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Emissions source apportionment - Putney High Street

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Abstract

The aim of this project was to determine the vehicle emission sources in Putney High Street in London Borough of Wandsworth. This street was chosen because kerbside measured nitrogen dioxide (NO\textsubscript{2}) concentrations are some of the highest in London, exceeding both the annual and hourly mean Air Quality Strategy Objective by a large margin.

A combination of automatic number plate recognition (ANPR) cameras and video traffic counts were employed to characterise the vehicle fleet and determine emissions from each vehicle type for each hour of the day. Recommendations for further work to overcome some of the limitations of this study are provided in the report.

The headline results from the study showed that buses contributed over two-thirds of NO\textsubscript{x} emissions and 21 percent of particulate (PM) emissions in Putney High Street despite making up only ten percent of vehicle flow. Overall, cars made up two-thirds of the total vehicle flow in the street and contributed to 14 percent of NO\textsubscript{x} emissions and 35 percent of PM emissions. Emission rates were similar on weekdays and Saturday and the diurnal profile reflected that of the hourly NO\textsubscript{2} concentrations measured at the kerbside monitoring site.

The majority of the fleet met either Euro 3/III or Euro 4/IV emissions standard, i.e. were 10 years old or newer. 93 percent of heavy goods vehicles, buses and coaches were found to meet the required standard of Phase 2 of the London Low Emission Zone scheme.
Executive Summary

Measured air pollution levels in the London Borough of Wandsworth are among the highest in the UK, with concentrations exceeding the annual mean Air Quality Strategy Objective for nitrogen dioxide (NO$_2$) at urban background monitoring sites. The hourly objective is also exceeded at some roadside sites and the whole borough has been declared an Air Quality Management Area (AQMA).

This report focuses on identifying the key emission sources in Putney High Street. This site has been chosen for this study as the kerbside measured NO$_2$ concentrations are some of the highest in London. This study has used a combination of automatic number plate recognition (ANPR) cameras and video traffic counts during October 2011 to characterise the vehicle fleet. The data obtained from the survey were used to determine the fleet composition and nitrogen oxide (NO$_x$) and particulate (PM) emissions of each vehicle type for each hour of the day.

The headline results from the study showed that **buses contributed over two-thirds of NO$_x$ emissions** in Putney High Street despite making up only ten percent of vehicle flow. This was in contrast to a previous source apportionment study that showed buses contributed to 35 percent of NO$_x$ concentrations. Overall, cars made up two-thirds of the total vehicle flow in the street and contributed to 14 percent of NO$_x$ emissions and 35 percent of PM emissions, compared to 21 percent of PM emissions from buses.

The vehicle fleet was characterised by assuming Euro emission standards for all vehicles (based on date of first registration). The majority of the fleet met either Euro 3/III or Euro 4/IV standard, i.e. 10 years old or newer. Older vehicles in the fleet included ten percent of taxis and 19 percent of coaches being Euro 1 emission standard or older. The majority of heavy goods vehicles, buses and coaches (93 percent) were found to meet the standards required for Phase 2 of the London Low Emission Zone scheme.

The study also presented diurnal profiles of hourly emission rates for each vehicle type. This showed that emissions were highest during the morning peak period (seven to nine am) and stayed relatively high during the day before dropping off in the evening (after six pm). Emission rates were similar on weekdays and Saturday and the diurnal profile reflected that of the hourly NO$_2$ concentrations measured at the kerbside monitoring site.

The report provided recommendations for further work to overcome some of the limitations of this study. These included using an instantaneous modelling approach rather than average speed approach to better reflect real life driving styles and obtaining better data on vehicle registration details and Euro standards of TfL licensed buses and taxis as well as on particle trap and catalytic converter failure rates.
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1 Introduction

This section provides an introduction to the London Borough of Wandsworth with an overview of the levels of air pollution and traffic characteristics of the study area. The aims of the study are also provided.

1.1 Air Quality in Wandsworth

The London Borough of Wandsworth is located in South West London. It covers an area of around 34km². It is the most populated inner London borough with a residential population of 290,000 - 40 percent aged between 25 and 39. Putney is one of five major town centre areas in the borough.

