Air Quality Modelling for the London Borough of Hackney

Final Report

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London Borough of Hackney

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1. Summary

The whole of the London Borough of Hackney has been declared an Air Quality Management Area due to concentrations of nitrogen dioxide (NO$_2$) and fine particles (PM$_{10}$) exceeding the UK air quality standards. Air quality modelling was previously carried out to determine the extent of any exceedences of the standards, however more up-to-date monitoring and emissions data are now available and these are expected to affect the modelled concentrations. In particular, two important sets of air quality data have been updated: the London Atmospheric Emissions Inventory (LAEI) and the Department for Transport (DfT) road traffic emission factors.

Cambridge Environmental Research Consultants was commissioned by the London Borough of Hackney to carry out air quality modelling, taking into account the new LAEI and DfT emission factors, to create air quality maps for NO$_2$, PM$_{10}$ and PM$_{2.5}$.

Air quality modelling was carried out using ADMS-Urban (version 2.3.3.1) air quality modelling software using emissions and traffic data from the London Atmospheric Emissions Inventory (LAEI) 2008.

Traffic emissions were calculated using the latest set of DfT emission factors, taking into account the lack of expected reduction in NO$_x$ emissions from new diesel vehicles. PM$_{10}$ and PM$_{2.5}$ emissions included contributions from exhaust, brake and tyre-wear, and road-wear and resuspension, as applicable.

Model verification was carried out by comparing measured and modelled concentrations at Hackney’s continuous monitoring sites for 2008. The modelling shows generally good agreement between the measured and modelled concentrations indicating that the emissions data and model set-up are appropriate for the area. For NO$_x$ and NO$_2$, there is generally over-prediction at HK6, Old Street but under-prediction at HK4, Clapton. PM$_{10}$ and PM$_{2.5}$ concentrations show good agreement.

Air quality maps were created for ground level concentrations of NO$_2$, PM$_{10}$ and PM$_{2.5}$, for 2011 and 2015, for comparison against air quality standards.

The air quality standard of 40 µg/m$^3$ for annual average NO$_2$ concentrations is predicted to be exceeded around major roads in Hackney for both 2011 and 2015. The air quality standard of 200 µg/m$^3$ for the 99.79$^{th}$ percentile of hourly average NO$_2$ concentrations is predicted to be exceeded around the busiest roads and junctions in the borough for both 2011 and 2015.

There are no predicted exceedences of the air quality standards for PM$_{10}$ and PM$_{2.5}$ concentrations for either 2011 or 2015.

Based on predicted concentrations for 2011, a 10% reduction in annual average PM$_{2.5}$ concentrations is required at urban background locations in Hackney by 2020, to meet the national exposure reduction target. Concentrations are predicted to reduce by 4% - 6% at these locations between 2011 and 2015, indicating that a similar reduction is required between 2015 and 2020 to meet the target.
2. Introduction

The whole of the London Borough of Hackney has been declared an Air Quality Management Area due to concentrations of nitrogen dioxide (NO$_2$) and fine particles (PM$_{10}$) exceeding the UK air quality standards. Air quality modelling was previously carried out to determine the extent of any exceedences of the standards, however more up-to-date monitoring and emissions data are now available and these are expected to affect the modelled concentrations. In particular, two important sets of air quality data have been updated: the London Atmospheric Emissions Inventory (LAEI) and the Department for Transport (DfT) road traffic emission factors.

Cambridge Environmental Research Consultants was commissioned by the London Borough of Hackney to carry out air quality modelling, taking into account the new LAEI and DfT emission factors, to create air quality maps for NO$_2$, PM$_{10}$ and PM$_{2.5}$.

The air quality limit values and target values with which the calculated concentrations are compared are presented in Section 3. The emissions data and model set-up are described in Sections 4 and 5. The results of the modelling are then presented: the model verification in Section 6; and the concentration maps in Section 7. A discussion of the results is presented in Section 8.
3. Air quality standards

The EU ambient air quality directive (2008/50/EC) sets binding limits for concentrations of air pollutants. The directive has been transposed into English legislation as the Air Quality Standards Regulations 2010\(^1\), which also incorporates the provisions of the 4th air quality daughter directive (2004/107/EC).

