Environmental Research Group

The air quality impact of the Regent Street 'traffic free day', 3rd November 2012

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Summary

Background

In recent years the level of public concern relating to the health impacts of air pollution has increased, fuelled by a number of high profile Government reports and related media coverage. First, in March 2010 the cross-party Environmental Audit Committee reported on their enquiry into UK air quality (House of Commons, 2010). The report concluded that "poor air quality probably causes more mortality and morbidity than passive smoking, road traffic accidents or obesity. Yet it receives little or no attention in the media and scant attention in Parliament." The Committee recommended that greater emphasis should be placed on public awareness raising and action taken to tackle the problem. The second high impact report was released in June 2010 by the Mayor of London, ascribing the premature deaths of more than 4,000 Londoners per year to fine particulate air pollution (IOM, 2010). These reports were followed in September 2011 with a formal Government submission to the European Commission stating that even with current and planned initiatives to improve air quality, nitrogen dioxide levels within Greater London will not meet the required standard by 2015, raising the prospect of fines levied by the EU (Defra, 2011).

This coverage has led to an unprecedented level of support within Central Government, the London Boroughs, the Mayor of London and, importantly, members of the public for initiatives that aim to improve London's air quality.

Recent research has shown that exhaust emission controls dictated by EU new vehicle emission limits ('Euro Standards') have not delivered the expected improvements in air quality resulting from modern diesel engines entering the vehicle fleet (Carlaw *et al*, 2011). In some cases, exhaust technology has acted to increase nitrogen dioxide emissions close to the roadside (AQEG, 2007). This reinforces the view that decreasing the number of vehicles on London's roads is likely to have a greater and more immediate effect than relying on technology to clean up vehicle emissions.

Air quality along Regent Street and Oxford Street

Despite the area's high international profile, long term measurements of air pollution levels along Oxford Street and Regent Street are extremely limited. However, daily measurements of PM_{10} (particulate matter less than 10 µg in diameter) recorded close to the kerb on Oxford Street since late 2010 suggest that PM_{10} levels along both streets are within EU Limit Values. Conversely, fortnightly measurements of nitrogen dioxide (NO_2) taken at the same location indicated that annual mean concentrations of NO_2 were around three times higher than the EU Limit Value of 40 µg m^{-3} in 2009 and 2010 (144 µg m^{-3} and 114 µg m^{-3} respectively). Extrapolation of short-term monitoring during 2011 carried out by King's College London indicated that NO_2 levels on Regent Street were as high as those on Oxford Street and both were likely to experience frequent peak hourly mean pollution levels above the short term EU Limit Value of 200 µg m^{-3}.

In summary, NO_2 concentrations along Oxford Street and Regent Street are currently in breach of legal air quality limits. Without action additional to that planned by central Government and TfL, this situation is likely to continue beyond 2015.

No long-term assessments of $PM_{2.5}$ concentrations along either street have been made.

The health impacts of poor air quality

PM_{10} and NO_2 concentrations along Oxford Street and Regent Street are not exceptional in comparison with other busy roadside locations in Central London. However, two characteristics of the area make the potential health impacts of air pollution more acute than in most of London's streets. This is one of the most popular shopping destinations in Europe, with most major stores fronting directly onto the major densely trafficked thoroughfare. Exposure to air pollution multiplied both in numbers of people affected and duration, as shoppers spend significant periods walking to and from stores. Secondly, all vehicles passing along Oxford Street and the majority of vehicles passing along Regent Street are diesel fuelled. Current research suggests that particulate pollution arising specifically from diesel combustion is more closely linked to health impacts than particulate pollution from other sources (van Vliet *et al*, 1997).