The major source of pollution in the borough is road traffic, due to the dense network of roads, including the A205 (South Circular), A3 and A214. The whole borough has been declared an Air Quality Management Area (AQMA) for nitrogen dioxide (NO₂). The Council has had an Air Quality Action Plan (London Borough of Wandsworth, 2004) for a number of years, which has a range of measures to improve air quality in the borough. Many of these measures are ongoing and involve the co-operation of several council departments, as well as neighbouring authorities. Measures include:

- Pursuing Council fleet ‘greening’ strategy, including investigating the use of cleaner fuel options for the Council’s vehicle fleet.
- Encouraging and promoting the benefits of cleaner road vehicles.
- Promoting and encouraging the development of a ‘green fuelling’ infrastructure within the Borough.
- Implementing and reviewing the Council Services Transport Plan (CSTP) promoting alternative modes of transport to the car, for both journeys to work and business related journeys.
- Reducing carbon dioxide emissions from Council premises by 20 percent below the 1990 level.
- Promoting travel awareness campaigns, including initiatives with TfL

Despite progress with the Council’s Air Quality Action Plan, measured NO₂ concentrations in the borough are not declining as expected. The local authority’s most recent Air Quality Progress Report (London Borough of Wandsworth, 2011) demonstrated that both the hourly and annual mean objective are exceeded at monitoring sites in the borough. Data from the local authority’s long-running urban background site, taken from the

1 Wandsworth mid-year population estimates (2010).
http://www.wandsworth.gov.uk/info/1022/planning_service_and_performance/719/population_estimates_and_projections
report, are presented in Figure 1. Concentrations at this site are above the annual mean Air Quality Strategy (AQS) objective and are at a similar level in 2010 as they were in 2000.

![Figure 1: Annual mean NO₂ concentrations, Wandsworth Town Hall.](image)

### 1.2 Putney High Street

Putney High Street (the A219) is a busy route running north to south from the South Circular (A205). The road is controlled by the local authority and has one lane of traffic in both directions. There are parking and loading restrictions in operation throughout the day.

#### 1.2.1 Air quality concentrations

The local authority currently monitors NO₂ concentrations at three locations around Putney: a kerbside location on Putney High Street (see Figure 2), a roadside site further back at the façade of a building and an urban background site which was established in January 2011. The location of all of these sites is indicated in Figure 3. Recent NO₂ concentrations and exceedences of the hourly mean recorded at these locations have been taken from the Londonair website² and are shown in Table 1 and Table 2, compared to the relevant AQS objectives.

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² [www.londonair.org.uk](http://www.londonair.org.uk)
Figure 2: Putney High Street, kerbside NO₂ monitoring site.

Figure 3: Location of Putney air quality monitoring sites.
Table 1: Annual mean NO\textsubscript{2} concentrations, Putney.

<table>
<thead>
<tr>
<th>Site name</th>
<th>Grid reference</th>
<th>2010</th>
<th>2011#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Putney High Street, kerbside</td>
<td>524036, 175336</td>
<td>168*</td>
<td>151</td>
</tr>
<tr>
<td>Putney High Street, facade</td>
<td>524032, 175336</td>
<td>135*</td>
<td>119</td>
</tr>
<tr>
<td>Putney Felsham Road, background</td>
<td>524046, 175495</td>
<td>n/a</td>
<td>42</td>
</tr>
</tbody>
</table>

AQS objective

40

Table 2: Number of exceedences of the hourly mean objective, Putney.

<table>
<thead>
<tr>
<th>Site name</th>
<th>Grid reference</th>
<th>2010</th>
<th>2011#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Putney High Street, kerbside</td>
<td>524036, 175336</td>
<td>2485*</td>
<td>2563</td>
</tr>
<tr>
<td>Putney High Street, facade</td>
<td>524032, 175336</td>
<td>1064+</td>
<td>1192</td>
</tr>
<tr>
<td>Putney Felsham Road, background</td>
<td>524046, 175495</td>
<td>n/a</td>
<td>3</td>
</tr>
</tbody>
</table>

AQS objective

18

*85% data capture, +51% data capture, #Data unratified, up to 16/12/11.

