Further Assessment of Air Quality for the Hastings Borough Council

(For the Council’s Air Quality Management Area in Bulverhythe)

November 2004
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Executive Summary

This report provides a Further Assessment of air quality for the Hastings Borough Council (“the Council”) that fulfils the Council’s next step, of the Local Air Quality Management (LAQM) process. Section 84(1) of the Environment Act 1995 requires the Council to undertake this further assessment. This follows the Council’s designation of an air quality management area (AQMA) along the A259 through Bulverhythe, to the west of Hastings town centre.

The Council’s earlier Detailed Assessment report identified this area as one where particulate matter (specifically PM$_{10}$) measured as a daily mean was predicted to exceed the government objective as laid down in the Air Quality (England) Regulations 2002. The basis for the Detailed Assessment conclusions were monitored results from a site located at the roadside of the A259 and a modelling exercise based on PM$_{10}$ emissions arising from the road.

The report follows the guidance produced by the Department of Environment, Food and Rural Affairs (DEFRA) for further assessments and this allows the Council to:

- confirm the original assessment of air quality against the prescribed objectives and thus to ensure that they were right to designate the AQMA in the first place;
- calculate more accurately how much of an improvement in air quality would be needed to deliver air quality objectives within the AQMA;
- refine the knowledge of the sources of pollution so that air quality action plans can be properly targeted;
- take account of any new national policy developments, which have come to light since the AQMA declaration and the Detailed Assessment report, were prepared;
- take account as far as possible of any new local policy developments which are likely to affect air quality by the relevant date, and which were not fully factored into the Detailed Assessment report;
- respond to comments from statutory consultees in respect of the Detailed Assessment report;
- check the other assumptions previously made on which the designation of the AQMA has been based and to check that the designation is still correct;
- carry out further monitoring in problem areas to check earlier findings.
The monitoring undertaken by the Council is important to the understanding the daily mean PM$_{10}$ objective. Since the Detailed Assessment the Council has continued monitoring at its Hastings 1 roadside site. It has also undertaken short term monitoring campaigns at two other sites nearby.

The monitoring for both 2002 and 2003 indicates that the objective will be exceeded at the Council’s monitoring site, although monitoring for 2004 indicates that concentrations are lower and that the site may meet the objective for this year. It is too early to be certain that the reduction is a result of a fall in atypical resuspended PM$_{10}$ or meteorology.

In addition to the latest monitoring data, new modelling has been developed for the report, incorporating a series of improvements over and above that undertaken in Detailed Assessment. These improvements include a detailed analysis of source apportionment and further dispersion modelling.

The source apportionment of PM$_{10}$ has been determined in the AQMA. Based on this, the sources have been split into the following components: PM$_{10}$ related to NOx, PM$_{10}$ related to secondary and coarse particles, the contribution from sea salt spray and the contribution from a local component (termed in the main report as atypical re-suspension of material). The source apportionment model developed for the area has determined the complex local relationship between the daily mean objective and annual mean objective.

The source apportionment is described in chapter 4 and this highlights that the atypical re-suspension is the second largest source after secondary and natural sources. The Council however can only affect local primary and atypical re-suspension sources, although action on primary emissions alone will not lead to the daily mean objective being achieved.

New predictions have been made using the above source apportionment model and dispersion modelling. These confirm the Detailed Assessment findings that the AQS objective will be exceeded. Pollution maps representing the pollution around the AQMA where there is relevant exposure are provided in the report in Chapter 5. The extent of the area predicted to exceed has remained the same and therefore the original designation of the AQMA is still correct.

Two scenarios have been modelled, based on potential changes in the area. These refer to: 1) the reduction of traffic on the A259 Bexhill Road only and 2) the removal of the additional atypical re-suspended component. The extent by which the prediction exceeds the objective has been assessed; the results have also been presented as pollution maps. The reduction of traffic scenario causes only a very marginal improvement (i.e. reduction) in annual mean concentrations. The second scenario to remove the atypical component reduces concentrations to typical concentrations comparable with other Sussex monitoring sites and is less than the daily mean objective.
As a result of the findings in this report the Council is recommended to undertake the following actions, in respect of the findings for the daily mean PM$_{10}$ statutory objective:

1. Investigate possible reasons for the marked reduction in concentrations during 2004.

2. Amend the designated Air Quality Management Area as necessary in the light this report and any other relevant findings.

3. Undertake consultation on the findings arising from this report with the statutory and other consultees as required.

4. Continue its ongoing PM$_{10}$ monitoring programme as part of its LAQM actions and extend this to include continuous NO$_x$ measurements.
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1 Introduction to further assessment of air quality

1.1 Overview

This is the Further Assessment report for the Hastings Borough Council (“the Council”). This report is intended to fulfil the statutory requirement for this, the Council’s next step, of the Local Air Quality Management (LAQM) process.

1.2 Background – national perspective

The LAQM process forms a key part of the government’s strategies to achieve the air quality objectives. Section 84(1) of the Environment Act 1995 requires local authorities to undertake a further assessment, where the local authority has designated an air quality management area (AQMA); this is to supplement the information it has on its AQMA.

The Department of Environment, Food and Rural Affairs (DEFRA) has produced guidance on undertaking the further assessment (DEFRA, 2001).

The following provides a check list of the requirements for the further assessment, as given in the DEFRA guidance:

- To allow the Council to confirm the original assessment of air quality against the prescribed objectives and thus to ensure that they were right to designate the AQMA in the first place;

- To calculate more accurately how much of an improvement in air quality would be needed to deliver air quality objectives within the AQMA;

- To refine the knowledge of the sources of pollution so that air quality action plans can be properly targeted;

- To take account of any new national policy developments, which have come to light since the AQMA declaration and the Detailed Assessment report, were prepared;

- To take account as far as possible of any new local policy developments which are likely to affect air quality by the relevant date, and which were not fully factored into the Detailed Assessment;

- To respond to comments from statutory consultees in respect of the Detailed Assessment report;

- To check the other assumptions previously made on which the designation of the AQMA has been based and to check that the designation is still correct;
• To carry out further monitoring in problem areas to check earlier findings.

1.3 **Background – Hastings Borough Council perspective**

The Council has undertaken the earlier stages of review and assessment of the Local Air Quality Management (LAQM) process within its area (see the individual Updating and Screening and Detailed Assessment reports prepared in 2003). These reports present a staged approach whereby the seven air pollutants in the Government’s Air Quality Strategy related to LAQM, were assessed and screened as to their relative importance to air quality within the Council’s area.

The Detailed Assessment report assessed air quality along the A259 through Bulverhythe in accordance with DEFRA revised guidance (TG03). The findings of the Detailed Assessment report were that the Government’s daily mean PM$_{10}$ objective was exceeded (see Table 1).

**Table 1** Air quality objective relevant to Stage 4

<table>
<thead>
<tr>
<th></th>
<th>Concentration</th>
<th>Measured as</th>
<th>Date to be achieved by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate matter (PM$_{10}$)</td>
<td>50µgm$^{-3}$ not be exceeded more than 35 times a year</td>
<td>24 hour mean</td>
<td>31-Dec-04</td>
</tr>
</tbody>
</table>

Based on these findings, the Council designated its AQMA by order, following the production of its Detailed Assessment report. That report confirmed that an area close to the roadside of the A259 in Bulverhythe in the Council’s area was likely to exceed one of the future air quality objectives. The Council also confirmed that there is the likelihood of relevant public exposure in the identified area.

An important factor behind this decision has been recognition by the Council of the need for high quality continuous monitoring, as this provides a more accurate indication of current PM$_{10}$ concentrations. Hence the Council has invested in high quality continuous monitoring sites in the area to aid understanding.

The other six AQS pollutants (benzene, 1,3 butadiene, carbon monoxide, lead, nitrogen dioxide and sulphur dioxide) were considered in the Council’s Updating and Screening Assessment and found not to need further investigation.

1.4 **National Developments**

New technical guidance (LAQM.TG03) was produced by DEFRA to aid local authorities with their duties (DEFRA, 2003). This replaced earlier versions and is designed to support local authorities in carrying out their duties under the Environment Act 1995. The guidance provides advice to local authorities for the purposes of undertaking their statutory review and assessments. It also provides comment on factors that need to be taken into account for assessing exposure.
The daily mean PM$_{10}$ objective however allows a number of occurrences where the standards might be exceeded for reasons of feasibility and practicality. The guidance describes the objective as a long-term objective, and as such it includes all locations where a member of the public might be regularly present. The guidance also confirms that this latter phrase does not imply that the same persons need to be regularly present at that location (paragraph 1.20). Relevant locations for this objective include building facades of residential properties, schools, hospitals, libraries and gardens of residential properties (this may not include the extremities of gardens or front gardens).

The Air Quality (England) Regulations as amended, also relate to “the quality of air at locations which are situated outside of buildings or other natural or man made structures, above or below ground, and where members of the public are regularly present.”

The following objectives for 2010 have not been brought into regulation for the purposes of LAQM yet. The TG03 guidance states that whilst there is no obligation on local authorities to have regard for these yet, it may be helpful to do so for longer term planning.