The Air Quality Standards Regulations 2010 include limit values and target values. The limit values are presented in Table 3.1.

**Table 3.1: Air quality limit values**

<table>
<thead>
<tr>
<th>Compound</th>
<th>Value (µg/m(^3))</th>
<th>Description of standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO(_2)</td>
<td>200</td>
<td>Hourly mean not to be exceeded more than 18 times a calendar year (modelled as 99.79(^{th}) percentile)</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>Annual average</td>
</tr>
<tr>
<td>PM(_{10})</td>
<td>50</td>
<td>24-hour mean not to be exceeded more than 35 times a calendar year (modelled as 90.41(^{st}) percentile)</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>Annual average</td>
</tr>
<tr>
<td>PM(_{2.5})</td>
<td>25</td>
<td>Annual average</td>
</tr>
</tbody>
</table>

Note that the limit value for PM\(_{2.5}\) includes a margin of tolerance of 20% in June 2008, decreasing on the next 1st January and every 12 months thereafter by equal annual percentages to reach 0% by 1st January 2015. A target value of 25µg/m\(^3\) also exists for PM\(_{2.5}\).

The regulations also include national exposure reduction targets for PM\(_{2.5}\), as set out in Table 3.2. These are based on the average exposure indicator (AEI) which is calculated as the three-year average of all measured PM\(_{2.5}\) concentrations at urban background locations, e.g. the AEI for 2010 must be based on measurements for the years 2009, 2010 and 2011.

Table 3.2: Exposure reduction target for PM$_{2.5}$ relative to the AEI in 2010

<table>
<thead>
<tr>
<th>Initial concentration (µg/m³)</th>
<th>Reduction target (%)</th>
<th>Year by which exposure reduction target should be met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than or equal to 8.5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>More than 8.5 but less than 13</td>
<td>10</td>
<td>2020</td>
</tr>
<tr>
<td>13 to less than 18</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>18 to less than 22</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>22 or more</td>
<td>All appropriate measures to reach 18 µg/m³</td>
<td></td>
</tr>
</tbody>
</table>

The short-term standards considered are specified in terms of the number of times during a year that a concentration measured over a short period of time is permitted to exceed a specified value. For example, the concentration of NO$_2$ measured as the average value recorded over a one-hour period is permitted to exceed the concentration of 200 µg/m$^3$ up to 18 times per year. Any more exceedences than this during a one-year period would represent a breach of the objective.

It is convenient to model objectives of this form in terms of the equivalent percentile concentration value. A percentile is the concentration below which lie a specified percentage of concentration measurements. For example, consider the 98$^{th}$ percentile of one-hour concentrations over a year. Taking all of the 8760 one-hour concentration values that occur in a year, the 98$^{th}$ percentile value is the concentration below which 98% of those concentrations lie. Or, in other words, it is the concentration exceeded by 2% (100 – 98) of those hours, that is, 175 hours per year. Taking the NO$_2$ objective considered above, allowing 18 exceedences per year is equivalent to not exceeding for 8742 hours or for 99.79% of the year. This is therefore equivalent to the 99.79$^{th}$ percentile value.
4. Emissions data

The modelling for this study has been based on emissions data taken from the London Atmospheric Emissions Inventory (LAEI 2008), released by the Greater London Authority (GLA) in 2010.

4.1. Traffic flow data

Traffic flows and speeds for all major roads in London were taken from the LAEI, where data are provided for the years 2008, 2011 and 2015.

For the model verification, all major roads within 1500 metres of the monitoring sites were modelled in detail, with all other roads in London modelled as part of a 1-kilometre resolution grid source. In order to generate pollution maps, all major roads inside and within a distance of 1500 metres of Hackney were modelled in detail. Figure 4.1 shows the major roads in Hackney.
Figure 4.1: Major roads in the London Borough of Hackney
4.2. Traffic emissions

Emission rates for each road were calculated using the LAEI traffic flows and speeds and the latest set of DfT emission factors released in 2009. These include primary NO\textsubscript{2} emission factors for each vehicle type resulting in accurate road-by-road NO\textsubscript{x} and NO\textsubscript{2} emission rates.

