1 engines in accordance with CERC methods employed; 2010-2012. Depending on other variables this gives emission rates for NOx that are between 1.6 and 3.3 times higher. Assuming euro-1 for diesel primary $NO_2$ emission is almost six times greater than standard emission assumptions. Using this approach the primary $NO_2$ ranges from between 29 to 36% for each road link. Whilst we know that almost all local lorries, buses, taxis and vans run on diesel we may have under estimated the number of private cars that run on diesel - now thought to be between 50 and 60% of the total.

When the model is run assuming all diesels as euro-1 predictions show an excellent agreement with recent monitoring results and the pollution contour maps are closer to those expected especially in the area of interest within ten metres of transport corridors.

The emission rates are influenced by all of the variables listed above. Each road link is defined by a change to one of the parameters for example tally of traffic (car, van or bus) street gradient or a different degree of building enclosure adjacent to the road.

### 2.1.11 Street Canyons

Where road sections are enclosed by buildings close to the kerb separated by a narrow pavement the scenario is often referred to in air quality terms as a street canyon. As with natural canyons enclosed man made canyons in the built realm can have micro-climates with different air flows and sunshine hours compared to the plane above. Some of the road links listed have been characterised as street canyons in order represent the influence of road enclosure on the dispersion of emissions from vehicle tail-pipes.

### 2.1.12 Selected Model Receptors

A series of discrete receptors have been selected at the building-lines of residential properties parallel with the road sources to be included as interrogation points in the model. Figure 8-1 and Figure 8-2 depicts the location of these receptors that complement the real diffusion tube localities listed in Table 8-1.

### 2.1.13 Industrial Sources

No large chimneys are included in the model set-up. Brighton and Hove is not a heavily industrialised area and the Shoreham power station is deemed to be sufficient distance not to warrant specific inclusion with either of the detailed assessment areas.

### 2.1.14 Commercial and Domestic Emissions

All other emission sources are included in the model as area sources this includes domestic and commercial sources such as home and business heating, minor roads and industrial processes. 16 $km^2$ of grid sources are surround the detailed assessment area for Preston Road and 45 $km^2$ around Rottingdean either including sources in the adjacent local authority of Lewes District Council. It is likely that background sources have been over estimated in the model and actual concentrations away from roads are likely to be slightly lower than those reported for example at Roadean School.

### 2.1.15 Ambient Background Levels

Regional background concentrations in the model derive from the Automatic Urban Rural Network (AURN) continuous analyser at Lullington Health in East Sussex. The regional background represents concentrations that would hypothetically prevail if the urban area was subtracted. Generally 2010 had higher background concentrations compared with 2009 and 2011. For example the following background data is included as part of the model input:

| | |
|---|---|
| Nitrogen Dioxide $NO_2$ | 12.6 |
| Nitrogen Monoxide NO | 9.7 |
| Ozone $O_3$ | 58.8 |

### 2.1.16 Chemistry

The chemical reaction scheme within the ADMS-urban model has been used to calculate the chemical reactions in the atmosphere between nitric oxide (NO), nitrogen dioxide ($NO_2$) ozone ($O_3$) and free radical VOC (Volatile Organic Compounds). Eight standard photochemical reactions are included. Due to photochemical reactions near ground level ozone tends to be more concentrated in the spring and summer and this can have some influence $NO_2$ levels.

### 2.1.17 Meteorological Data

Hourly sequential meteorological data from Shoreham-by-Sea for 2010 has been used to assess dispersion of emission in the model. The dispersion model requires the following meteorological parameters:

| | |
|---|---|
| Year (not a leap) | 2010 |
| Julian Day, | 1-365 |
| Hour of Year | 1-8760 |
| Wind speed | m/sec |
| Wind Direction | 0-360° |
| Relative Humidity | % |
| Temperature | °C |
| Cloud Cover Oktas | 1-8 |