The measured concentrations show the kerbside and roadside sites on Putney High Street exceed both NO\textsubscript{2} objectives by a large margin. In fact this road is known to be one of the most polluted sites in London\textsuperscript{3}. The results from 2011 to date indicate that the annual mean objective is also likely to be exceeded at the urban background site.

1.2.2 Traffic flows

The local authority undertakes regular vehicle speed and classification surveys along this stretch of Putney High Street, with an automatic traffic counter sited next to the kerbside air quality monitoring site. Average two-way 24-hour traffic flows from a week’s survey in February 2011 were around 20,000 vehicles with heavy duty vehicles (HDVs, vehicles over 3.5 tonnes gross vehicle weight) making up ten percent of the total flow. The average speed during this time was measured as 26.9 km/h. These figures are similar to data in the GLA’s London Atmospheric Emission Inventory (LAEI)\textsuperscript{4}. The annual

\textsuperscript{3} www.londonair.org.uk

\textsuperscript{4} http://data.london.gov.uk/laei-2008
average daily traffic flow (AADT) in the LAEI for the most recent year of 2008 is 22,635 with eight percent HDVs and an average speed of 18 km/h.

A recent study on delivery and servicing in Putney High Street, by Transport and Travel Research (TTR) for the local authority (TTR, 2011) concluded that the road has a dual functionality - a busy through route from the South Circular into central London and a local shopping area. This means that vehicles stopping to make deliveries have a large impact on traffic flow. Loading and unloading are already prohibited during peak hours and there is not enough space for in-set loading bays in the road, so there are few options to improve delivery arrangements. However, the study concluded that improvements could be made by more use of loading bays in side streets (by smaller vehicles) and a facilities map showing the location of all loading bays/areas could be distributed to retailers/suppliers.

Traffic light signals are located to the north and south extents of Putney High Street. According to Wandsworth Council\(^5\) this stretch of road includes a SCOOT traffic light timing optimisation system which should take into account traffic signals being activated by pedestrians wishing to cross the road. However traffic congestion builds up between Lacy Road and Montserrat Road as there are high levels of pedestrian activity along this stretch of road.

1.2.3 Existing source apportionment

A source apportionment exercise was conducted as part of the local authority’s Stage 4 review and assessment (London Borough of Wandsworth, 2004). Based on data from 1999, the study found that buses were the most significant source of NO\(_x\) concentrations measured in Putney High Street (contributing 28 percent) followed by cars (27 percent) and heavy goods vehicles (25 percent). The contribution from background sources (primarily other roads) was 20 percent. If this component is removed, then buses contribute 35 percent of emissions from all vehicles. As part of this work, a forecast was carried out for 2004/5 which predicted similar results, with a slight increase in the contribution from buses and heavy goods vehicles (HGVs) and a decrease in contribution from cars (by up to nine percent).

1.3 Aims and objectives

Due to the very high measured concentrations of NO\(_2\) at Putney High Street and the fact that background concentrations in the borough are not declining as previously forecast, the local authority is looking at new ways to improve air quality, specifically in the High Street.

To do this, the local authority would like to determine the main source of emissions in Putney High Street before identifying suitable measures. For this stretch of road, the specific aims of the project are therefore to:

\(^5\) Personal communication with David Kennett (Wandsworth Council, Environmental Health) on 16/12/2011.
1. determine the coarse composition of the fleet (i.e. the observed proportion of buses, coaches, HGVs, light goods vehicles (LGVs), cars and taxis) and compare this with information in the LAEI;

2. determine the diurnal emission characteristics of vehicles adjacent to the air quality monitoring site;

3. establish the proportion of NO\textsubscript{x} and PM\textsubscript{10} emissions on Putney High Street from each vehicle type.
2 Methodology

This section outlines the steps taken to determine the Euro emission standards and emission rates of each vehicle to carry out the source apportionment study.