4.2.1. Diesel NO\textsubscript{x} emissions

Recent evidence from NO\textsubscript{x} and NO\textsubscript{2} monitoring data in urban areas has shown that diesel NO\textsubscript{x} emissions are not decreasing at the expected rate, as discussed in a Defra Frequently Asked Question in September 2010. In this modelling study, in line with Defra guidance, NO\textsubscript{x} emissions from all EURO 2 to EURO 5 diesel vehicles have been set to be the same as the equivalent EURO 1 vehicles. Primary NO\textsubscript{2} emissions have been calculated by applying the primary NO\textsubscript{2} fraction for each vehicle type to the EURO 1-equivalent NO\textsubscript{x} emissions. It is expected that emissions from EURO 6 vehicles will meet the expected emission reductions so these emission factors are unchanged. These changes have the effect of increasing NO\textsubscript{x} and NO\textsubscript{2} road traffic emission rates for all years; PM\textsubscript{10} and PM\textsubscript{2.5} emissions are unaffected.

4.2.2. Brake and tyre-wear

Brake and tyre-wear emissions data have been taken directly from the LAEI and added to the exhaust emissions of PM\textsubscript{10} and PM\textsubscript{2.5} for each road.

4.2.3. Road-wear and resuspension

Concentrations of PM\textsubscript{10} and PM\textsubscript{2.5} at roadside locations are affected by road-wear, and concentrations of PM\textsubscript{10} are affected by resuspension. These are not quantified in the LAEI but a recent study prepared for Defra presented combined road-wear and resuspension emission factors for light and heavy vehicles. These were used to calculate road-by-road road-wear and resuspension emission rates and were added to the exhaust and brake and tyre-wear emission rates.

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2 http://www.dft.gov.uk/pgr/roads/environment/emissions/
3 Measured nitrogen oxides (NOx) and/or nitrogen dioxide (NO2) concentrations in my local authority area do not appear to be declining in line with national forecasts. Should I take this into account in my Review and Assessment work? http://laqm2.defra.gov.uk/FAQs/General/Measured nitrogen oxides (NOx) and-or nitrogen dioxide (NO2) concentrations do not appear to be declining in line with national forecasts.pdf
4 Road vehicle non-exhaust particulate matter: initial air quality model development and application, model uncertainty analysis and further model improvements, prepared by TRL for DEFRA 2007 http://www.airquality.co.uk/archive/reports/cat15/0706061626_Report3__Modelling_Development.pdf
4.2.4. Daily traffic variation

The variation of traffic flow during the day has been taken into account by applying a set of diurnal profiles to the road emissions. These profiles were taken from the report *Air pollution and emissions trends in London*\(^5\) used in the compilation of the LAEI, and are shown in Figure 4.2.

![Diurnal profiles for Central London](image)

*Figure 4.2: Diurnal profiles for Central London*

4.3. Industrial sources

The South East London Combined Heat and Power Plant (SELCHP) is approximately 5 km to the south of Hackney so, due to its high NO\(_x\) emission rate, has been included explicitly in the modelling.

4.4. Other emissions

Emission rates for all other sources were taken from the LAEI and modelled as aggregated 1-kilometre resolution grid sources covering the whole of London.

\(^5\) *Air pollution and emissions trends in London*, King’s College London, Environmental Research Group and Leeds University, Institute for Transport studies [http://www.airquality.co.uk/reports/cat05/1004010934_MeasurementvsEmissionsTrends.pdf](http://www.airquality.co.uk/reports/cat05/1004010934_MeasurementvsEmissionsTrends.pdf)
5. Model set-up

Modelling was carried out using the ADMS-Urban model (version 2.3.3.1). The model uses the detailed emissions data described in Section 4 together with a range of other input data to calculate the dispersion of pollutants. This section summarises the data and assumptions used in the modelling.