**Table 2** Proposed air quality objectives of PM$_{10}$

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Measured as</th>
<th>Date to be achieved by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particle (PM$_{10}$)</td>
<td>50µgm$^{-3}$ not be exceeded more than 7 times a year</td>
<td>24 hour mean</td>
</tr>
<tr>
<td></td>
<td>20µgm$^{-3}$</td>
<td>Annual mean</td>
</tr>
</tbody>
</table>
This page is left blank intentionally.
2 Air Pollution Measurements in Hastings B.C and surrounding area

2.1 Monitoring Update

The monitoring of air quality in a local authority’s area provides an important source of information for understanding air quality. This is particularly so for the AQMA in Hastings, which is based in a challenging location close to the both an active household waste site and the sea. The monitoring provides important information on concentrations and allows an understanding to be developed of the conditions when episodes arise.

The Council undertakes continuous monitoring of PM$_{10}$ as part of the Sussex Air Quality Monitoring Network (SAQMN). This network operates in accordance with QA/QC procedures that meet those given in LAQM.TG (03). All monitoring sites use Tapered Element Oscillating Microbalance (TEOM) instruments. As a consequence all results in this chapter are expressed as TEOM multiplied by 1.3 to equate to gravimetric measurements as required by TG03, although a comment on the appropriateness of this factor is discussed below. The monitoring equipment in all instances was regularly serviced; a procedure that included checks of flow and microbalance accuracy and the measurements from the Sussex monitoring sites were subject to retrospective ratification by the ERG.

This section of the report provides an update on recent air pollution monitoring undertaken by both the Council and neighbouring local authorities and supplements the earlier Review and Assessment reports with recent results for PM$_{10}$ and brings it up to date (i.e. to September 2004). It should be noted however that the data provided in this report for 2004 are currently not fully ratified.

2.2 Hastings PM$_{10}$ monitoring

The Council operates one permanent site within the AQMA i.e. Hastings 1; this is indicated in Figure 1 overleaf and shown in Figure 2. The site began operating in 2001 and is located at the roadside of the A259, which runs in a northeast to southwest direction from Hastings to Bexhill. The site is situated on the north side of the road approximately 4m from the kerb and it represents areas where there is relevant public exposure as defined earlier.
**Figure 1** Location of Hastings AQMA and continuous air quality monitoring site

Notes: Red line represents boundary of Hastings AQMA
Blue arrow represents location of Hastings permanent monitoring site
Mauve arrows represent locations of Hastings temporary monitoring sites
The orientation of the map is such that the top of the page represents an approximate northwest direction and bottom southeast

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**Figure 2** Photograph of the Hastings 1 site (showing A259 Bexhill Road) looking towards St. Leonards
Additional monitoring has also been undertaken at the kerbside of the road to Pebsham Household Waste site (Sussex 5) and further along the A259 at the Community Centre (Sussex 3), approximately 400m east of the junction with Harley Shute (B2092). In both instances TEOM instruments have been used and the monitoring has only been undertaken for limited periods (i.e. less than six months). The purpose of this monitoring has been to help inform the understanding of the PM$_{10}$ concentrations and this is discussed later in the report.

2.3 Summary of Hastings 1PM$_{10}$ measurements

Table 3 below updates the information provided in the Detailed Assessment report. It should be noted that the data are summarised for calendar years in line with normal reporting practice.

Table 3 Summary of continuous PM$_{10}$ monitoring at the Hastings 1 site

<table>
<thead>
<tr>
<th>Results</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual data capture %</td>
<td>49%</td>
<td>81%</td>
<td>95%</td>
<td>NA</td>
</tr>
<tr>
<td>Days &gt; 50µgm$^{-3}$</td>
<td>24</td>
<td>52</td>
<td>62</td>
<td>17*</td>
</tr>
<tr>
<td>Annual mean</td>
<td>33</td>
<td>36</td>
<td>38</td>
<td>29*</td>
</tr>
</tbody>
</table>

(Note - * indicates that monitoring is still in progress, thus these data are provisional for the period to end of September 2004)

This table indicates that the data capture at the monitoring site met the data capture requirements of over 90% for 2003 only. The measurements for both 2002 and 2003 however confirm that there were far more than 36 periods when the daily mean standard of 50 µgm$^{-3}$ was exceeded; hence the daily mean objective was exceeded during those years.

For the current year the number of days when the standard has been exceeded is 17 (to the end of September). These results indicate that the objective may not be exceeded for this year.

The table also includes the annual mean results. These indicate for all years that the annual mean objective has not been exceeded; it was however approached for both 2002 and 2003.

2.4 Comparison with Sussex network monitoring

The results for all continuous PM$_{10}$ monitoring undertaken by the Sussex network are given in Table 4 below. The table shows both the type of location of the monitoring site, plus details of data capture, annual mean concentrations and the number of days that the daily mean exceeded 50 µgm$^{-3}$ for the inclusive period 2001 to 2003. This information allows the results at the Hastings 1 site to be
compared with neighbouring sites. The TG03 guidance advises that 90% data capture is preferred for the purposes of review and assessment.

Table 4  PM$_{10}$ measurements from permanent monitoring sites in Sussex 2001 – 2003

<table>
<thead>
<tr>
<th>Site</th>
<th>Data Capture (%)</th>
<th>Annual Mean µgm$^{-3}$</th>
<th>Daily means &gt; 50 µgm$^{-3}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crawley Background</td>
<td>99</td>
<td>22</td>
<td>5</td>
</tr>
<tr>
<td>Chichester Roadside</td>
<td>49</td>
<td>28</td>
<td>2</td>
</tr>
<tr>
<td>Eastbourne Background</td>
<td>99</td>
<td>25</td>
<td>5</td>
</tr>
<tr>
<td><strong>Hastings 1 Roadside</strong></td>
<td><strong>49</strong></td>
<td><strong>33</strong></td>
<td><strong>24</strong></td>
</tr>
<tr>
<td>Lewes Roadside</td>
<td>99</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>2002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crawley Background</td>
<td>98</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>Chichester Roadside</td>
<td>96</td>
<td>28</td>
<td>3</td>
</tr>
<tr>
<td>Eastbourne Background</td>
<td>99</td>
<td>27</td>
<td>10</td>
</tr>
<tr>
<td>Horsham Background</td>
<td>82</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td><strong>Hastings 1 Roadside</strong></td>
<td><strong>81</strong></td>
<td><strong>36</strong></td>
<td><strong>52</strong></td>
</tr>
<tr>
<td>Lewes Roadside</td>
<td>99</td>
<td>32</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>2003</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crawley Background</td>
<td>97</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>Chichester Roadside</td>
<td>96</td>
<td>30</td>
<td>17</td>
</tr>
<tr>
<td>Eastbourne Background</td>
<td>99</td>
<td>28</td>
<td>18</td>
</tr>
<tr>
<td>Horsham Background</td>
<td>92</td>
<td>24</td>
<td>8</td>
</tr>
<tr>
<td><strong>Hastings 1 Roadside</strong></td>
<td><strong>95</strong></td>
<td><strong>38</strong></td>
<td><strong>62</strong></td>
</tr>
<tr>
<td>Lewes Roadside</td>
<td>96</td>
<td>31</td>
<td>21</td>
</tr>
</tbody>
</table>

The annual mean PM$_{10}$ at all sites in Sussex was below the AQS objective during the three years 2001 to 2003. The results in Table 4 indicate for that annual mean PM$_{10}$ concentration in Sussex was lowest at the inland background sites at Crawley and Horsham, whereas the annual mean PM$_{10}$ concentration at the Eastbourne background site, on the East Sussex coast, exceeded these concentrations by between 3 and 7 µgm$^{-3}$.

As expected the annual mean PM$_{10}$ at the roadside sites exceeded that measured at background locations, with the greatest concentration being measured at the Hastings 1 roadside site.

The results show that Hastings 1 roadside site was the only Sussex site that exceeded the daily mean PM$_{10}$ objective during the three years 2001 to 2003. The results demonstrate that the lowest numbers of days with mean PM$_{10}$ concentrations above 50 µgm$^{-3}$ were measured at the inland background sites. The number of days with mean PM$_{10}$ concentrations above 50 µgm$^{-3}$ at Eastbourne exceeded that both these sites and also the Chichester Roadside site.
The greatest numbers of days with mean PM$_{10}$ concentrations above 50 µgm$^{-3}$ were measured at the two coastal roadside sites, at Lewes and at Hastings. Upon initial investigation both sites appear similarly located, i.e. both are located close to the north side of the A259 coastal road. However during both 2002 and 2003 the Hastings Roadside site exceeded the daily mean objective, of 35 days per year, by a wide margin, whereas the Lewes site did not exceed the objective in either year.

2.5 Monthly distribution of episodes at the Hastings site

The data from the site have been analysed below to understand the distribution of the episodes (i.e. which month the daily mean standard has been exceeded) for the duration of the monitoring. The time relates to time periods averaged for the preceding 24 hours. The data presented below in Figure 3 show the distribution of episodes greater than 50 µgm$^{-3}$ for the respective periods of monitoring.