Diesel engines are known to emit a higher proportion of NO_2 and a greater mass of fine particulate matter ($PM_{2.5}$), than petrol and engines. While the health impacts of NO_2 remain the subject of some uncertainty, the health impacts of $PM_{2.5}$ on short and long term health are now well established. A well-publicised study

published in 2007 found that both during and after a two hour walk along Oxford Street, volunteers experienced increased asthmatic symptoms, reduced lung capacity and inflammation in the lungs (McCreanor *et al*, 2007). A similar study is currently underway investigating the impact of a two hour walk along Oxford Street on the cardiovascular health of volunteers. The WHO estimates that average life expectancy of residents in EU countries is 8.6 months lower due to exposure to $PM_{2.5}$ produced by human activities (WHO, 2006).

The EU Limit Values discussed above are based on WHO Air Quality Guidelines. These guidelines represent the most widely agreed and up-to-date assessment of health effects of air pollution, recommending targets for air quality at which the health risks are significantly reduced[8]. As no threshold for PM has been identified below which no damage to health is observed, the aim is to achieve the lowest concentrations possible. While PM_{10} concentrations along Oxford Street have been shown to be within the EU Limit Values, they are above the more stringent WHO Guideline, which represents "an acceptable and achievable objective to minimize health effects in the context of local constraints, capabilities and public health priorities."

The impact of traffic free days on air quality

Researchers at King's College London have carried out two studies into the impact of traffic free days on air quality along Oxford Street and Regent Street (Barratt, 2011). Pollution levels were recorded for periods prior to, during and following the traffic free days in fixed locations and carried by pedestrians using mobile monitors. A range of analysis methods were used to quantify changes in concentrations resulting from the traffic ban, independent of other influences such as the weather and unrelated vehicle emissions.

These studies found that during the hours of the vehicle ban black carbon, PM_{10} and nitrogen dioxide levels were between 50% and 75% lower than on a day of normal operation, dependent on pollutant and weather conditions. Nitrogen dioxide concentrations during the vehicle ban fell to a level similar to those recorded at the same time in a nearby park. The mobile monitoring showed that Red Cap Wardens were exposed to half of the pollution they would have been exposed to on a normal patrol day. Levels of black carbon (a component of fine particulate matter closely linked to diesel exhaust) breathed by pedestrians during the second study were 70% lower on Regent Street, which was closed to traffic, than on Oxford Street, which remained open.

As well as creating a more relaxed and pleasant environment, reductions in pollution concentrations associated with a vehicle ban far exceed those predicted by other initiatives, such as exhaust emission controls, speed restrictions, taxi age restrictions, dust suppression and green walls.

Contents

1. Background

In recent years, the New West End Company and Regent Street Association have organised a series of successful vehicle closure days in the Christmas period in order to provide a safer, healthier and more pleasant shopping environment for shoppers. It is hoped that this initiative can be extended during 2013 to include 'Summer Streets' traffic free days similar to those held in New York.

King's College London was commissioned to carry out a study of the air quality impacts of the Oxford and Regent Street VIP day held in November 2010. This study showed that during the closure period pollution concentrations dropped by between 50% and 76% in comparison with concentrations recorded during normal operation. On 3rd November 2012 the southern end of Regent Street was closed to all traffic between 8:00 and 17:30. This vehicle ban provided a second opportunity to measure the impact of vehicle emissions on air quality at the kerb, and that breathed by pedestrians.

This report contains methodology and results of the study as well as a discussion of the findings.

2. Introduction

In recent years the level of public concern relating to the health impacts of air pollution has increased. A number of high profile public documents, and related media coverage, have fuelled this exposure. First, in March 2010 the cross-party Environmental Audit Committee reported on their enquiry into the role of the UK Government in improving air quality (House of Commons, 2013). The report concluded that "poor air quality probably causes more mortality and morbidity than passive smoking, road traffic accidents or obesity. Yet it receives little or no attention in the media and scant attention in Parliament." The Committee recommended that greater emphasis should be placed on public awareness raising and action taken to tackle the problem. The second high impact report was released in June 2010 by the Mayor of London, ascribing the premature deaths of more than 4,000 Londoners per year to fine particulate air pollution (IOM, 2010). These reports were followed in September 2011 with a formal Government submission to the European Commission stating that even with current and planned initiatives to improve air quality, nitrogen dioxide levels within Greater London will not meet the required standard by 2015, raising the prospect of fines levied by the EU (Defra, 2011).