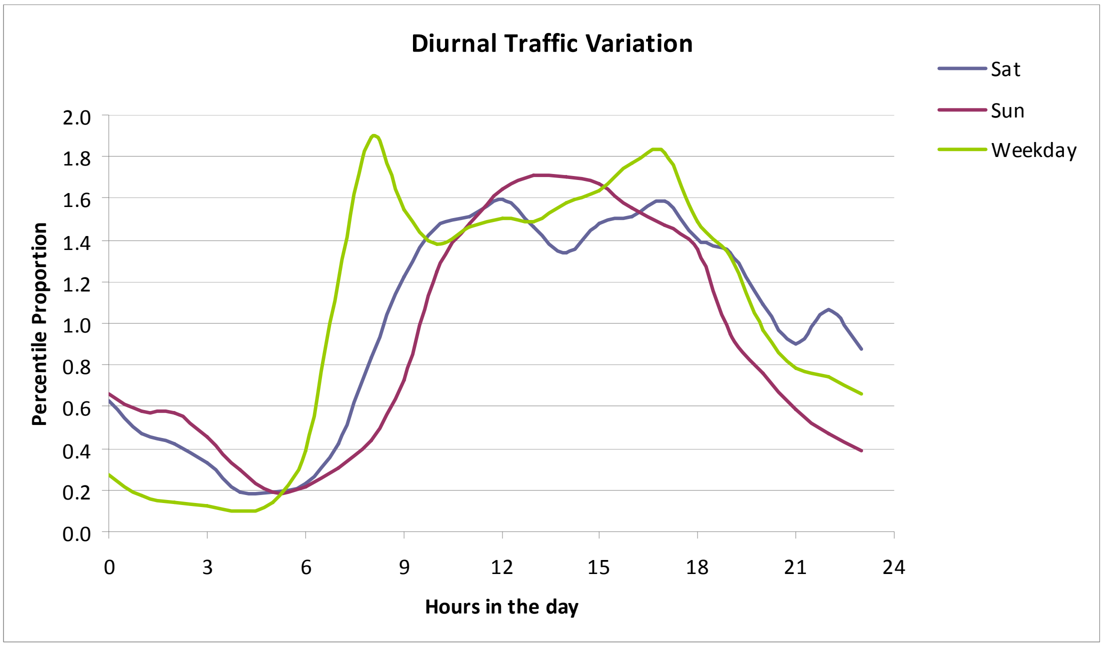
Data from Gatwick for the same calendar year has also been used as a comparison with interesting findings, discussed in paragraph 3.2.1. Wind Rose diagrams show the annual distribution of wind velocities from Shoreham-by-Sea.

### 2.1.18 Time Varying Emissions

Traffic emissions rates are based on daily traffic counts. That said the model acknowledges that emissions from traffic are not equal for every hour midnight to midnight. Within a 24-hour period the tally of traffic has a high degree of deviation compared with the mean and this pattern varies between transport corridors. Brighton has an active night time economy and a significant proportion of traffic especially buses and taxis happen during the night or shortly after licence premises close. As shown in the typical local traffic distribution

Figure 2-3. Partly to avoid other road users large articulated lorry deliveries can arrive at five and six in the morning.

**Figure 2-3 Twenty-Four hour Traffic Variability A259 Brighton**




The distribution is from the A259 which passes through Rottingdean. The pattern derives from a seven day count approximately 3 km further west nearer to the centre of Brighton. Whilst the week day commuter patterns are comparable the counts are likely to be more skewed towards the night compared with Rottingdean village. This is likely to represent worse-case. If bus, taxi and truck emissions occur in the night this is likely to be less favourable for dispersion. At night atmospheric conditions are more likely to be stable, the layered nature of the air lacks convective, thermal lift and low level inversions can trap ground level emission sources. Local coastal breezes also have less influence in mid-winter and at night.

## 2.1.19 Latitude and Sunlight

Brighton has latitude of: 50.8 °N and the standard model set-up has been altered to reflect the actual local latitude. Throughout the year noon time sun climbs to a higher azimuth in the sky compared to further north. In comparison with the majority of the British Isles the south coast of Sussex receives more hours of sunshine. This relates to the cloud cover parameter in the hourly sequential meteorological data. Summer sunshine is likely give rise to greater incidence of thermals and convective movements in the lower atmosphere (troposphere). This may be advantageous for vertical dispersion in the summer in combination with sea to land breezes. Sunlight also creates a photochemical reaction that produces ozone in the troposphere that can influence the amount of NO conversion to $NO_2$. In theory the hours of strong light at roadside may influence the rate at which NO emissions convert to $NO_2$ in ambient air. Tall street canyons influence wind velocities in the urban realm and can also shade streets potentially altering the rate of photochemical reactions at roadside. Local monitoring records consistently show higher ambient $NO_2$[6] between November to February and this usually raises the annual average.