Figure 3 indicates that there have been episodes during most months when the site has been operating, with a peak of 16 in March 2003, with 11 episodes in January 2002. There were also 11 episodes in February and August 2003.
The highest number of episodes for 2004 was in February with 6 episodes. The data for 2004 also highlights that the number of episodes has been low compared to the previous two years (although this is to the end of September only).

Many of the periods with high numbers of episodes correspond with higher concentrations elsewhere e.g. with those measured by the London Air Quality Network and can be related to episodes of transboundary pollution, such as those during the spring and summer of 2003. The fact that results include episodes during most monthly periods of monitoring suggests that there are other sources of PM\textsubscript{10}.

2.6 Sensitivity of measurements at Hastings Roadside to the TEOM to Gravimetric ‘Correction’ Factor

As advised earlier, the 1.3 ‘correction’ factor was applied to PM\textsubscript{10} measurements in this report. It is however also acknowledged that the ‘correction’ factor varies according to the PM\textsubscript{10} composition and ambient conditions, plus also site and season. The importance of this factor is further examined here to test the sensitivity of the measurements from the Hastings site to different ‘correction’ factors.

Figure 4 shows the number of days with mean PM\textsubscript{10} above 50 µgm\textsuperscript{-3} estimated from available measurements. A range of TEOM to gravimetric ‘correction’ factors, from 1.0 to 1.5, was applied.

**Figure 4** Comparison of varied correction factors for the Hastings 1 site
Using the recommended correction factor of 1.3 the daily mean objective was exceeded in each of the three years. A site specific ‘correction’ factor of 1.05 or below however would have led to the achievement of the above objective for all three years. The total number of daily means of PM$_{10}$ above 50 $\mu$g m$^{-3}$ was multiplied pro rata to estimate the measurements obtained with 100% data capture.
3  **PM$_{10}$ on roads near to Waste Handling Facilities.**

3.1  **Background**

Landfill and similar sites are identified in the TG03 guidance as potential sources of PM$_{10}$, both as a source of direct fugitive emissions and as a contributor to the re-suspension of material on roads. Furthermore several other local authorities have expressed concerns regarding the PM$_{10}$ on access road to waste handling facilities and similar installations.

3.2  **Specific monitoring sites close waste handling sites**

The ERG is currently undertaking measurements at two such sites in London. This includes work to identify and quantify the PM$_{10}$ arising from waste transfer sites. The sites involved are as follows:

3.2.1  **Manor Road, Erith**

In collaboration with the London Borough of Bexley, PM$_{10}$ has been monitored near a waste transfer site in Erith since 1999. PM$_{10}$ concentrations at the site are amongst the highest in London and the site has exceeded the EU Limit Value consistently since measurements began. During 2003 the site measured 135 days with mean PM$_{10}$ above 50 µg m$^{-3}$ (TEOM*1.3), which represented approximately one day in every three.

During 2001 LB Bexley funded the ERG to undertake a bespoke measurement campaign and source apportionment exercise (Fuller and Baker 2001). This project successfully separated the PM$_{10}$ at Manor Road into three sources and quantified their contributions to the measured concentrations. The three sources were background, local tail pipe emissions and local non-tail pipe emissions. Overall the composition of the measured PM$_{10}$ at Manor Road during the study period was:

<table>
<thead>
<tr>
<th>Source</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>61%</td>
</tr>
<tr>
<td>Local tail pipe</td>
<td>4%</td>
</tr>
<tr>
<td>Local non-tail pipe</td>
<td>35%</td>
</tr>
</tbody>
</table>

The diurnal and day of week behaviour of the local emission sources were also examined and a distinct pattern emerged. This showed elevated concentrations during the operating period of the waste transfer site, i.e. on weekdays and Saturday mornings. The diurnal and day of week concentrations of the local tail pipe and non-tail pipe sources is shown in Figure 5, it should be noted that the pollution from each source is averaged by hour of day and day of week.
Subsequent analysis of each of the PM$_{10}$ components with wind direction, determined that the local non-tail pipe PM$_{10}$ arose from the road, both from the resuspension of material deposited on the road surface and also directly from dirty vehicles using the waste transfer site. No measurable fixed fugitive sources were detected from this analysis.

3.2.2 Neasden Lane, Brent

During late February 2004 the LB Brent installed a monitoring site in a roadside location used by vehicles entering and leaving several waste transfer facilities. Daily mean PM$_{10}$ has since exceeded 50 µg m$^{-3}$ (TEOM*1.3) on over 120 days, approximately 70% operating period. The measured concentrations have been averaged by day of week and hour of day are shown in . The daily mean PM$_{10}$ averaged by day of week and hour of day clearly shows a similar pattern to that at Manor Road, with elevated local PM$_{10}$ concentrations during working hours on weekdays and to a lesser extent on Saturday mornings. Overnight and on Sundays, the mean local PM$_{10}$ concentration at Neasden Lane drops considerably and resembles those measured at other nearby roadside sites. A full source apportionment of the measured PM$_{10}$ is yet to be undertaken.
Figure 6 Averaged measurements for Neasden Lane, Brent.

3.3 Access road to the Pebsham waste site

A visit to the above site confirmed that material is being brought onto roads in similar fashion to the above sites. This is shown below in Figure 1 below.

Figure 7 Road from Pebsham Household Waste site to A259
4 PM$_{10}$ source apportionment in the Hastings AQMA

4.1 Outline method

To develop an understanding of the PM$_{10}$ concentrations and sources arising in the Hastings AQMA it is necessary to use source apportionment methods, this then enables scenarios to be developed and tested. The PM$_{10}$ source apportionment model employed by the ERG (Fuller et al. 2002) divides PM$_{10}$ by source through analysis of measurements of annual mean NO$_X$, PM$_{10}$ and PM$_{2.5}$ across a network of monitoring sites. Similar source apportionment techniques have been applied elsewhere in the UK and to a lesser extent in Europe (Deacon et al. 1997, Harrison et al. 1997, APEG 1999, Kukkonen et al. 2001 and Stedman et al. 2001).

The ERG model identifies PM$_{10}$ as arising from three source components:

**Primary** - associated with NO$_X$ and therefore determined from the local NO$_X$ concentration;

**Secondary** - mainly the PM$_{2.5}$ not associated with NO$_X$; and

**Natural** - coarse component not associated with NO$_X$.

Measurements of NO$_X$ and measured NO$_X$: PM$_{10}$ relationships from monitoring sites throughout London and South East England were used to calculate the local primary PM$_{10}$.

The model assumes that the secondary and natural components do not vary across a region (over distances of around 100 km) for medium term averaging periods, i.e. a day or more. While this assumption is reasonable in many applications of the technique, analysis of measurements along the Sussex coast (AQEG 2004, Fuller 2004) provides evidence of a coastal increment in PM$_{10}$ concentration when compared to inland PM$_{10}$ measurements. This additional coastal PM$_{10}$ is thought to arise from sea salt spray.

The total PM$_{10}$ at any coastal monitoring site is therefore a combination of;

- regional (inland) secondary and natural particulate
- site specific coastal particulate
- local primary (tail pipe) particulate from road transport and combustion sources.

The PM$_{10}$ source apportionment model used in this study has separated the inland natural and secondary sources of PM$_{10}$. Co-located measurements of PM$_{2.5}$ required by the full method were therefore not needed. The internal TEOM offset (3 µgm$^{-3}$ TEOM*1.0) was attributed to the secondary and natural fraction.

The source apportionment model described above does not predict PM$_{10}$ from local sources that are not also sources of NO$_X$, local fugitive sources for instance. The
modelling approach used measured NO\textsubscript{X}: PM\textsubscript{10} relationships from monitoring sites throughout London and South East England and thus the NO\textsubscript{X} related PM\textsubscript{10} component also includes typical PM\textsubscript{10} from non tail pipe transport sources including brake and tyre wear and the re-suspension of particulate from the road surface (approximately 17% of the local primary PM\textsubscript{10}). The PM\textsubscript{10} from fugitive sources and from atypical re-suspension was however quantified by determining the difference between the total PM\textsubscript{10} determined by source apportionment model and that measured at the monitoring site. This approach has been successfully used to quantify the local sources of PM\textsubscript{10} at Manor Road, Erith (Fuller and Baker 2001) and in Grays, Essex (Fuller and Tremper 2004). A similar application of the model has been successfully used to quantify the fugitive PM\textsubscript{10} from road works and building works (Fuller and Green 2004).

4.1.1 Monitoring sites used for source apportionment

The PM\textsubscript{10} source apportionment used measurements of PM\textsubscript{10} and NO\textsubscript{X} from the period 2001 to 2003 inclusive from the measurement sites detailed in Table 5.