5.1. Surface roughness

A length scale parameter called the surface roughness length is used in the model to characterise the study area in terms of the effects it will have on wind speed and turbulence, which are key factors in the modelling. A value of 1 metre was used in the modelling.

The difference in land use at Heathrow compared to the study area was taken into account by entering a different surface roughness for the meteorological site. See Section 5.3 for further details.

5.2. Monin-Obukhov Length

In urban and suburban areas a significant amount of heat is emitted by buildings and traffic, which warms the air within and above a city. This is known as the urban heat island and its effect is to prevent the atmosphere from becoming very stable. In general, the larger the urban area the more heat is generated and the stronger the effect becomes.

In the ADMS-Urban model, the stability of the atmosphere is represented by the Monin-Obukhov parameter, which has the dimension of length. In very stable conditions it has a positive value of between 2 metres and 20 metres. In near neutral conditions its magnitude is very large, and it has either a positive or negative value depending on whether the surface is being heated or cooled by the air above it. In very convective conditions it is negative with a magnitude of typically less than 20 metres.

The effect of the urban heat island is that, in stable conditions, the Monin-Obukhov length will never fall below some minimum value; the larger the city, the larger the minimum value. A value of 75 metres was used in the modelling.

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6 http://www.cerc.co.uk/environmental-software/ADMS-Urban-model.html
5.3. Meteorological data

Meteorological data from Heathrow for the year 2008 were used in the modelling. A summary of the data is given in Table 5.1. Figure 5.1 shows a wind rose giving the frequency of occurrence of wind from different directions for a number of wind speed ranges.

The difference in land use at Heathrow compared to the study area was taken into account by entering a different surface roughness for the meteorological site. The surface roughness for Heathrow was set to 0.1 metre, compared to 1 metre for Central London.

Table 5.1: Summary of meteorological data

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (°C)</td>
<td>-3.7</td>
<td>29.1</td>
<td>11.3</td>
</tr>
<tr>
<td>Wind speed (m/s)</td>
<td>0</td>
<td>14.4</td>
<td>4.4</td>
</tr>
<tr>
<td>Cloud cover (oktas)</td>
<td>0</td>
<td>8</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Figure 5.1: Wind rose for Heathrow, 2008
5.4. **NO\textsubscript{x} chemistry and background data**

Nitrogen dioxide (NO\textsubscript{2}) results from direct emissions from combustion sources together with chemical reactions in the atmosphere involving NO\textsubscript{2}, nitric oxide (NO) and ozone (O\textsubscript{3}). The combination of NO and NO\textsubscript{2} is referred to as nitrogen oxides (NO\textsubscript{x}).

The chemical reactions taking place in the atmosphere were taken into account in the modelling using the Generic Reaction Set (GRS) of equations. These use hourly average background concentrations of NO\textsubscript{x}, NO\textsubscript{2} and O\textsubscript{3}, together with meteorological and modelled emissions data to calculate the NO\textsubscript{2} concentration at a given point.

All emissions of NO\textsubscript{x} and NO\textsubscript{2} from within the city are included in the modelling. Hourly background data for these pollutants and ozone were input to the model to represent the concentrations in the air being blown into the city. These data were obtained from rural monitoring sites around the city as described in Section 5.4.1.

PM\textsubscript{10} concentrations at any location can be thought of as being made up of a primary component (directly emitted), a secondary component (formed from primary particulates by subsequent reactions) and a coarse component (such as resuspended dust). Only primary particulates are included in the emissions inventory, with secondary PM\textsubscript{10} concentrations calculated by the model using SO\textsubscript{2} background and emissions data.

5.4.1. **Background data for 2008**

NO\textsubscript{x}, NO\textsubscript{2} and O\textsubscript{3} concentrations from Rochester, Harwell, Lullingston Heath and Wicken Fen were input to the model, the monitored concentration used for each hour depending upon the wind direction for that hour, as shown in Figure 5.2.