2.1 ANPR camera survey

1. Automatic number plate recognition (ANPR) cameras (Model Type Sanyo 600) were chosen as a means to record vehicle registration (number) plates.
2. Putney High Street was surveyed to determine the optimal locations for the cameras.
3. Four synchronised cameras were set up from 00:00 on Thursday 6th October to 00:00 on Sunday 8th October 2011 in the locations indicated in Figure 4. Figure 5 provides a photograph of one of the cameras.
4. Video traffic counts were taken in 15-minute periods at the camera locations to identify the percentage of registration plates recognised by the cameras.
5. Registration plates were verified for consistency using a bespoke checking programme to manually identify any misread plates.
6. The data were matched between camera pairs to provide an origin-destination matrix (i.e. vehicles travelling between entry and exit cameras in both directions).
7. Motorcycles were not included in the survey as the ANPR cameras are not able to accurately detect their number plates.

Figure 4: Location of ANPR cameras in Putney High Street.
2.2 DVLA classification

1. The DVLA (Driver and Vehicle Licensing Agency) database contains a wealth of vehicle information by number plate, including tax class (HGV, bus, ambulance, private etc), fuel type (diesel, petrol, hybrid, electric etc), body type (cars, motorcycle, coach, taxi etc), make and model, date of first registration, gross and unladen weight, number of seats, wheel plan, engine type and vehicle category type (N1, N2 etc).

2. The matched ANPR data were formatted and matched to the DVLA database.

3. Body type and tax class were used to classify vehicle types into the following categories; taxis, cars, LGVs, TfL buses, coaches and HGVs. Petrol and diesel vehicles were also distinguished.

4. TfL buses were distinguished from other coaches based on their make and model of the vehicles and information provided by TfL buses.\(^6\)

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\(^6\) Personal communication with Nicola Cheetham (TfL, Surface Transport).
5. The Euro emission standard of each vehicle was estimated based on the date of first registration of each vehicle (according to Table 3), its body type and category type (N1, N2 etc). Appendix A provides an example of how the Euro standard was derived for a specific vehicle and Appendix B provides details of some of the assumptions that were made to classify vehicles and issues encountered.

Table 3: Date of introduction of Euro emission standards.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Passengers cars</td>
<td>1 July 1992</td>
<td>1 Jan 1996</td>
<td>1 Jan 2000</td>
<td>1 Jan 2005</td>
<td>1 Sept 2009</td>
<td>1 Sept 2014</td>
</tr>
<tr>
<td>Taxis/Light commercial vehicles (category N1-1)</td>
<td>1 Oct 1994</td>
<td>1 Jan 1998</td>
<td>1 Jan 2001</td>
<td>1 Jan 2006</td>
<td>1 Sept 2009</td>
<td>1 Sept 2014 (diesel only)</td>
</tr>
<tr>
<td>Light commercial vehicles (category N1-II, NIII)</td>
<td>1 Oct 1994</td>
<td>1 Jan 1998</td>
<td>1 Jan 2001</td>
<td>1 Jan 2006</td>
<td>1 Sept 2010</td>
<td>1 Sept 2015 (diesel only)</td>
</tr>
</tbody>
</table>

2.3 Emissions modelling and source apportionment

1. The coarse fleet composition was compared with the latest version of the London Atmospheric Emission Inventory (LAEI).²

2. The Emission Factor Toolkit (EFT) v4.2.2 was used to determine the NOₓ and PM emission rate for every vehicle observed by the cameras, based on their Euro emission standard and recorded speed.

3. For those vehicles which were unmatched (i.e. not seen in both the entry and exit cameras), their emission rate was assumed based on matched data (e.g. from previous or following hours, or from data from the previous day at the same hour).

4. These data were used to derive an emission rate (in g/km/h) for every hour of the day according to six vehicle types (car, taxi, LGV, HGV, TfL bus and coach). Based on numbers of vehicles captured by the cameras and recorded in the video count, traffic flows for every hour of the day were also derived.