Table 5 Monitoring sites used for PM\textsubscript{10} source apportionment

<table>
<thead>
<tr>
<th>Site</th>
<th>Network</th>
<th>NO\textsubscript{X}</th>
<th>PM\textsubscript{10}</th>
<th>Wind Speed</th>
<th>Wind Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chichester</td>
<td>SAQSG</td>
<td>•</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>Eastbourne</td>
<td>SAQSG</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hastings</td>
<td>SAQSG</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lewes</td>
<td>SAQSG</td>
<td>•</td>
<td>•</td>
<td></td>
<td>•</td>
</tr>
<tr>
<td>Dover 3</td>
<td>KAQMN</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dover 5</td>
<td>KAQMN</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canterbury 1</td>
<td>KAQMN</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Folkestone 1</td>
<td>KAQMN</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maidstone 3</td>
<td>KAQMN</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mole Valley 2</td>
<td>LAQN</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mole Valley 3</td>
<td>LAQN</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sevenoaks 2</td>
<td>LAQN</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reigate &amp; Banstead 1</td>
<td>LAQN</td>
<td>•</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


All measurements of NO\textsubscript{X} were undertaken by chemi-luminescence and measurements of PM\textsubscript{10} were undertaken by TEOM. All NO\textsubscript{X} instruments were subject to regular calibration using gas sources traceable to national metrological standards. Instruments in the LAQN and KAQMN were subject to independent
audit by the National Physical Laboratory. All measurements were subject to retrospective ratification.

4.1.2 NO\textsubscript{X} measurements

Measurements of NO\textsubscript{X} were essential to the PM\textsubscript{10} source apportionment. However, NO\textsubscript{X} measurements were not available from all of the Sussex coastal PM\textsubscript{10} monitoring sites including the Hastings site itself. Several assumptions were made to estimate the NO\textsubscript{X} concentrations at Eastbourne, Lewes and Hastings in order to deduce the primary PM\textsubscript{10} at these sites:

- The NO\textsubscript{X} concentration at Eastbourne was assumed to be equal to that at Folkestone. Both sites are in background / suburban locations on the edge of towns on the south coast. Although NO\textsubscript{X} measurements were not made at Eastbourne during the period 2001 to 2003, a NO\textsubscript{X} analyser was installed at the site during March 2004. From March 2004 to October 2004 the mean NO\textsubscript{X} measurements at Eastbourne and Folkestone were comparable: 13ppb and 14ppb respectively. NO\textsubscript{X} measurements from Folkestone were also assumed to be representative of background concentrations at the Hastings monitoring site.

- The NO\textsubscript{X} concentration at Lewes was estimated from that measured at the Chichester roadside site. Both monitoring sites are located to the north of trunk roads that are orientated in approximately east-west. A NO\textsubscript{X} analyser was installed at Lewes during 2004 and a factor was derived, based on measurements from 20\textsuperscript{th} February 2004 to 20 June 2004, to allow NO\textsubscript{X} measurements from Chichester to represent concentrations at Lewes for the period 2001 to 2003.

- No measurements of NO\textsubscript{X} were available for the A259 near the Hastings site and the Sussex 3 mobile site. The NO\textsubscript{X} concentration at these sites was therefore estimated from that measured at the Chichester roadside site. Both monitoring sites are located to the north of trunk roads that are orientated approximately east west. A factor was derived from modelled NO\textsubscript{X} predictions at the Hastings and Chichester sites to allow the NO\textsubscript{X} measurements from Chichester to represent concentrations to Hastings for the period 2001 to 2003.

4.1.3 PM\textsubscript{10} from sea salt spray

To apportion the PM\textsubscript{10} measured at Hastings it was necessary to quantify the sea spray component. The sea spray component was quantified and incorporated into the source apportionment model by considering the difference in the daily mean concentration of secondary and natural PM\textsubscript{10} at coastal sites and the daily mean concentration of secondary and natural PM\textsubscript{10} at a network of inland sites. Relationships were derived for the three years 2001 to 2003, inclusive, between onshore wind speed and the additional secondary and natural PM\textsubscript{10} measured at the coast. On-shore wind speed was then used to calculate the sea spray component averaged as daily mean, by wind direction and by hour of day and day of week.
The episodic behaviour of the PM$_{10}$ from sea spray could also be reproduced in this way (Fuller, 2004).

At the Chichester and Folkestone sites, which are located around 2 km inland, the annual mean PM$_{10}$ from sea spray was found to be up to 2 µgm$^{-3}$ (TEOM*1.3) and the additional PM$_{10}$ from sea spray caused the daily mean PM$_{10}$ to exceed 50 µgm$^{-3}$ (TEOM*1.3) on up to 2 days per year. Greater concentrations of PM$_{10}$ from sea spray were measured at the Eastbourne and Lewes sites that are located within 500 m of the coast. At Eastbourne the annual mean PM$_{10}$ from sea spray was found to be 3 µgm$^{-3}$ (TEOM*1.3), however, the additional PM$_{10}$ from this source did not cause additional days with mean PM$_{10}$ concentration above 50 µgm$^{-3}$ (TEOM*1.3). The Lewes site is located on the cliff top at Peacehaven where waves break over the wave cut platform and against the sea defences below. Here the annual mean PM$_{10}$ from sea spray may have been over 10 µgm$^{-3}$ (TEOM*1.3) and sea spray may have been responsible for the majority of occasions when the daily mean PM$_{10}$ exceeded 50 µgm$^{-3}$ (TEOM*1.3).

The contribution of PM$_{10}$ from sea spray to the total PM$_{10}$ concentrations at Hastings could not be derived directly. The PM$_{10}$ from the atypical re-suspension from the road surface may also have a wind dependency and thus PM$_{10}$ from this source may be wrongly attributed to sea spray and visa versa. Instead the PM$_{10}$ from sea spray at Hastings was assumed to be equal to that at Eastbourne, both sites are located at similar distances from pebble beaches and are located approximately 19 km apart.

4.1.4 Sites modelled

The source apportionment model was principally used to analyse the PM$_{10}$ measurements at the Hastings 1 roadside site. The model was also used to analyse the measurements made by the Sussex mobile monitoring site in two deployments in the area; Sussex 3 further east on the A259 and Sussex 5 on the access road to the Pebsham waste site. NO$_{X}$ and therefore primary PM$_{10}$ concentrations at Sussex 3 were assumed to be equal to those at the Hastings monitoring site. This is likely to be an over estimate due to lower traffic flow at Sussex 3 than that experienced at Hastings 1. Measurements of NO$_{X}$ at Sussex 5 were used directly in the source apportionment at this site.

4.2 Results of source apportionment

4.2.1 Model data capture

The source apportionment of PM$_{10}$ using measurements of other pollutants could only be undertaken when such measurements existed. Measurements across several sites were required. Sufficient measurements were available to apportion the PM$_{10}$ at Hastings for 715 days (65%) during the three year period 2001 – 2003. The availability of source apportioned measurements for each year is provided in Table 6.
Table 6 Availability of PM$_{10}$ source apportionment at Hastings (daily means)

<table>
<thead>
<tr>
<th>Year</th>
<th>Data availability for Source Apportionment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>42%</td>
</tr>
<tr>
<td>2002</td>
<td>66%</td>
</tr>
<tr>
<td>2003</td>
<td>88%</td>
</tr>
</tbody>
</table>

4.2.2 Uncertainty

Overall the source apportionment model, with additional sea spray component, performed well at the coastal sites in Sussex and Kent with accurate predictions of both the annual mean PM$_{10}$ and number of days with mean PM$_{10}$ above 50 µgm$^{-3}$ (TEOM*1.3).

The model was derived and tested for 2001 to 2003 at four coastal sites, totally 12 site years. The average difference between model outputs and measured values are listed in Table 7.

Table 7 Difference between modelled and measured PM$_{10}$ 2001 – 2003

<table>
<thead>
<tr>
<th></th>
<th>Mean Difference</th>
<th>2 $\sigma$</th>
<th>Mean Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Mean (µgm$^{-3}$ (TEOM*1.3))</td>
<td>0</td>
<td>4.6</td>
<td>27</td>
</tr>
<tr>
<td>Annual number of daily means &gt; 50 µgm$^{-3}$ (TEOM*1.3)</td>
<td>1</td>
<td>4.8</td>
<td>11</td>
</tr>
</tbody>
</table>

4.2.3 Source apportionment at Hastings 1

The overall source apportionment of PM$_{10}$ at the Hastings site from 2001 to 2003 inclusive is shown in Figure 8. The main contributions to PM$_{10}$ at the site were the background secondary and natural sources (54%) that determine background concentrations across South East England. The second largest source affecting the site was the atypical re-suspension from the A259 accounting for 24% of the total measured PM$_{10}$. Primary PM$_{10}$ from combustion sources (which includes typical non tail pipe PM$_{10}$ from transport sources) accounted for 16% of the PM$_{10}$ divided between background sources and that arising specifically from the A259. Sea spray accounted for 6% of the measured PM$_{10}$.
**Figure 8** Overall source apportionment of PM$_{10}$ at Hastings 1 2001 – 2003

The time series of the PM$_{10}$ source contributions is shown in Figure 9. This figure shows that the mean concentration of PM$_{10}$ from each source sector varied on a daily basis. With the notable exception of the August 2003 secondary PM$_{10}$ episode, daily mean concentrations above 50 µg m$^{-3}$ (TEOM*1.3) were not caused by a single source sector but instead are caused by the different PM$_{10}$ sources acting in combination. The source apportionment of PM$_{10}$ on days when the mean concentration exceeds 50 µg m$^{-3}$ (TEOM*1.3) is not the same as the overall source apportionment shown in Figure 8. The change in concentration of PM$_{10}$ from a particular source sector therefore has a complex relationship to the change in the annual number of days with mean PM$_{10}$ greater than 50 µg m$^{-3}$ (TEOM*1.3).
The contribution of each PM$_{10}$ source sector to the annual number of daily means above 50 µgm$^{-3}$ (TEOM*1.3) may be shown by the removal of each PM$_{10}$ source from the model in turn as shown in the table below. Table 8 shows that relationship between the number of days with mean concentrations of PM$_{10}$ above 50 µgm$^{-3}$ (TEOM*1.3) is complex, reflecting the differing composition of PM$_{10}$ on each day and the threshold nature of the daily mean objective for PM$_{10}$.