Two sources of PM\textsubscript{10} and PM\textsubscript{2.5} background data were used for the 2008 validation modelling. For hours for which the wind direction was from the west, rural PM\textsubscript{10} and PM\textsubscript{2.5} data from Harwell were used and for hours for which the wind direction was from the east, rural PM\textsubscript{10} and PM\textsubscript{2.5} measurements from Rochester were used.

The PM\textsubscript{10} and PM\textsubscript{2.5} background concentrations were calculated using data from Harwell and Rochester only, as these are the only rural sites which monitor hourly average PM\textsubscript{10} and PM\textsubscript{2.5} in the south of England. A coarse component of 2µg/m\textsuperscript{3} was added to the monitored PM\textsubscript{10} concentrations.

Table 5.2 summarises the annual statistics of the resulting background concentrations used in the modelling for 2008.
Air Quality Modelling for the London Borough of Hackney

Figure 5.2 Wind direction segments used to calculate background concentrations for NO$_x$, NO$_2$ and O$_3$ (left) and PM$_{10}$ and PM$_{2.5}$ (right)

Table 5.2: Background concentrations for 2008 (µg/m$^3$)

<table>
<thead>
<tr>
<th></th>
<th>NO$_x$</th>
<th>NO$_2$</th>
<th>O$_3$</th>
<th>PM$_{10}$</th>
<th>PM$_{2.5}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual average</td>
<td>13.0</td>
<td>9.4</td>
<td>54.5</td>
<td>19.5</td>
<td>9.4</td>
</tr>
<tr>
<td>99.79$^{th}$ percentile of hourly average</td>
<td>147.9</td>
<td>60.3</td>
<td>127.1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>90.41$^{st}$ percentile of 24-hour average</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>36.0</td>
<td>16.0</td>
</tr>
</tbody>
</table>

5.4.2. Background data for 2011 and 2015

Background concentrations of NO$_x$, NO$_2$ and O$_3$ for 2008 were used for 2011 and 2015. Defra guidance$^3$, discussed in section 4.2.1, suggests that forecast reductions in background NO$_x$ and NO$_2$ concentrations in future year projections are likely to be optimistic. In line with this guidance, background concentrations of NO$_x$, NO$_2$ and O$_3$ are assumed to remain constant between 2008 and 2015 in this modelling study.

Background concentrations of PM$_{10}$ and PM$_{2.5}$ for 2011 and 2015 were obtained by projecting forward hourly measured data from 2008. Factors for the projection were calculated by comparing 2008 concentrations against 2011 and 2015 concentrations in the LAQM 2008 base year background maps$^7$, for the locations of the Harwell and Rochester stations.

Table 5.3 summarises the annual statistics of the resulting background PM$_{10}$ and PM$_{2.5}$ concentrations used in the modelling for 2011 and 2015.

---

Table 5.3: PM$_{10}$ and PM$_{2.5}$ background concentrations for 2011 and 2015 (µg/m$^3$)

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th></th>
<th>2015</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PM$_{10}$</td>
<td>PM$_{2.5}$</td>
<td>PM$_{10}$</td>
<td>PM$_{2.5}$</td>
</tr>
<tr>
<td>Annual average</td>
<td>18.7</td>
<td>8.9</td>
<td>18.2</td>
<td>8.5</td>
</tr>
<tr>
<td>90.41$^{st}$ percentile of 24-hour average</td>
<td>34.5</td>
<td>15.0</td>
<td>33.6</td>
<td>14.4</td>
</tr>
</tbody>
</table>
6. Model verification

The first stage of a modelling study is to model a current case in order to verify that the input data and model set-up are representative for the area. This was carried out by calculating hourly average concentrations of NO\textsubscript{x}, NO\textsubscript{2}, PM\textsubscript{10} and PM\textsubscript{2.5} at the sites of the continuous monitors in Hackney and comparing the measured and modelled concentrations. Note that the meteorological data used in the modelling and the measured pollutant concentrations contain some missing values; the statistics compared in this exercise therefore only include hours for which both measured and modelled concentrations are available.