This coverage has led to an unprecedented level of support within Central Government, the London Boroughs, the Mayor of London and, importantly, members of the public for initiatives that aim to improve London's air quality.

This report presents the results of a recent study into the air quality impact of the closure to vehicles of the southern end of Regent Street on 3rd November 2012. Results are discussed in the context of related studies on Regent Street and Oxford Street carried out in recent years. The report's objective is to provide a source document in support of future initiatives by the Crown Estate and associates in the development of future traffic reduction initiatives, such as the Summer Streets programme.

3. Methods

3.1 Pollutant monitoring programme

The study was designed to assess the extent, duration and nature of changes in air pollution levels along Regent Street caused by a ban on vehicles between 8am and 5:30pm on 3rd November 2012.

As no air quality monitoring was routinely carried out on Regent Street, equipment had to be installed for the duration of the study. Two pollutants were selected for analysis – nitrogen dioxide (NO_2) and black carbon. Previous studies have shown that nitrogen dioxide levels along Regent Street are well above WHO health guidelines, principally due to diesel vehicle exhaust emissions. Black carbon is a component of fine particulate matter related to diesel vehicle exhaust. Current research suggests that black carbon is one of the main drivers of the health impacts of urban air pollution. Therefore, these two pollutants were considered the most relevant both in legislative and public health terms.

Nitrogen dioxide levels were continuously monitored for three weeks spanning the closure day at a fixed location on the west side of Regent Street. The equipment was housed on the first floor balcony outside of the Regent Street Direct offices at 177 Regent Street, with the sample inlet positioned at a height of 5m above street level (Figure 1). The monitor was an Environnement AC31M chemiluminescent NO_X analyser. While the analyser used for NO_2 monitoring was by a method approved for use on the national monitoring network, the short monitoring period prevented full QA/QC procedures to be followed. Consequently, results of NO_2 monitoring should be considered as indicative, particularly when measured against EU Limit Values.

Portable monitoring equipment was used to map NO_2 and black carbon concentrations along Regent Street and Oxford Street on the closure day and two days of 'normal' operation. During these deployments, two researchers simultaneously walked along both sides of both streets between 11am and 2pm on 27th November (Saturday before closure), 2nd November (day before closure) and 3rd November (closure day). One minute averages were aggregated and smoothed to produce the concentration maps. Black carbon was monitored via Aethlabs AE51 Microaethalometers. NO_2 was monitored using electrochemical sensors developed and operated by the University of Cambridge Chemistry Department.