Table 8 Number of days with PM$_{10}$ above 50 µgm$^{-3}$ (TEOM*1.3) at the Hastings 1 site from source apportionment model

<table>
<thead>
<tr>
<th></th>
<th>All Sources</th>
<th>Excluding A259 primary and typical re-suspension</th>
<th>Excluding A259 Atypical re-suspension</th>
<th>Excluding background primary</th>
<th>Excluding regional secondary and natural</th>
<th>Excluding Sea Spray</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>55</td>
<td>36</td>
<td>5</td>
<td>41</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td>2002</td>
<td>73</td>
<td>64</td>
<td>2</td>
<td>64</td>
<td>2</td>
<td>47</td>
</tr>
<tr>
<td>2003</td>
<td>67</td>
<td>60</td>
<td>19</td>
<td>56</td>
<td>0</td>
<td>65</td>
</tr>
</tbody>
</table>

(Notes – the table shows the results having excluded each source in turn and the results have been corrected pro rata for model data capture).

The table also shows that in the absence of PM$_{10}$ from atypical re-suspension along the A259, the number of daily means above 50 µgm$^{-3}$ (TEOM*1.3) was similar to other roadside PM$_{10}$ measurements in Sussex.
The time series of the atypical re-suspension from the A259 is shown in Figure 10. Weekly mean concentrations of the PM$_{10}$ from atypical re-suspension from the A259 showed considerable variability with maximum weekly means exceeding 20 µgm$^{-3}$ (TEOM*1.3) during February in 2002, 2003 and 2004. The weekly mean PM$_{10}$ from this source also exceeded 20 µgm$^{-3}$ (TEOM*1.3) during the August 2003 secondary PM$_{10}$ episode. The annual mean concentration of PM$_{10}$ from the atypical re-suspension from the A259 was greatest for the year ended May 2003 with a mean concentration of 10.8 µgm$^{-3}$ (TEOM*1.3). During 2004 the annual mean PM$_{10}$ from this source declined steadily and had a mean concentration of 6.4 µgm$^{-3}$ (TEOM*1.3) at the end of September 2004.

**Figure 10** Atypical re-suspension from the A259 near Hastings 1

(Notes - Rolling weekly and annual means are shown. Annual means were calculated when the availability of model outputs exceeded 50% and weekly means were calculated when model outputs were available for more than 5 days in a 7 day period).

Further insight into the sources of PM$_{10}$ affecting the site was obtained by considering the mean concentration averaged by time of day and day of week, as shown in the figure below.
The measured PM$_{10}$ concentration, averaged by day of week and hour of day at Hastings exhibited the typical variation expected from a local road traffic source, with mean concentrations highest during the daylight hours on weekdays, in line with traffic flow. The maximum mean concentrations at weekends were lower than those measured on weekdays, again reflecting traffic flow. The PM$_{10}$ concentration dropped to a minimum each night; with the minimum concentration determined by background sources.

The variation of PM$_{10}$ concentrations when averaged by day of week and hour of day from the individual sources indicated a more complex situation. The greatest contribution to the overall mean PM$_{10}$ arose from secondary and natural sources. These exhibited a diurnal variation with the highest concentrations measured during the late afternoon and evening, possibly reflecting the cumulative generation of secondary PM$_{10}$ from photochemical processes.

The PM$_{10}$ from sea spray also exhibited a diurnal variation with highest concentrations measured in the middle of each day reflecting the daily variation in wind speed and the frequency of on-shore air flows.

The variation in the concentration of the PM$_{10}$ from the two primary sources showed twin peaks on each of the weekdays reflecting the emission peak from road traffic sources. At night the concentration of primary PM$_{10}$ arising from the A259 fell to around zero. The PM$_{10}$ arising from the atypical re-suspension along the A259 also exhibited a distinct diurnal pattern with highest mean concentrations arising in the middle of the day. Peak mean concentrations of PM$_{10}$ from this source were higher on weekdays than at weekends. The variation in the mean
concentration of PM$_{10}$ by day of week and hour of day were similar to that expected from a road traffic source supporting the view that this source arose from atypical emissions from road traffic on the A259.

The PM$_{10}$ concentration averaged by wind direction are shown in Figure 12 and this provides further insight into the sources of PM$_{10}$ at the site. The maximum mean concentration of PM$_{10}$ arose from wind directions approximately perpendicular to the alignment of the A259. The direction of the maximum concentration was as expected at a monitoring site with a large PM$_{10}$ contribution from a local road.

However, this does not necessarily provide evidence that the sources of PM$_{10}$ arising from the A259 dominate the mean PM$_{10}$ measured at the site since the mean PM$_{10}$ from secondary and natural is also expected to have a maximum in this direction. There was no evidence from this analysis to suggest that the site was affected directly by sources within the landfill site to the north. The total PM$_{10}$ expected at the site without the atypical PM$_{10}$ is also shown and the atypical PM$_{10}$ from re-suspension from the A259 was determined by difference. The distribution of the atypical re-suspension suggests that this source did not arise from fugitive emissions from the landfill site to the north.

The results of the source apportionment model, with respect to wind direction, must be treated with caution since it may not have accurately reflected the alignment of the coast and A259 at the monitoring site. This was due to two assumptions within the source apportionment. Firstly it was assumed that on-shore winds lie between 80° and 270°, reflecting the overall alignment of the south coast between Folkestone and Chichester, whereas the coast line near the monitoring site has an alignment closer to 60° to 240°. Secondly, measurements of NO$_X$ at Chichester, which were used to calculate primary PM$_{10}$ at Hastings, showed a clear east – west bias reflecting the east-west alignment of the road at the Chichester monitoring site. This differs from the A259 near the Hastings site.
Figure 12 Mean concentration of PM$_{10}$ at Hastings 1 (averaged by wind direction)

(Notes - analysis was undertaken by 10 degree sector. Measured and modelled concentration without atypical resuspension are shown (µgm$^{-3}$ TEOM*1.3)).

4.2.4 Source Apportionment at the Sussex 3 Mobile Site

Measurements from both the Hastings 1 site and the Sussex 3 mobile site were compared to the results from the source apportionment model without the atypical re-suspension from the A259. This comparison related to the deployment period of 47 days for the Sussex 3 site. The atypical re-suspension in both locations was then quantified and compared over the same time period.

This is shown in Table 9, which indicates that the measured PM$_{10}$ at Sussex 3 was lower than that measured at Hastings 1 and that the PM$_{10}$ from atypical re-suspension was also lower, with a mean difference of 5.3µgm$^{-3}$ (TEOM*1.3). The atypical re-suspension at Sussex 3 is, however, likely to be underestimated due to differences in traffic flow between the Hastings and Sussex 3 monitoring sites that are not reflected in the source apportionment.
Table 9 Measured and modelled PM$_{10}$ at Hastings 1 and Sussex 3 for same period

<table>
<thead>
<tr>
<th></th>
<th>Model without atypical re-suspension</th>
<th>Hastings 1</th>
<th>Sussex 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean µgm$^{-3}$ (TEOM*1.3)</td>
<td>25.7</td>
<td>33.2</td>
<td>7.5</td>
</tr>
<tr>
<td>Daily means &gt;50 µgm$^{-3}$ (TEOM*1.3)</td>
<td>0</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

4.2.5 Source Apportionment at the Sussex 5 Mobile Site

The time series of daily mean PM$_{10}$ measurements at the Hastings roadside site and the Sussex 5 mobile site are shown in Figure 13. To enable comparison of measurements at both sites the result set was filtered to only include periods when both sites were operating and when sufficient supporting measurements were available to enable source apportionment. The daily mean concentrations were highly correlated ($r^2 = 0.75$), however, in general the daily mean PM$_{10}$ concentration at the Hastings 1 site exceeds that measured at Sussex 5.