² http://data.london.gov.uk/laei-2008
5. The split of vehicles captured by video but not captured by ANPR cameras was assumed to be the same as for vehicles captured by ANPR, and emissions from these vehicles were estimated using the emission rates derived by hour and vehicle type.
3 Results

3.1 Survey data

This section provides a summary of the data recorded from the cameras and video surveys over the three days. In total 62,496 number plates were recorded. Of these, 302 had to be corrected due to misreads (e.g. zeros for the letter ‘O’ and number 1 instead of the letter ‘I’). 3,256 errors were identified in the raw dataset such as foreign plates that did not conform to any of the known UK number plate conventions.

An estimate of the 24-hour average daily traffic (ADT) flow taken from the video count is given in Table 4 for each day of the camera survey and each direction (entry and exit cameras). The results show that the two-way flow on each day is around 20,000 which is similar to that recorded by the local authority’s automatic traffic count (ATC) surveys.

![Table 4: 24-hour traffic flow from video survey.](image)

The 24-hour traffic flows recorded by the ANPR cameras are shown in Table 5. This also provides the number of plates matched between the entry and exit cameras. It is not possible to record every vehicle due to errors in plate-reading, queuing vehicles obscuring following vehicles’ plates and high-sided vehicles stationary at the kerb, obscuring the plate.

![Table 5: 24-hour traffic flows from ANPR camera survey.](image)

Table 6 shows the percentage of number plates recorded by the ANPR cameras (from Table 5) compared to the 24-hour traffic flows estimated from the video surveys in Table 4. Typically, the percentage recorded was around 70-90 percent, with a lower rate on Saturday due to a higher number of unmatched plates.
Table 6: Percentage of vehicles recorded by the ANPR cameras.

<table>
<thead>
<tr>
<th>Day</th>
<th>Camera boundary</th>
<th>Northbound (%)</th>
<th>Southbound (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thursday</td>
<td>Entry</td>
<td>81</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>Exit</td>
<td>91</td>
<td>88</td>
</tr>
<tr>
<td>Friday</td>
<td>Entry</td>
<td>74</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Exit</td>
<td>73</td>
<td>96</td>
</tr>
<tr>
<td>Saturday</td>
<td>Entry</td>
<td>65</td>
<td>61</td>
</tr>
<tr>
<td></td>
<td>Exit</td>
<td>67</td>
<td>70</td>
</tr>
</tbody>
</table>

The time taken for vehicles to travel from the entry to the exit camera was used to calculate their speed on Putney High Street. Table 7 shows that the average speeds were around 20 km/hour or lower. Numerous speeds above the speed limit of 30mph (48 km/hour) were recorded, with maximum speeds typically found during the late evening and middle of the night.

Table 7: Measured speeds estimated by ANPR cameras.

<table>
<thead>
<tr>
<th>Survey date</th>
<th>Average speed (km/h)</th>
<th>Minimum speed (km/h)</th>
<th>Maximum speed (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N/bound</td>
<td>S/bound</td>
<td>N/bound</td>
</tr>
<tr>
<td>Thursday</td>
<td>20.1</td>
<td>22.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Friday</td>
<td>15.2</td>
<td>14.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Saturday</td>
<td>16.4</td>
<td>13.8</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Of the number plates recorded by the cameras, 59,240 were compared against the DVLA database. Of these, 14 percent were unrecognised, giving 50,973 matched plates. The main reason for this is due to number plates in the wrong format required by the database. Other reasons for unrecognised plates include mis-reads not previously identified (e.g. the letter S instead of number 5), foreign plates, illegible/dirty plates and illegal plates.

3.2 Emissions modelling and source apportionment

This section presents the results from the emissions modelling and source apportionment calculations.

3.2.1 Hourly flows and composition of fleet

The hourly vehicle numbers identified by the ANPR cameras were adjusted to determine an actual flow, based on data from the video count. Flows for each hour are given in Appendix C (Tables C1 and C2). Summary data are given in Table 8.
Table 8: Total hourly vehicle flows and percentage contribution over the three survey days.