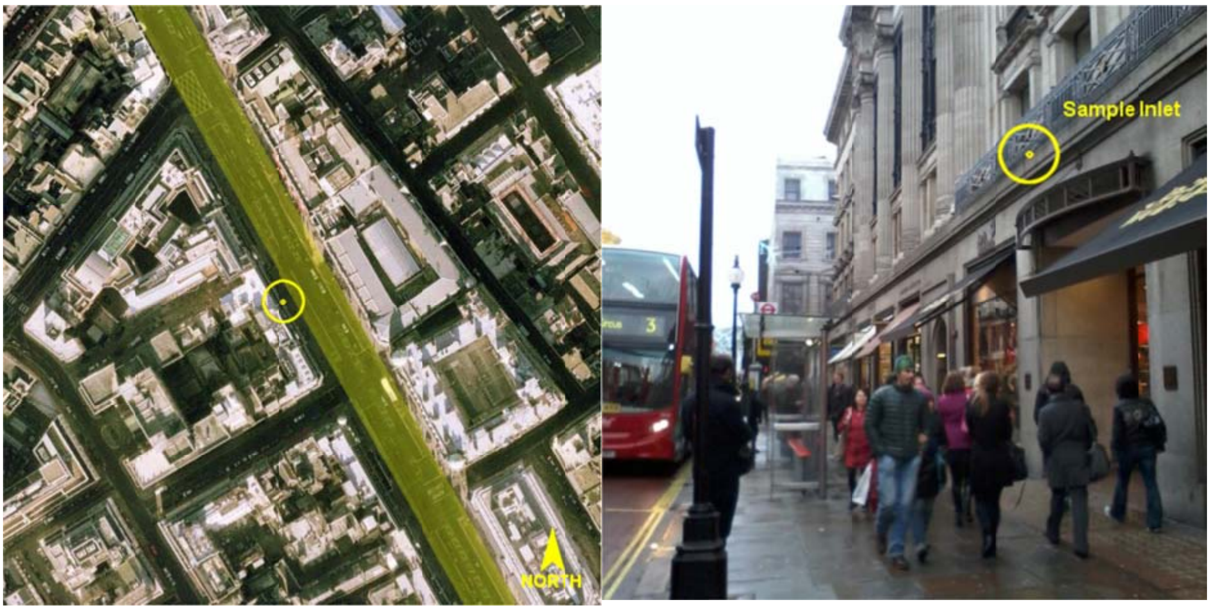

Figure 1: Aerial view of the fixed NO_2 monitoring location on Regent Street (left panel), with a photograph of the monitoring inlet (right panel).
The location of the monitoring inlet is shown by a yellow circle, the road carriageways by a yellow band.

3.2 Analysis methods

Pollution concentrations at a fixed point close to a road are dictated by a combination of four major factors; local vehicle emissions, local non-vehicle emissions, non-local emissions arising within London and beyond and weather conditions. The methodology used in this study aimed to minimise the effect of variations in non-local emissions and weather conditions in order to attribute changes in pollution concentrations to the impact of the vehicle ban. The precise method used varied between pollutants, dependent on the nature of the pollutant and available data.

There is a strong relationship between pollution concentrations close to a road and weather conditions. During calm conditions pollution emitted from the vehicles is not dispersed by the wind as quickly as during windy conditions. Wind direction is also extremely important. If the local wind direction is such that pollution emitted from vehicles on the road is blown away from the sample inlet of the analyser, pollution measurements will be much lower than if pollution is blown towards the inlet. The importance of wind direction on pollution levels is discussed in more detail in the 2010 VIP day report (Barratt, 2011).

Unlike the previous road closure study, weather conditions throughout the monitoring period were characterised by steady south westerly winds. This stable weather pattern made assessment of the road closure more straightforward; measured concentrations on the closure day could be compared to those on non-closure days when winds were from the south west. Measurements taken on Sundays were excluded from the analysis dataset.

However, these stable weather conditions meant that an estimate of annual mean concentrations could not be made, as produced in the previous study. This is because an insufficient range of wind directions occurred during the three week monitoring period to extrapolate results over the full year. Similarly, as NO_2 diffusion tube monitoring on Oxford Street ceased in March 2011, no comparison with long-term measured concentrations could be made.

4. Results

4.1 Fixed nitrogen dioxide monitoring

Figure 2 shows mean NO_2 concentrations for each hour of the closure day (red line) compared to the mean concentrations on days of normal operation (blue line). The green line shows mean NO_2 concentrations on the same days taken from a nearby urban background site (Russell Square, Bloomsbury), representing pollution from sources throughout London and beyond.

Concentrations dropped rapidly following the closure. By 10am they had reached a similar level to those recorded in the park at Russell Square. From 4pm concentrations started to rise above the urban background until resuming close to 'normal operation' after the re-opening between 5pm and 6pm. Between 10am and 4pm, NO_2 the mean concentration was around half of what would have been recorded had the road not been closed on that day. This result matches that reported in the previous VIP day study.