Figure 13 Time series of daily mean PM$_{10}$ at Hastings 1 and Sussex 5 site (showing corresponding measurements)
Table 10 shows the measured PM$_{10}$ and modelled PM$_{10}$ without atypical re-suspension at the Hastings and Sussex 5 monitoring sites. The atypical re-suspension in both locations was quantified and compared over the same time period, and is also shown. The measured PM$_{10}$ at Sussex 5 was lower than that measured at Hastings 1. However the PM$_{10}$ arising from atypical re-suspension at Sussex 5 was higher than that at Hastings 1. In contrast the measured concentration of NO$_X$ at Sussex 5 was equal to that at the Folkestone background site.

**Table 10 Measured and Modeled PM$_{10}$ at Hastings and Sussex 5**

<table>
<thead>
<tr>
<th></th>
<th>Hastings</th>
<th>Sussex 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model without</td>
<td>Measured</td>
</tr>
<tr>
<td></td>
<td>atypical re-suspension</td>
<td>Atypical re-suspension</td>
</tr>
<tr>
<td>Mean $\mu$gm$^{-3}$</td>
<td>24.7</td>
<td>29.9</td>
</tr>
<tr>
<td>(TEOM*1.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily means $&gt;50$ $\mu$gm$^{-3}$</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>(TEOM*1.3)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Insight into the sources of PM$_{10}$ at Sussex 5 can be gained from considering the measured pollution concentration averaged by wind direction as shown in Figure 14. The mean PM$_{10}$ concentration at Sussex 5 shows a very similar pattern to that measured at the Hastings 1 site, although the concentration at Sussex 5 is less for wind directions between 30° and 290°. For wind directions from the north, between 330° and 20°, the PM$_{10}$ concentration at Sussex 5 exceeds that measured at Hastings 1.

The distribution of the mean PM$_{10}$ measured at both Hastings 1 and Sussex 5 is similar to that shown in Figure 11 for Hastings 1 for the period 2001 to 2003. Figure 14 also shows mean PM$_{10}$, averaged by wind direction at the Folkestone background site. Compared to Folkestone both Hastings and Sussex 5 show elevated concentrations perpendicular to the orientation of the A259 again suggesting this to be a local source of PM$_{10}$.

The mean NO$_X$ concentration at Sussex 5 is equal to that at the background site in Folkestone. Mean of NO$_X$ concentration at Sussex 5, with respect to wind direction, shows both the influence of NO$_X$ emissions from the A259, as indicated by the distribution of mean concentration to the south (from wind directions perpendicular to the A259) and the influence of emissions from the access road to the Pebsham site on a bearing of approximately 350°. The mean NO$_X$ concentration is used within the source apportionment model to calculate the
primary PM$_{10}$ but also provides insight into the origins of all of the transport related emissions affecting the site.

The mean NO$_X$ concentration shows a similar distribution to the mean PM$_{10}$, with respect to southerly wind directions with greatest concentrations being measured approximately perpendicular to the A259. The mean NO$_X$ concentration from wind directions between 290° and 30° clearly shows a peak indicating the NO$_X$ emissions from the access road to the Pebsham waste site.

Theoretically the distribution of mean NO$_X$ from the access road should be similar on southerly wind directions to those measured from the north, however, the NO$_X$ emissions from the A259, 50m to the south, dominate those from the access road to the Pebsham waste site. Emissions of PM$_{10}$ from this access road are the likely explanation for the mean PM$_{10}$ at Sussex 5 exceeding the mean measured at Hastings 1 for wind directions from the north, between 330° and 20°. Overall the PM$_{10}$ at the Sussex 5 appear dominated by the PM$_{10}$ atypical re-suspension from the A259.

**Figure 14** Mean concentrations of PM$_{10}$ and NO$_X$ at Sussex 5 averaged by wind direction

(Notes - NO$_X$ concentrations are also shown. Analysis was undertaken by 10-degree sector. PM$_{10}$ concentrations are in µgm$^{-3}$ (TEOM*1.3) and NO$_X$ concentrations are in ppb. The approximate orientation of the access road to the access road to the Pebsham waste site and A259 are shown as dotted lines).
4.3 Source apportionment summary

The results from the source apportionment model suggest that the PM$_{10}$ from secondary and natural sources was the largest source sector (54%) affecting the measurements at the Hastings monitoring site. The PM$_{10}$ from this source made an equal contribution to all monitoring sites across southeast England and this source did not therefore account for the local elevation in PM$_{10}$ concentration at the Hastings 1 monitoring site when compared to measurements at other sites on the south coast.

The second largest source is the atypical re-suspension from the A259 (24%) with relatively minor contributions from primary emissions from vehicle tail pipes and typical re-suspension and brake wear (9%) and other background combustion sources (7%). The contribution of PM$_{10}$ from sea spray (6%) provides an additional complication to the apportionment of PM$_{10}$ at the site.

The contribution of each PM$_{10}$ source sector to the number of daily means above 50 $\mu$g m$^{-3}$ (TEOM*1.3) may be shown by the removal of each PM$_{10}$ source from the model in turn as shown in Table 8. The results from this selective exclusion may be carried forward into action planning. Clearly the Council cannot affect the sea salt spray, or secondary and natural sources and the management of background primary sources may be equally impractical. Actions can therefore be focused on the primary PM$_{10}$ emissions and the atypical re-suspension from the A259. However, action on primary emissions alone cannot achieve the daily mean objective at the Hastings 1 site.

Analysis of measurements of the atypical PM$_{10}$ at the Sussex 3 and Sussex 5 mobile sites allows the estimation of the atypical re-suspension at two further locations in the vicinity of the Hastings 1 site. At Sussex 3 the concentration from atypical re-suspension is lower than that at Hastings 1 and the concentration from atypical re-suspension is higher at the Sussex 5 site on the access road to the Pebsham site.

The modelled results in Table 9 and Table 10 can be used, pro rata to estimate the concentration of PM$_{10}$ from atypical re-suspension at Sussex 3 and Sussex 5 during 2002 and therefore the annual mean PM$_{10}$ and number of days when mean PM$_{10}$ exceeded 50 $\mu$g m$^{-3}$ (TEOM*1.3). The source apportionment model can then be used to estimate the likely annual number of days with mean PM$_{10}$ above 50 $\mu$g m$^{-3}$ (TEOM*1.3) at each location as shown in Table 11.

A reduction in the annual mean concentration of PM$_{10}$ from atypical re-suspension was apparent with increased distance from the Pebsham site; the greatest concentration (11.6 $\mu$g m$^{-3}$ (TEOM*1.3)) arising at the south end of the access road, falling to 9.6 $\mu$g m$^{-3}$ (TEOM*1.3) at Hastings 1 and to 2.8 $\mu$g m$^{-3}$ (TEOM*1.3) further west along the A259 at the Sussex 3 site. In estimating the annual mean PM$_{10}$ from all sources it was assumed that the NO$_X$ concentration at Sussex 5 was equal to that measured at background locations.
Table 11 Modelled PM$_{10}$ during 2002

<table>
<thead>
<tr>
<th>2002</th>
<th>Annual mean Atypical re-suspension (µgm$^{-3}$ (TEOM*1.3))</th>
<th>Annual Mean PM$_{10}$ (µgm$^{-3}$)</th>
<th>Number of days with mean PM$_{10}$ &gt; (TEOM*1.3).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sussex 3</td>
<td>2.8</td>
<td>30.9</td>
<td>8</td>
</tr>
<tr>
<td>Hastings</td>
<td>9.6</td>
<td>37.6</td>
<td>73</td>
</tr>
<tr>
<td>Sussex 5</td>
<td>11.6</td>
<td>36.4</td>
<td>74</td>
</tr>
</tbody>
</table>

Although all three locations meet the annual mean objective it is likely that the daily mean objective was exceeded at the Sussex 5 mobile location, at the south end of the access road to the Pebsham site in addition to Hastings 1.
5 Predictions of PM$_{10}$ near the Hastings D.C AQMA

5.1 Outline of modelling developments

The Further Assessment represents significant progress beyond the Detailed Assessment report. As a summary the developments include:

- Detailed modelling of the emissions of PM$_{10}$ over the area of interest to allow an improved assessment of exposure;
- Predictions plotted on OS base maps;
- Detailed estimates of emissions from different sources;
- Additional monitoring data to assist the modelling.

A detailed explanation of the method used is given in the Appendix.

The overall aim of this part of the report was to use the source apportionment model with dispersion modelling to predict concentrations of PM$_{10}$ across the AQMA and its immediate surrounding area for comparison with the AQS objectives.

The area of interest investigated was the A259 Bexhill Road extending beyond the current AQMA to the Sussex 3 monitoring site location at the West St. Leonards County Primary School, the modelling has also incorporated the southern end of the B2092 (Harley Shute).

5.2 Figures showing model predictions

The following pages provide isopleths of the modelled predictions for PM$_{10}$ for the Bulverhythe area$^1$. It should be noted that the objectives relates to the annual mean concentrations of PM$_{10}$. A plot showing the predicted area, which exceeds the daily mean objective, is also included. The area modelled has been based on the Council’s AQMA and therefore there is relevant exposure.