### 2.1.20 Local Surface Parameters

A surface roughness figure is included to consider how air flows over different surfaces for example ice provides less resistance than a city. Surface albedo is considered in the model and is defined at the ratio of reflective to shortwave incoming radiation. The Albedo varies with land type. The Monin-Obukhov length is a factor used to account for the heat produced by urban areas. Man made heat can potentially disrupt stable atmospheric conditions that would normally prevail at night. The selected values represent a small urban area with some fields and open spaces.

### 2.1.21 Model Performance and Uncertainty

Dean literally means valley and Rott, leader or people. The periglacial valley and surrounding topography provided some degree of natural shelter from the strongest winds providing a natural haven for the ancient settlement and passing ships. Wind speeds are often likely to be lower than elsewhere along the coast a local condition probably appreciated by ancient settlers 4,000 years ago. The village sits in a natural cleft in the topography a situation that is less favourable for dispersion of emissions from fires, chimneys and vehicle tail pipes. However because the residential localities of interest for air quality are so close to traffic sources meteorology and topography are not likely to be the principal variables. The model does not take account of coastal and topographical effects on wind

[6] An ambient concentration differs considerably from an emission discharge from an exhaust pipe or chimney

velocities.  It does not predict future air quality – all of these options would considerably increase the level of model uncertainty and confidence in predictions.  Section 3.2.1 discusses sensitivity analysis, followed by verification of model predictions compared with façade monitoring.

# 3 Results

## 3.1 *Monitoring Results*

### 3.1.1 Model Verification

In order to verify model predictions results have been compared with annual monitoring data. Due to the thorough consideration of all parameters in the previous chapter the model estimations show excellent agreement with the all the monitors shown in Figure 2-1 Therefore no adjustment is required in accordance with the methods set out in LAQM Technical Guidance TG (09). CERC note 89 (2010) refers to the method of adjusting $NO_x$ emissions vehicles to Euro-1 and post dates TG 09. The modelling and monitoring results are compared in Table 8-10 and Table 8-11.

## 3.2 *Results of Modelling Predictions*

### 3.2.1 Sensitivity Analysis

Sensitivity analysis suggests that meteorological data is not the primary variable where residential receptors are in very close proximity to emission sources, for example in Rottingdean High Street and The Drove near the bridge under the railway. In order to interrogate the meteorological variable hourly sequential data (2010) from Gatwick has been compared with Shoreham-by-Sea. The finding show that Gatwick air flows and conditions are slightly less favourable scenario for dispersion compared with the near-coastal site at Shoreham. In theory the model sensitivity suggest that if wind speeds were lower as they are for more hours of the year inland, pollution levels could be higher for. Air Monitors suggest that 2010 was a worse case year for airborne nitrogen dioxide. This challenges previous model assumptions which assumed year on year improvements for air quality. Fresher winds from the English Channel and Atlantic help dilute local airborne pollution; however this does not happen for all the hours in the year. Wind Rose patters from Shoreham for 2008 and 2010 are shown in Figure 8-5. Uncommon wind speeds and still conditions that can happen for 20 or 25% of the year are likely to be more significant for airborne pollution than the stronger prevailing winds which helps replenish local air quality.

### 3.2.2 Results at Receptors

Model predictions for the selected residential receptors are presented in Table 8-12 and Table 8-13. The highest concentrations of $NO_2$ are found closest to the kerb in confined spaces or on hill climbs. The highest traffic counts do not always give the highest ambient pollution concentrations where people live.

### 3.2.3 Contour Map Results

The maps presenting model prediction are shown from Figure 8-6. There is a high level of scientific confidence that nitrogen dioxide exceeds the EU and English limit values within three to five metres of road kerbs at:

- The junction of Preston Drove and Preston Road,
- The hill climb of The Drove
- Rottingdean High Street.

## 3.3 *Discussion of Results*

Concentrations drop off with distance back from road sources. Road slopes and street canyons also influence the distribution and concentrations of pollutants. The total tally of traffic is not as significant as the degree to which road links are confined, the number of heavier or more powerful diesel vehicles and the driving style in each road link for example repeated rapid acceleration, idling engines in one place for longer durations.

Usually facades in close proximity to the road are exposed to higher concentrations. Although traffic counts are highest for the A259 pollution is not the highest. This is because residences are set back from the road. The extra space allows for better ventilation and air entrainment over more hours of the year.