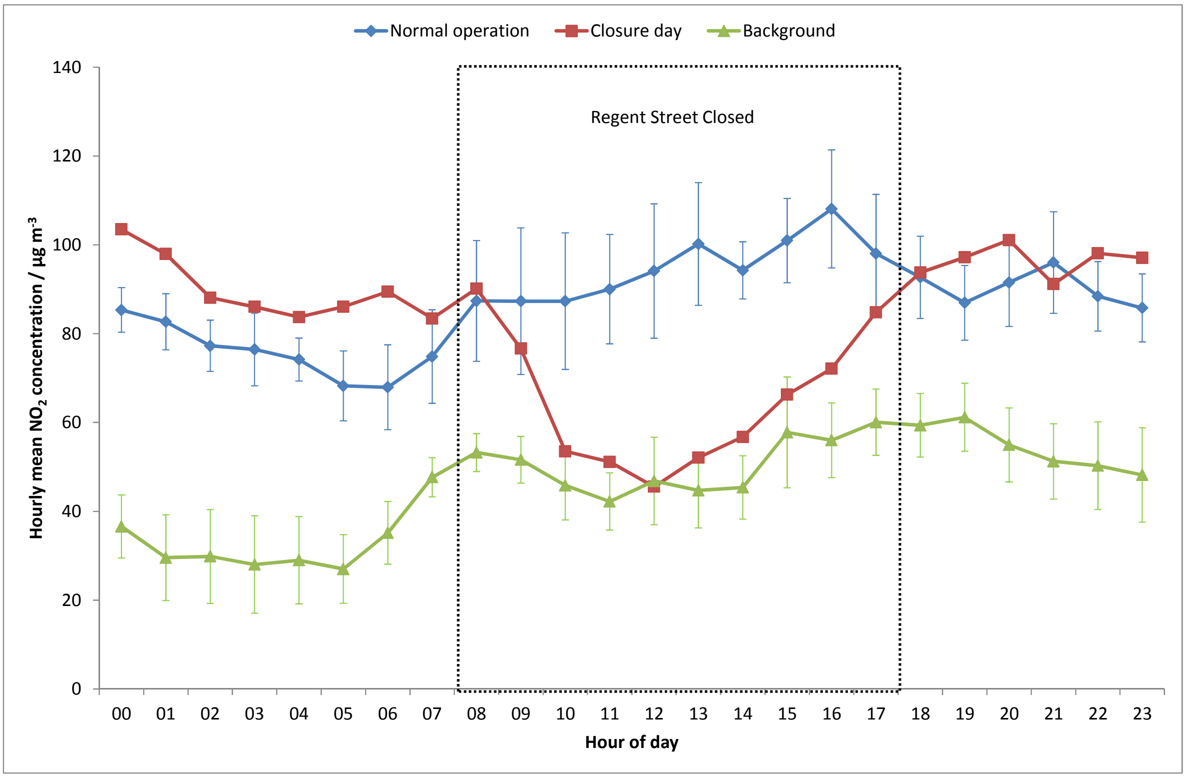

Figure 2: Mean NO_2 concentrations for each hour of the closure day compared to days of normal operation. Concentrations recorded at a nearby background site (Russel Square, Bloomsbury) are shown for comparison. Measurements taken on Sundays and wind directions not between 180 and 270 degrees N are excluded. Uncertainties are shown at 2 sigma.

4.2 Mobile nitrogen dioxide and black carbon monitoring

The use of mobile air pollution sensors, coupled with GPS trackers allowed the decrease identified by the fixed monitoring to be mapped throughout Regent Street, thereby showing the extent of the reduction. As described in the methods section, measurements taken at 1 minute intervals over a two hour period were interpolated to produce a pollution concentration surface map on the closure day, plus the Saturday before and day before.

The monitoring results and associated maps indicated that during normal operation, median concentrations of black carbon were comparable on Oxford Street and Regent Street (5.3 µg m^{-3} and 4.9 µg m^{-3} respectively). The highest concentrations were typically recorded around Oxford Circus. On the closure day, median black carbon concentrations on Oxford Street were 24% lower than the two control days (3.7 µg m^{-3}), whereas concentrations on lower Regent Street were 81% lower (1.0 µg m^{-3}).