<table>
<thead>
<tr>
<th></th>
<th>Car</th>
<th>Taxi</th>
<th>LGV</th>
<th>HGV</th>
<th>Bus</th>
<th>Coach</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of vehicles</td>
<td>40,157</td>
<td>4,371</td>
<td>8,058</td>
<td>1,196</td>
<td>5,789</td>
<td>27</td>
<td>59,599</td>
</tr>
<tr>
<td>Total as percentage</td>
<td>67.4%</td>
<td>7.3%</td>
<td>13.5%</td>
<td>2.0%</td>
<td>9.7%</td>
<td>0.05%</td>
<td>100%</td>
</tr>
<tr>
<td>LAEI – percentage*</td>
<td>76.1%</td>
<td>4.1%</td>
<td>11.3%</td>
<td>2.8%</td>
<td>5.7%</td>
<td>-</td>
<td>100%</td>
</tr>
</tbody>
</table>

*Adjusted as motorcycles taken out.

The results from the ANPR survey show that more than two thirds of the fleet are cars, with LGVs contributing only 14 percent. TfL buses contribute almost ten percent to total flow, and there are very few HGVs and coaches. Table 8 also provides a comparison of percentage vehicle composition with data from the most recent version of the LAEI (for 2008). The LAEI has an even high proportion of cars in the fleet (76 percent). There are similar proportions of LGVs and HGVs in both datasets. Buses and coaches are combined into one category in the LAEI and contribute less than six percent of all vehicles compared to almost ten percent from the ANPR data.

3.2.2 Euro emission standards

Those vehicles that could be classified by the DVLA database were categorised by Euro emission standard based on the date of first registration (see Table 9 and Table 10). The data show that the majority of the fleet are Euro 3/III or Euro 4/IV. Only 12 percent of cars captured by the ANPR cameras were older than Euro 3. Coaches and taxis appear to have the oldest vehicles, with 19 percent of coaches meeting the Euro I standard. These vehicles are unlikely to meet the current London Low Emission Zone (LEZ) standard of Euro III for PM. Ten percent of the London taxis identified are Euro I standard or older. Although taxis are not part of the London LEZ scheme, the Mayor has his own taxi emission strategy, which is described in Section 4 and Appendix D.

Table 9: Proportion of Euro emission standards (light duty vehicles).

<table>
<thead>
<tr>
<th>Euro emission standard</th>
<th>Car</th>
<th>Taxi</th>
<th>LGV</th>
<th>Total</th>
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<tbody>
<tr>
<td>Pre–Euro</td>
<td>1%</td>
<td>2%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Euro 1</td>
<td>2%</td>
<td>8%</td>
<td>1%</td>
<td>2%</td>
</tr>
<tr>
<td>Euro 2</td>
<td>9%</td>
<td>20%</td>
<td>4%</td>
<td>9%</td>
</tr>
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<td>Euro 3</td>
<td>32%</td>
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<td>Euro 4</td>
<td>40%</td>
<td>25%</td>
<td>50%</td>
<td>40%</td>
</tr>
<tr>
<td>Euro 5</td>
<td>17%</td>
<td>13%</td>
<td>10%</td>
<td>16%</td>
</tr>
</tbody>
</table>
Using information on those vehicles with reduced pollution certificates (RPC) in the DVLA database, heavy duty vehicles with and without a diesel particulate filter (DPF) could be distinguished (see Table 10 and Appendix B). Of the Euro III buses, all are fitted with a DPF, whereas only one percent of HGVs are fitted with a DPF and no coaches are fitted with one. There are also some Euro IV and Euro V HGV and/or buses fitted with a DPF.

Table 10: Proportion of Euro emission standards (heavy duty vehicles).