The London Borough of Hackney had two continuous monitors in operation in 2008; both measuring NO\textsubscript{x}, NO\textsubscript{2} and PM\textsubscript{2.5}, and one (HK6, Old Street) measuring PM\textsubscript{10}. Figure 6.1 shows the locations of the monitoring sites and Table 6.1 summarises their locations.

Table 6.1: Monitoring site details

<table>
<thead>
<tr>
<th>Site</th>
<th>Grid reference</th>
<th>Height (m)</th>
<th>Distance from road (m)</th>
<th>Street canyon height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HK4 Clapton</td>
<td>534830 186234</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>HK6 Old Street</td>
<td>532947 182573</td>
<td>3</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>
Figure 6.1: London Borough of Hackney continuous monitoring sites
Tables 6.2 to 6.5 show the measured and modelled concentrations of NO\(_x\), NO\(_2\), PM\(_{10}\) and PM\(_{2.5}\) for 2008 at the two continuous monitoring sites, together with the modelled concentrations expressed as a percentage of the measured concentrations. A value of 100% would indicate perfect agreement between measured and modelled data, with values greater than 100% indicating that the model is over-predicting concentrations and values less than 100% showing model under-prediction.

Table 6.2: Measured and modelled concentrations of NO\(_x\) for 2008

<table>
<thead>
<tr>
<th>Site</th>
<th>Annual average (µg/m³)</th>
<th>99.79(^{th}) percentile (µg/m³)</th>
<th>Measured</th>
<th>Modelled</th>
<th>%</th>
<th>Measured</th>
<th>Modelled</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>HK4 Clapton</td>
<td>86.3</td>
<td>79.4</td>
<td>92</td>
<td>734.0</td>
<td>529.4</td>
<td>72</td>
<td>983.7</td>
<td>168</td>
</tr>
<tr>
<td>HK6 Old Street</td>
<td>143.1</td>
<td>185.4</td>
<td>130</td>
<td>585.8</td>
<td>983.7</td>
<td>168</td>
<td>935.7</td>
<td>168</td>
</tr>
</tbody>
</table>

Table 6.3: Measured and modelled concentrations of NO\(_2\) for 2008

<table>
<thead>
<tr>
<th>Site</th>
<th>Annual average (µg/m³)</th>
<th>99.79(^{th}) percentile (µg/m³)</th>
<th>Measured</th>
<th>Modelled</th>
<th>%</th>
<th>Measured</th>
<th>Modelled</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>HK4 Clapton</td>
<td>50.7</td>
<td>42.8</td>
<td>84</td>
<td>200.9</td>
<td>159.0</td>
<td>79</td>
<td>258.2</td>
<td>160</td>
</tr>
<tr>
<td>HK6 Old Street</td>
<td>69.5</td>
<td>74.7</td>
<td>108</td>
<td>161.3</td>
<td>258.2</td>
<td>160</td>
<td>258.2</td>
<td>160</td>
</tr>
</tbody>
</table>

Table 6.4: Measured and modelled concentrations of PM\(_{10}\) for 2008

<table>
<thead>
<tr>
<th>Site</th>
<th>Annual average (µg/m³)</th>
<th>90.41(^{nd}) percentile (µg/m³)</th>
<th>Measured</th>
<th>Modelled</th>
<th>%</th>
<th>Measured</th>
<th>Modelled</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>HK6 Old Street</td>
<td>31.3</td>
<td>27.9</td>
<td>89</td>
<td>42.9</td>
<td>44.8</td>
<td>104</td>
<td>44.8</td>
<td>104</td>
</tr>
</tbody>
</table>

Table 6.5: Measured and modelled concentrations of PM\(_{2.5}\) for 2008

<table>
<thead>
<tr>
<th>Site</th>
<th>Annual average (µg/m³)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HK4 Clapton</td>
<td>11.7</td>
<td>11.5</td>
<td>98</td>
</tr>
<tr>
<td>HK6 Old Street</td>
<td>14.4</td>
<td>14.8</td>
<td>102</td>
</tr>
</tbody>
</table>

The modelling shows generally good agreement between the measured and modelled concentrations indicating that the emissions data and model set-up are appropriate for the area.