A similar decrease in concentrations was recorded in nitrogen dioxide. Mean concentrations fell from 58 µg m^{-3} along lower Regent Street on days of normal operation, to 16 µg m^{-3} during the closure period, a decrease of 73%.

The extent of this reduction can clearly be seen in Figure 3. Black carbon concentrations south of Oxford Circus quickly decreased and, aside from a few isolated peaks, concentrations were generally below 1 µg m^{-3}. These isolated peaks may have been caused by non-vehicle combustion sources such as charcoal burning, stationary diesel generators or vehicles taking part in the vintage car exhibition. The equivalent map of NO_2 concentrations showed a similar pattern.

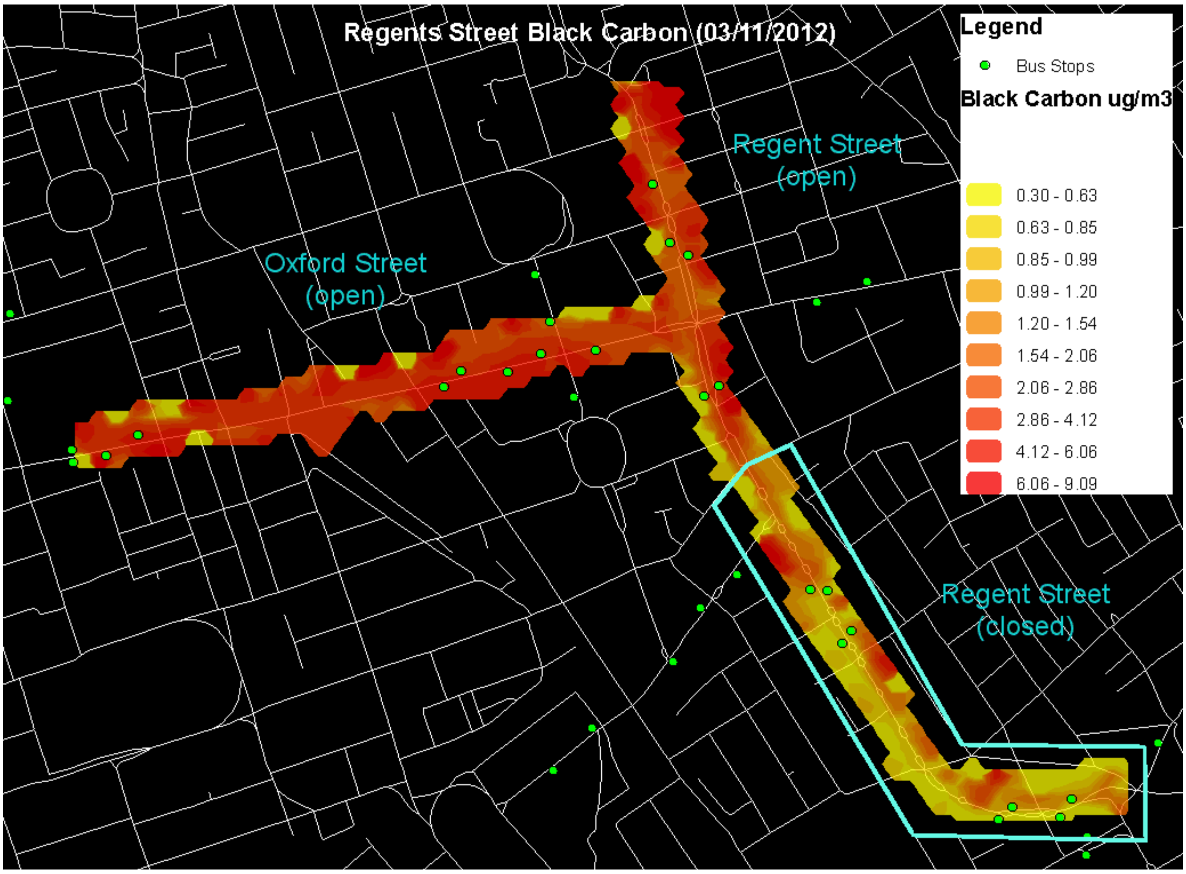

Figure 3: Mapped black carbon concentrations along Oxford Street and Regent Street on the 'traffic free' day. interpolated from mobile sensor measurements linked to GPS locations between 11 am and 2 pm.