# 4 Conclusions

LAQM reports show that the problem of poor air quality arises because of internal combustion engines in confined spaces. It is less dependent on the total count of traffic as relatively few vehicles can cause a breach of the air quality limits where roadside space is limited. This report shows examples of how a road link with approximately 13,500 vehicles a day can give higher emissions than a road link with 25,000 vehicles a day. Important variables to consider are the uninterrupted flow of the traffic, the count of diesel vehicles, road gradient the power of engines – driving style and the number heavy vehicles. Furthermore dispersion of the quoted emission rates (tonnes per year) will be influenced by building enclosure surrounding the road carriageway. The outdoor pollutant concentration (g/m$^3$ of air) that people inhale over longer durations is a function of both tail pipe emissions and ambient dispersion.

Over recent years it is evident air quality action plan policies such as; modal transport shift, better public transport, more walking and cycling, 20 mph speed limits and high parking charges alone will not eradicate failure to comply with nitrogen dioxide limits at all locations. Shift from petrol to diesel is the most pronounced change in travel since 2005 and this is not a beneficial trend for air quality adjacent to slow roads. The dash for diesel is not driven by government policy but by economic market considerations.

# 5 Future Work and Recommendations

Following two detailed assessments the City Council has legal responsibility to review its existing Air Quality Management Area (AQMA). The review must redefine the AQMA to include the new areas identified by this report. The next steps in the LAQM process are as follows:

- Further Assessment dispersion model to justify changes to the AQMA to consider Portslade, Central Brighton and Rottingdean
- New AQMA map to be agreed by elected members
- Further Assessment model with source apportionment i.e. what sources (lorry, truck, bus taxi or car) cause the airborne pollution to exceed limits adjacent to various road links included within the new AQMA.
- 2013 action plan with traffic and none traffic measures to improve air quality throughout the city with priority focus on the new AQMA.
- New air quality action plan policies for the city
- Recommendations on more effective air quality action plans to UK Government

# 6 Action Plan Options

The previous section outlines how determining the contribution to pollution from various vehicle categories will help to justify future measures in the air quality action plan. With a view to action local residents have suggested the following options to minimise airborne pollution in Rottingdean:

- **One way traffic along the High Street** with northbound traffic via an alternative route with a wider street and carriageway for example Steyning Road and Chailey Avenue.

- **Restriction to Heavy Vehicles** The proposed Rottingdean neighbourhood plan[7] requires a weight limit of 7.5 tonnes on vehicles through the High Street. This is unlikely to include double-decker buses at nearly 12 tonnes.

- **A by-pass around the village** Rottingdean is surrounded by the South Downs National Park so options for a new road are very limited. A by-pass could improve airborne nitrogen dioxide, particulate and noise in the centre of the village. A new road risks interruption to the serenity and tranquillity of surrounding countryside and other homes. Additional fuel consumption and $CO_2$ emissions would result if vehicles have to drive further to get to their destinations (even if this reduced journey times with faster speeds). The community have identified an alternative route for the B2123 to the north with traffic via Warren Road and Warren Avenue.

- **A tunnel -** although tunnel building is not as common in the UK as in many Alpine countries costs have come down. If the B2123 was tunnelled for a short distance of 600-850m (estimated at £30 to £42 million) the historical character of the High Street could be restored without need to accommodate through traffic. Further information is presented in the AA report[8]

[7] The Parish Council's Consultation Document for the Production of Rottingdean Neighbourhood Plan 2012
[8] AA Going Underground TUNNELS: what role in Town and Country?
http://www.theaa.com/public_affairs/reports/going_underground.pdf

# 7 References

[1] Reference to the 2011 Census Results
http://www.brightonbusiness.co.uk/htm/ni20120717.660827.htm

[2] Cambridge Environmental Research Consultants CERC
http://www.cerc.co.uk/environmental-software.html

[3] Trends in $NO_x$ and $NO_2$ emissions and ambient measurements in the UK, March 2011
http://ukair.defra.gov.uk/reports/cat05/1103041401_110303_Draft_NOx_NO2_trends_report.pdf

[4] Brighton and Hove City Council, 2012 Updating Screening and Assessment
http://www.brighton-hove.gov.uk/index.cfm?request=c1001183

[5] AA Going Underground TUNNELS: what role in Town and Country?
http://www.theaa.com/public_affairs/reports/going_underground.pdf

[6] The Parish Council's Consultation Document for the Production of Rottingdean Neighbourhood Plan 2012