For NO\(_x\) and NO\(_2\), there is generally over-prediction at Old Street but under-prediction at Clapton. PM\(_{10}\) and PM\(_{2.5}\) concentrations show good agreement.
7. Air quality maps

Ground level concentrations of NO$_2$, PM$_{10}$ and PM$_{2.5}$, for 2011 and 2015, were calculated on a grid of receptor points across the whole borough, with a grid resolution of 50m. Extra receptor points were added close to the modelled roads, where concentration gradients are highest. Concentrations were predicted to allow comparison against the air quality standards presented in Section 3 and presented in the form of coloured contour maps.

7.1. NO$_2$ air quality maps

Figure 7.1 and Figure 7.2 show predicted annual average NO$_2$ concentrations across Hackney for 2011 and 2015 respectively. Predicted 99.79$^{th}$ percentile of hourly average NO$_2$ concentrations are shown in Figure 7.3 and Figure 7.4 for 2011 and 2015 respectively.

The air quality standard of 40 µg/m$^3$ for annual average NO$_2$ concentrations is predicted to be exceeded around major roads in Hackney for both 2011 and 2015. The area of exceedence is predicted to be smaller for 2015, than for 2011.

The air quality standard of 200 µg/m$^3$ for the 99.79$^{th}$ percentile of hourly average NO$_2$ concentrations is predicted to be exceeded around the busiest roads and junctions in the borough for both 2011 and 2015. The predicted areas of exceedence are similar for 2011 and 2015.
Figure 7.1: Predicted annual average NO\textsubscript{2} concentrations (µg/m\textsuperscript{3}), 2011
Figure 7.2: Predicted annual average NO\textsubscript{2} concentrations (µg/m\textsuperscript{3}), 2015
Figure 7.3: Predicted 99.79th percentile of hourly average NO\textsubscript{2} concentrations (µg/m\textsuperscript{3}), 2011
Figure 7.4: Predicted 99.79th percentile of hourly average NO₂ concentrations (µg/m³), 2015
7.2. PM\textsubscript{10} air quality maps

Figure 7.5 and Figure 7.6 show predicted annual average PM\textsubscript{10} concentrations across Hackney for 2011 and 2015 respectively. Predicted 90.41\textsuperscript{st} percentile of 24-hour average PM\textsubscript{10} concentrations are shown in Figure 7.7 and Figure 7.8 for 2011 and 2015 respectively.

There are no predicted exceedences of the air quality standard of 40 µg/m\textsuperscript{3} for annual average PM\textsubscript{10} concentrations for either 2011 or 2015.

There are no predicted exceedences of the air quality standard of 50 µg/m\textsuperscript{3} for the 90.41\textsuperscript{st} percentile of 24-hour average PM\textsubscript{10} concentrations for either 2011 or 2015.
Figure 7.5: Predicted annual average PM$_{10}$ concentrations ($\mu$g/m$^3$), 2011
Figure 7.6: Predicted annual average $PM_{10}$ concentrations ($\mu g/m^3$), 2015
Figure 7.7: Predicted 90.41\textsuperscript{st} percentile of 24-hour average PM\textsubscript{10} concentrations (µg/m\textsuperscript{3}), 2011

PM\textsubscript{10} concentration (µg/m\textsuperscript{3})

- < 34
- 34 - 36
- 36 - 38
- 38 - 40
- 40 - 45
- 45 - 50
- > 50
Figure 7.8: Predicted 90.41st percentile of 24-hour average PM$_{10}$ concentrations (µg/m$^3$), 2015
7.3. PM$_{2.5}$ air quality maps

Figure 7.9 and Figure 7.10 show predicted annual average PM$_{2.5}$ concentrations across Hackney for 2011 and 2015 respectively.

There are no predicted exceedences of the air quality standard of 25 µg/m$^3$ for annual average PM$_{2.5}$ concentrations for either 2011 or 2015.