5. Discussion

Regent Street's 'traffic free day' on 3rd November 2011 demonstrated that a relatively small road closure over a short working day can have a marked impact on the quality of the environment experienced by pedestrians.

This report presents the results of the second of two studies into the air quality impact of traffic free days in the area. In common with the previous study, pollution levels were recorded for periods prior to, during and following the traffic free day in fixed locations and carried by pedestrians using mobile sensors. A range of analysis methods were used to quantify changes in concentrations resulting from the traffic ban, independent of other influences such as the weather and unrelated vehicle emissions.

In combination, these studies found that during the hours of the vehicle ban black carbon, PM_{10} and nitrogen dioxide levels were between 50% and 75% lower than on a day of normal operation, dependent on pollutant and weather conditions. Nitrogen dioxide concentrations during the vehicle ban fell to a level similar to those recorded at the same time in a nearby park. The mobile monitoring showed that Red Cap Wardens were exposed to half of the pollution they would have been exposed to on a normal patrol day. Levels of black carbon (a component of fine particulate matter closely linked to diesel exhaust) and nitrogen dioxide breathed by pedestrians during the second study were 70% lower on Regent Street, which was closed to traffic, than on Oxford Street, which remained open.

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As well as creating a more relaxed and pleasant environment, reductions in pollution concentrations associated with a vehicle ban far exceed those predicted by other initiatives, such as exhaust emission controls, speed restrictions, taxi age restrictions, dust suppression and green walls.

Despite the area's high international profile, long term measurements of air pollution levels along Oxford Street and Regent Street are extremely limited. However, daily measurements of PM_{10} (particulate matter less than 10 μg in diameter) recorded close to the kerb on Oxford Street since late 2010 suggest that PM_{10} levels along both streets are within EU Limit Values. Conversely, fortnightly measurements of nitrogen dioxide (NO_2) taken at the same location indicated that annual mean concentrations of NO_2 were around three times higher than the EU Limit Value of 40 μg m^{-3} in 2009 and 2010 (144 μg m^{-3} and 114 μg m^{-3} respectively). Extrapolation of short-term monitoring during 2011 carried out by King's College London indicated that NO_2 levels on Regent Street were as high as those on Oxford Street and both were likely to experience frequent peak hourly mean pollution levels above the short term EU Limit Value of 200 μg m^{-3}.

In summary, NO_2 concentrations along Oxford Street and Regent Street are currently in breach of legal air quality limits. Without action additional to that planned by central Government and TfL, this situation is likely to continue beyond 2015. Westminster City Council installed a continuous NO_2 monitor alongside their PM_{10} monitor on Oxford Street in January 2013. The results from this monitor will be publically available on the London Air Quality Network website (www.londonair.org.uk), ensuring progress towards meeting the EU Limit Values in the area can be openly scrutinised in future. No long-term measurements of $PM_{2.5}$ concentrations along either street have been made or are planned.

PM_{10} and NO_2 concentrations along Oxford Street and Regent Street are not exceptional in comparison with other busy roadside locations in Central London. However, two characteristics of the area make the potential health impacts of air pollution more acute than in most of London's streets. This is one of the most popular shopping destinations in Europe, with most major stores fronting directly onto the major densely trafficked thoroughfare. Exposure to air pollution multiplied both in numbers of people affected and duration, as shoppers spend significant periods walking to and from stores. Secondly, all vehicles passing along Oxford Street and the majority of vehicles passing along Regent Street are diesel fuelled. Current research suggests that particulate pollution arising specifically from diesel combustion is more closely linked to health impacts than particulate pollution from other sources (van Vliet *et al*, 1997).

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