<table>
<thead>
<tr>
<th>Euro Standard</th>
<th>Emission</th>
<th>HGV</th>
<th>Bus</th>
<th>Coach</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Euro</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Euro I</td>
<td>1%</td>
<td>0%</td>
<td>19%</td>
<td>0%</td>
<td>1%</td>
</tr>
<tr>
<td>Euro I with DPF</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Euro II</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
</tr>
<tr>
<td>Euro II with DPF</td>
<td>1%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>1%</td>
</tr>
<tr>
<td>Euro III</td>
<td>28%</td>
<td>0%</td>
<td>15%</td>
<td>0%</td>
<td>5%</td>
</tr>
<tr>
<td>Euro III with DPF</td>
<td>1%</td>
<td>76%</td>
<td>0%</td>
<td>0%</td>
<td>63%</td>
</tr>
<tr>
<td>Euro IV</td>
<td>36%</td>
<td>2%</td>
<td>38%</td>
<td>0%</td>
<td>8%</td>
</tr>
<tr>
<td>Euro IV with DPF</td>
<td>3%</td>
<td>6%</td>
<td>0%</td>
<td>0%</td>
<td>6%</td>
</tr>
<tr>
<td>Euro V</td>
<td>24%</td>
<td>14%</td>
<td>27%</td>
<td>0%</td>
<td>16%</td>
</tr>
<tr>
<td>Euro V with DPF</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

3.2.3 Emission rates

The NO\textsubscript{x} and PM emission rates derived for each vehicle type for each hour of the day are given in Appendix E (Tables E1 – E4). These data are also presented graphically in Figures 7 -10.

Figures 7 and 8 clearly show a diurnal variation in overall emission rates over the three days, with highest emissions typically found in the morning peak time (seven to nine am). The figures also show that buses (blue lines) have the highest NO\textsubscript{x} emission rates. In contrast, although PM emission rates have a similar diurnal pattern, Figures 9 and 10 show that emissions are highest from cars and LGVs. This reflects their larger numbers in the fleet and the fact that the majority of buses either meet the Euro III emission standard and are fitted with a particle abatement device or are Euro IV standard.
Figure 6: NO\textsubscript{x} emission rates per hour of the day by vehicle type (southbound).

Figure 7: NO\textsubscript{x} emission rates per hour of the day by vehicle type (northbound).
Figure 8: PM emission rates per hour of the day by vehicle type (southbound).

Figure 9: PM emission rates per hour of the day by vehicle type (northbound).
Figure 10 shows the NO\textsubscript{x} emission rates and traffic flow (for both directions of traffic) compared to the hourly measured NO\textsubscript{2} concentrations at the Council’s kerbside monitoring site for the three survey days. The figure shows that both traffic flow and emissions follow a similar trend to measured concentrations with peaks seen during morning and evening rush hours and during the inter-peak period. The increase in traffic flow during the day is proportionally far less than the increase in NO\textsubscript{x} emission rate and measured NO\textsubscript{2}. This is likely to be due to far lower average speeds during the daytime.

**Figure 10: Hourly NO\textsubscript{2} concentrations at Putney High Street kerbside monitoring site vs total traffic flow and NO\textsubscript{x} emission rates.**

![Graph showing NO\textsubscript{2} concentrations, traffic flow, and NO\textsubscript{x} emissions over three days.]

### 3.2.4 Source apportionment

The data on total flows and emission rates have been compiled to determine the main emission sources of NO\textsubscript{x} and PM along Putney High Street as shown in Table 11 and Figure 11 (for NO\textsubscript{x}). The data clearly show that although buses only contribute ten percent of the overall traffic flow, they contribute disproportionately to total NO\textsubscript{x} emissions (over two-thirds), but only 21 percent of PM emissions. The majority of TfL buses are Euro III standard and all of these have been fitted with a DPF, which can reduce PM emissions by 90 percent. Euro IV vehicles are fitted with selective catalytic reduction (SCR) technology as standard which reduces NO\textsubscript{x} emissions, but the numbers of these in the bus fleet are low (i.e. eight percent over movements on the Putney High Street). Of these Euro IV buses, six percent have also been fitted with a DPF. Cars are found to contribute to 35 percent of PM emissions, but only 14 percent of NO\textsubscript{x} emissions. The PM emissions include both exhaust and non-exhaust (i.e. tyre and brake wear) sources so as the fleet is dominated by cars, then this would lead to higher non-exhaust emissions. Also, 63 percent of fleet of the cars identified in this survey were petrol-fuelled, which have lower emissions of NO\textsubscript{x} than diesel cars.
Table 11: Overview of NO\textsubscript{x} and PM emissions by vehicle type.