The predicted concentrations are shown for the 2004 base case, assuming that the meteorology of the year 1999 (representing a typical year) was repeated. The predicted daily mean objective of 35 days greater than 50 µg/m$^3$ (TEOM$^*1.3$) is shown in Figure 15 and annual mean predictions are shown in Figure 16. The number of days predicted to exceed the objective at the HT1 site is 73 (see Table 11).

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The predictions in Figure 15 confirm the Detailed Assessment findings that the daily mean air quality objective will be exceeded in and adjacent to the A259 in Bulverhythe. The areas coloured yellow to red in Figure 16 indicate the areas are those that are predicted to exceed the annual mean air quality objective.
Figure 15 Predicted number of PM$_{10}$ days with mean concentrations > 50µgm$^{-3}$ (TEOM*1.3) along the A259 in and near Bulverhythe (based on 1999 meteorology)

(Notes –
Red line represents area where daily mean objective is predicted to be exceeded.
Blue line represents above area incorporating model uncertainty)
In comparison with the Detailed Assessment predictions the area predicted to exceed the daily mean objective has remained the same. The changes to the area predicted to exceed are a result of the improved understanding of emissions and their source locations. The main difference between the Detailed Assessment and new predictions are that the area predicted to exceed extends eastwards toward the urban centre of Hastings. This arises as a result of modelling these roads and incorporating a component related to re-suspension. The additional area predicted to exceed however relates to the road centre and not to areas where there is relevant exposure.

The prediction incorporates the access road to the Pebsham waste site, Bulverhythe Road, part of the B2092 Harley Shute and the A259 further eastwards along the towards West St. Leonards. The area predicted to exceed incorporates the facades of buildings on both sides of the road along the A259 in the existing AQMA, from the junction with Harley Shute through to the Council’s western boundary with Rother D.C.

All the areas modelled incorporate an element for atypical re-suspension. The factor used for Harley Shute and the section of the A259 east of Harley Shute was derived from the Sussex 3 monitoring campaign and this reflects that there is an emission reduction. For the A259 west of Harley Shute the re-suspension element reduces was derived from the Hastings 1 monitoring site.
Figure 15 also highlights an area of uncertainty; this is based on the two standard deviations given in Table 7 for the source apportionment model. It is recognised that there is uncertainty in the model used. The source apportionment model in chapter 4 used monitored results for the Sussex 5 site and this indicated that this site exceeded the AQS daily mean objective. This however is not predicted by the dispersion modelling. The results from Sussex 5, which is 50m from the A259 along the access road to the Pebsham site, suggest that it is dominated by the A259. It is not however certain that this is from the higher levels of re-suspension taking place in this area only or in combination with other factors, such as junction effects.

Figure 16 below provides the predicted annual mean concentrations for the same area and 2004 base case. These predictions indicate that the annual mean objective is not exceeded, except in the very close to the road centre line. The extent of the area predicted to exceed also extends form the Harley Shute junction to the Council’s western boundary with Rother D.C.
Figure 16 Predicted PM$_{10}$ annual mean concentrations (µgm$^{-3}$ TEOM*1.3) for the A259 in and near Bulverhythe (based on 1999 meteorology)
6 Scenario testing

6.1 Selection of scenario tests

The Council is required to produce an action plan for its AQMA. The purpose of the action plan is to allow the Council to work towards reducing pollution concentrations and achieving the AQS objective that is likely to be exceeded.

Prior to developing an action plan it is helpful to utilise the source apportionment and dispersion modelling to test the effectiveness of possible measures to improve air quality within the AQMA. A series of scenario tests were considered and these reflect the fact that the most significant local sources of PM$_{10}$ emissions are related to road transport.

The scenario tests investigated were:

1. Based on a 30% traffic reduction along the A259 Bexhill Road only – with no removal of the atypical re-suspension of PM$_{10}$. This assumes that this material will continue to be deposited along the road and re-suspended to the same rate.

2. Based on the complete removal of atypical re-suspension of PM$_{10}$ from this area – with no change in traffic flows along the roads.

The scenarios were also modelled using the same meteorology, i.e. 1999 to represent a typical year.

4.2 Results of scenario tests

The results of the modelling for the Hastings 1 site are given in Table 12. Separate figures showing annual mean PM$_{10}$ concentrations are also shown in Figure 17 and Figure 18.

<table>
<thead>
<tr>
<th>Location</th>
<th>2004 base</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hastings 1</td>
<td>37.3</td>
<td>36.3</td>
<td>24.1</td>
</tr>
</tbody>
</table>

6.2.1 Scenario 1

The predictions in Table 12 all meet the annual mean objective. Scenario 1 shows that compared to the base case there is little reduction in annual mean concentration with the 30% reduction of traffic along the A259 Bexhill Road. This scenario has assumed that the atypical re-suspension element has remained constant, despite the reduction in the traffic flow. This is based on the assumption that same amount of
material is still deposited on the road and re-suspended by the road traffic using the road.

Figure 17 overleaf is very similar to Figure 16 and shows that there are areas predicted to exceed the annual mean objective close to the road centre of the A259 from the Harley Shute junction westward to the Council’s boundary with Rother D.C. It also indicates only a very small reduction in concentrations, as indicated by Table 12.

6.2.2 Scenario 2

Scenario 2 assumes that all the additional material currently re-suspended is fully removed. This scenario indicates in Table 12 a large reduction in annual mean concentration at the Hastings 1 site of over 30% at this location. This reduction is sufficient to ensure that the daily mean objective is achieved.

Figure 18 shows the major reduction in concentrations very clearly and all areas are predicted to be less than the annual mean objective.

6.2.3 Daily mean predictions

Figures showing concentrations for the daily mean objective are not shown for the two scenarios. For Scenario 1 the daily mean objective will be exceeded to the same degree as that for the 2004 base case shown in Figure 15.

For Scenario 2 the daily mean objective is not predicted to be exceeded anywhere and this reflects the current monitoring results from other sites in Sussex (see discussion in Chapter 2) as these other sites are not affected by the local factors that dominate the PM$_{10}$ concentrations in Hastings.
Figure 17 Predicted PM$_{10}$ annual mean concentrations ($\mu$gm$^{-3}$ TEOM*1.3) for the A259 in and near Bulverhythe with 30% traffic reduction (based on 2001 meteorology)
**Figure 18** Predicted PM$_{10}$ annual mean concentrations ($\mu$gm$^{-3}$ TEOM*1.3) for the A259 in and near Bulverhythe with no atypical re-suspension (based on 2001 meteorology)
Conclusion

This report fulfils the requirements of the DEFRA guidance for the Further Assessment and permits the Council to review and update its Detailed Assessment report and address relevant issues before continuing LAQM process. The Further Assessment has updated the monitoring, provided a detailed analysis of source apportionment of PM$_{10}$ in the area and based on this re-modelled the AQMA.

The monitoring undertaken at the Hastings 1 site confirmed that the daily mean PM$_{10}$ objective was exceeded for both 2002 and 2003. Compared to other comparable sites in the Sussex network the Hastings 1 measurements were substantially higher. The number of days exceeding the daily mean standard of 50 $\mu$gm$^{-3}$ is currently lower this year than previous years and therefore this objective may not be exceeded. The annual mean PM$_{10}$ objective has not been exceeded during any of the years that monitoring has been undertaken.

The monitoring from the three Hastings sites and other sites both in Sussex and in the wider southeast region were used to produce a model of source apportionment of PM$_{10}$ in the Council’s AQMA. The sources were split into the following components: PM$_{10}$ related to NOx, PM$_{10}$ related to secondary and coarse particles, the contribution from sea salt spray and the contribution from a local component (termed in the main report as atypical re-suspension of material). The source apportionment model developed for the area also determined the complex local relationship between the daily mean objective and annual mean objective.

The source apportionment highlighted that the atypical re-suspension is the second largest source after secondary and natural sources. The Council however can only directly influence local primary and atypical re-suspension sources. Use of the model also determined that action on primary emissions alone would not lead to the daily mean objective being achieved.

New predictions were made using the above source apportionment model and dispersion modelling. These confirm the Detailed Assessment findings that the AQS daily mean objective will be exceeded. The extent of the area predicted to exceed has remained the same and therefore the original designation of the AQMA is still correct.

Two scenarios were tested; these were a reduction in traffic along the A259 and the removal of the atypical re-suspension along the road. The predictions based on a reduction in traffic were that there was very little reduction in PM$_{10}$ concentrations and therefore the daily mean objective would still not be met. The predictions based on the removal of the atypical re-suspension however indicated that the daily mean objective would be met as a result of reduced concentrations.
Recommendations

The Council is recommended to undertake the following actions, in respect of the findings in this report for the daily mean PM\textsubscript{10} statutory objective:

1. Investigate possible reasons for the marked reduction in PM\textsubscript{10} concentrations during 2004.

2. Prepare an action plan, to work towards the achievement of the statutory objectives, including determining the cost effectiveness of the different measures proposed.

3. Undertake consultation on the findings arising from this report with the statutory and other consultees as required.

4. Continue its ongoing PM\textsubscript{10} monitoring programme as part of its LAQM actions and extend this to include continuous NO\textsubscript{3} measurements.
References:


Air Quality Expert Group (AQEG), 2004 Particulate matter in the United Kingdom, draft for comment, Department for the Environment, Food and Rural Affairs.