Across most of the borough, annual average PM$_{2.5}$ concentrations at urban background locations are predicted to be between 10 µg/m$^3$ and 11 µg/m$^3$ for 2011. For 2015, urban background concentrations across most of the borough are predicted to be between 9 µg/m$^3$ and 10 µg/m$^3$. 
Figure 7.9: Predicted annual average PM$_{2.5}$ concentrations (µg/m$^3$), 2011
Figure 7.10: Predicted annual average PM$_{2.5}$ concentrations ($\mu$g/m$^3$), 2015
8. Discussion

The whole of the London Borough of Hackney has been declared an Air Quality Management Area due to concentrations of nitrogen dioxide (NO$_2$) and fine particles (PM$_{10}$) exceeding the UK air quality standards. Air quality modelling was previously carried out to determine the extent of any exceedences of the standards, however more up-to-date monitoring and emissions data are now available and these are expected to affect the modelled concentrations. In particular, two important sets of air quality data have been updated: the London Atmospheric Emissions Inventory (LAEI) and the Department for Transport (DfT) road traffic emission factors.

Cambridge Environmental Research Consultants was commissioned by the London Borough of Hackney to carry out air quality modelling, taking into account the new LAEI and DfT emission factors, to create air quality maps for NO$_2$, PM$_{10}$ and PM$_{2.5}$.

Air quality modelling was carried out using ADMS-Urban (version 2.3.3.1) air quality modelling software using emissions and traffic data from the London Atmospheric Emissions Inventory (LAEI) 2008.

Traffic emissions were calculated using the latest set of DfT emission factors, taking into account the lack of expected reduction in NO$_x$ emissions from new diesel vehicles. PM$_{10}$ and PM$_{2.5}$ emissions included contributions from exhaust, brake and tyre-wear, and road-wear and resuspension, as applicable.

Model verification was carried out by comparing measured and modelled concentrations at Hackney’s continuous monitoring sites for 2008. The modelling shows generally good agreement between the measured and modelled concentrations indicating that the emissions data and model set-up are appropriate for the area. For NO$_x$ and NO$_2$, there is generally over-prediction at HK6, Old Street but under-prediction at HK4, Clapton. PM$_{10}$ and PM$_{2.5}$ concentrations show good agreement.

Air quality maps were created for ground level concentrations of NO$_2$, PM$_{10}$ and PM$_{2.5}$, for 2011 and 2015. Concentrations were predicted to allow comparison against the air quality standards.

The air quality standard of 40 µg/m$^3$ for annual average NO$_2$ concentrations is predicted to be exceeded around major roads in Hackney for both 2011 and 2015. The air quality standard of 200 µg/m$^3$ for the 99.79th percentile of hourly average NO$_2$ concentrations is predicted to be exceeded around the busiest roads and junctions in the borough for both 2011 and 2015.

There are no predicted exceedences of the air quality standard of 40 µg/m$^3$ for annual average PM$_{10}$ concentrations or the air quality standard of 50 µg/m$^3$ for the 90.41st percentile of 24-hour average PM$_{10}$ concentrations, for either 2011 or 2015.

There are no predicted exceedences of the air quality standard of 25 µg/m$^3$ for annual average PM$_{2.5}$ concentrations for either 2011 or 2015.
Across most of the borough, annual average PM$_{2.5}$ concentrations at urban background locations are predicted to be between 10 µg/m$^3$ and 11 µg/m$^3$ for 2011. Therefore a 10% reduction in annual average PM$_{2.5}$ concentrations is required at these locations by 2020, to meet the national exposure reduction target.

Figure 8.1 shows the percentage reduction in annual average PM$_{2.5}$ concentrations between 2011 and 2015. At urban background locations in Hackney concentrations are predicted to reduce by 4% - 6% between these years, indicating that a similar reduction is required between 2015 and 2020 to meet the national exposure reduction target.
Figure 8.1: Percentage change in predicted annual average PM$_{2.5}$ concentrations between 2011 and 2015