Charron, A., Harrison, R. M., Moorcroft, S., Booker, J., Quantitative interpretation of the divergence of PM$_{10}$ and PM$_{2.5}$ mass measurement by TEOM and gravimetric (Partisol) methods. Atmospheric Environment 38 415 – 413.


Fuller, G. and Tremer, A. 2004, Local Sources of PM$_{10}$ measured at Thurrock 1, ERG, King’s College London.


Appendix A

Dispersion Modelling Method

The overall objective of the air pollution dispersion modelling is to produce a robust method whereby concentrations of PM$_{10}$ can be determined and developed in conjunction with the source apportionment study to permit comparison with the AQS objectives. The achievement of this task enables the understanding of future changes in concentrations.

Area of interest

The area of interest was limited to the A259 in Bulverhythe and adjoining roads within the Council’s area. This was based on the findings in the Detailed Assessment report and earlier Updating and Screening Assessment.

Dispersion model and parameters used

The dispersion model used was ERG toolkit. This is a well-established dispersion model that meets the requirements of TG03 for traffic sources. It has also been extensively validated for use across London and the southeast. Numerous local authorities and the Mayor of London have used it for air quality modelling. The toolkit provides the functionality required for the prediction of air pollution concentrations both now and in the future and enables the ERG to produce emission estimates and dispersion modelling predictions.

The ERG’s PM$_{10}$ model uses a comprehensive set of PM$_{10}$, PM$_{2.5}$ and NO$_X$ measurements to derive a model to predict daily concentrations of PM$_{10}$. The model splits PM$_{10}$ into 4 component parts and relates each to the likely source/s of the particles (Fuller, et al., 2002). To achieve this, regression analysis of NO$_X$ with PM$_{10}$ has been employed. Stedman (2000, 2001) and APEG (1999) used a similar analysis, however the ERG model has extended this to include PM$_{2.5}$. The four component parts are summarised as:

- PM$_{2.5}$ that is related to NO$_X$;
- PM$_{2.5}$ that is not related to NO$_X$;
- Coarse particles that are related to NO$_X$;
- Coarse particles that are not related to NO$_X$.

To determine the relationship between NO$_X$ and PM$_{10}$, regression analysis has been undertaken for co-located rolling annual mean concentrations of NO$_X$, PM$_{10}$ and PM$_{2.5}$ at monthly intervals. Rolling annual means have been chosen to test the stability of the derived relationships over time. A total of over 10 million, 15 minute mean measurements have been averaged to produce the rolling annual means at each site and the data are from all site types: kerbside, roadside, urban background, suburban and rural.
The predicted concentrations of PM$_{10}$ at background locations i.e. greater than 50m from a major road, are based on use of the National Atmospheric Emissions Inventory data.

For predictions in future years each part of the emissions information has been changed independently. For example, in 2004 it has been assumed that the rural PM$_{10}$ concentration reduces in line with national predictions for the primary and secondary components.

A comprehensive validation of the PM$_{10}$ model for roadside and background locations has been undertaken for sites in the London Air Quality Network and the Kent Air Quality Monitoring Network (including Folkestone). This is fully described in the following report produced for the Mayor of London; see www.london.gov.uk/approot/mayor/air_quality/modelling.pdf.

Traffic data used in report

The traffic data used to model the area is given in Table 13 below. The data were derived from traffic count data obtained from the East Sussex County Council (ESCC) and the Council’s earlier review and assessment reports. In all instances the most conservative estimates were used. The vehicle split for the A259 and B2092 were factored from nearby Department for Transport count sites. The other roads were based on the vehicle split obtained from ESCC information, with the rigid/articulated HGVs split based on national information.

All roads are within urban areas and the A259 itself is prone to congestion. An average speed of 30kph was therefore used for all road links.

**Table 13 Traffic information used for base case 2004 modelling**

<table>
<thead>
<tr>
<th>Road number</th>
<th>M/cycles</th>
<th>Cars</th>
<th>Buses</th>
<th>LGVs</th>
<th>Rigid</th>
<th>Artic</th>
</tr>
</thead>
<tbody>
<tr>
<td>A259 Bexhill Rd</td>
<td>252</td>
<td>23877</td>
<td>151</td>
<td>2807</td>
<td>813</td>
<td>200</td>
</tr>
<tr>
<td>Z1_10</td>
<td>0</td>
<td>280</td>
<td>0</td>
<td>16</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>U3101_10</td>
<td>0</td>
<td>1136</td>
<td>0</td>
<td>49</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>B2092_5</td>
<td>172</td>
<td>12902</td>
<td>211</td>
<td>1949</td>
<td>387</td>
<td>80</td>
</tr>
<tr>
<td>A259 Filsham</td>
<td>237</td>
<td>17750</td>
<td>290</td>
<td>2681</td>
<td>532</td>
<td>109</td>
</tr>
<tr>
<td>Pebsham access road</td>
<td>0</td>
<td>1689</td>
<td>0</td>
<td>114</td>
<td>95</td>
<td>0</td>
</tr>
</tbody>
</table>

For the 30% traffic reduction scenario, it was assumed that there were 30% less vehicles using the A259 Bexhill Road only. The scenario also assumed that there was no reduction in vehicles using other roads, including the access road to the Pebsham waste site. It was also assumed that there was no reduction in atypical re-suspension. The vehicle speeds and stock information was also not altered from the base case.
Incorporation of atypical re-suspension

The use of a model provides the opportunity to produce a deterministic approach to understanding air pollution concentrations. Thus in an ideal situation specific emissions from sources are quantified and related to their location and any variance over time.

The situation in the Hastings AQMA however represents a highly unusual situation, as the area is close to both the coast and a site handling waste. The monitoring results from the Hastings 1 site in the AQMA further confirm that Hastings has measured far higher concentrations than other comparable sites in Sussex.

The source apportionment model developed in the study determined the influence to be from sea salt spray and more importantly atypical re-suspension related to road transport (see chapter 4). Applicable emission factors for these specific sources are not available and hence the source apportionment model has been further developed to quantify the specific local contributions from these sources.

The source apportionment model was derived from an understanding of each of the individual source components. These were developed from comparisons with extensive datasets from other representative sites, with the contribution from the component termed as atypical re-suspension identified as the difference between the Hastings measurements and those of the other sites. This provides a robust understanding of source apportionment at the location of the monitoring site.

To understand the dispersion of PM$_{10}$ in the area it is necessary to use a dispersion model. The ERG toolkit provides this from modelling local primary emissions from road vehicles and background PM$_{10}$. The primary vehicle emissions are determined from both vehicle activity and the nationally available emission factors. These factors represent emissions from vehicle exhausts and tyre and brake wear. They do not incorporate the additional atypical re-suspension observed at the Hastings sites and therefore this component has to be quantified and included separately within the Toolkit.

To enable this, outputs relating to background and primary vehicle emissions from the source apportionment model and ERG toolkit were made. This established that the models were similar. The primary vehicle contribution was identified from the ERG toolkit prediction in comparison with a background only prediction. This was then compared to the contribution from the source apportionment model for both primary and re-suspended components. The ratio of the source apportionment primary and re-suspended output to ERG toolkit primary output was derived. This ratio (5.16) was then applied to the primary emissions in the ERG toolkit. The emissions modelled by the ERG toolkit thus incorporate this quantified component.

The annual mean modelled by the ERG toolkit was checked against monitored annual mean for the Hastings 1 site. The results of the check are given in Table 14.
Table 14  Annual mean results for Hastings 1 site (µgm⁻³ TEOM*1.3)

<table>
<thead>
<tr>
<th>Address:</th>
<th>Easting</th>
<th>Northing</th>
<th>Re-suspended PM₁₀</th>
<th>Measured PM₁₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>A259 Bulverhythe</td>
<td>577627</td>
<td>108722</td>
<td>37.3</td>
<td>37.6</td>
</tr>
</tbody>
</table>

Use of the additional Hastings 1 component in this way, assumes that it remains constant throughout the area modelled. In reality it is likely that the Hastings 1 site represents a mid point between the maximum re-suspension arising and that that typically arises on every road.

The analysis of Sussex 3 monitoring data provided an indication that the re-suspension component was reduced at this monitoring location further east along the A259. The modelling of the link of A259 where the Sussex 3 site was located was therefore quantified using this information. The ratio derived for this site was less i.e. 3.67. It thus provides an indication of a gradient between the Hastings 1 and Sussex 3 sites, whereby the re-suspension element is reduced.

No account however has been made of any gradient whereby the contribution increases on the westward side of the Hastings 1 site towards the access road to the Pebsham waste site; similarly no account has been made of any gradient between the junction of the access road and the Council’s western boundary with Rother D.C.

It is important therefore to recognise that the predictions are limited to the immediate geographic area of the monitoring site locations. The modelling however is based on the information available and is considered to represent a best estimate of the dispersion of PM₁₀ in the AQMA.