<table>
<thead>
<tr>
<th></th>
<th>Car</th>
<th>Taxi</th>
<th>LGV</th>
<th>HGV</th>
<th>Buses</th>
<th>Coaches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of movements</td>
<td>67%</td>
<td>7%</td>
<td>14%</td>
<td>2%</td>
<td>10%</td>
<td>0%</td>
</tr>
<tr>
<td>Percent of NO\textsubscript{x} emissions</td>
<td>14%</td>
<td>5%</td>
<td>6%</td>
<td>7%</td>
<td>68%</td>
<td>0.30%</td>
</tr>
<tr>
<td>Percent of PM emissions</td>
<td>35%</td>
<td>14%</td>
<td>23%</td>
<td>7%</td>
<td>21%</td>
<td>0.27%</td>
</tr>
</tbody>
</table>

Figure 11: Percentage of NO\textsubscript{x} emissions by vehicle type.
4 Discussion

4.1 Key findings

The key findings of this emissions source apportionment study are outlined below;

- Buses contributed over two-thirds of NO\textsubscript{x} emissions in Putney High Street despite making up only 10 percent of vehicle flow.
- Particulate emissions from buses were less than from cars and LGVs, at 21 percent.
- Cars made up two-thirds of the vehicle flow and contributed 14 percent of NO\textsubscript{x} emissions and 35 percent of PM emissions.
- The majority of the vehicle fleet were either Euro 3/III or Euro 4/IV standard, i.e. 10 years old or newer.
- All of the Euro III buses were fitted with a particulate abatement device (e.g. a DPF) and some of the Euro IV and Euro V vehicles were also fitted with a DPF.
- Ten percent of the taxi fleet were Euro 1 emission standard or older.
- Based on the estimated Euro emission standard profile of the captured fleet, 93 percent of HGVs, buses and coaches meet the standards for Phase 2 of the London Low Emission Zone scheme.
- Diurnal profiles showed that emission rates varied over the day, with highest rates generally found during the morning, and to a less extent during evening peak periods. Concentrations remained relatively high during the day, with a decline seen after six pm. The lowest emission rates were determined at around three am.
- Hourly emissions correlated well with measured NO\textsubscript{2} concentrations at the kerbside monitoring site.
- Emissions were similar on weekdays (Thursday and Friday) to Saturdays.
- The Council’s previous source apportionment exercise conducted in 2004 showed that buses contributed approximately 28 percent to NO\textsubscript{x} concentrations in Putney High Street. If the background contribution is removed, this equates to 35 percent, which is almost half the contribution determined in this present study. By contrast, cars and HGVs were found to contribute less than previously determined.

4.2 Limitations of previous and current emissions assessment approaches

Previous studies have not taken into account the significant variation in vehicle average speeds along Wandsworth High Street and have used more limited local traffic data in
deriving vehicle emissions. The current study offers a substantial improvement over these by taking individual vehicle speeds and estimated Euro classification into account.

A limitation of the approach in this assessment is that it relies on average-speed vehicle emission factors, which are derived from vehicle test cycles. It cannot be established from this approach whether driving styles on Putney High Street are similar to those in the test cycles that the average-speed factors are based on, and whether driving styles change significantly during the day along the High Street.

4.3 Implications of Mayor’s Air Quality Strategy

The Mayor’s Air Quality Strategy (MAQS) was revised in 2010\(^8\) (see Appendix D for further details). The London Low Emission Zone (LEZ) is one of the headline measures in the MAQS to reduce vehicle emissions. The LEZ operates throughout most of Greater London and aims to reduce particulate emissions from the most polluting vehicle types, currently limited to vehicles over 3.5 tonnes in weight. Those vehicles that do not meet the emission standard of Euro III for PM have to pay a large daily charge or be liable to a fine. This study has found that the majority of the HGVs, buses and coaches (93 percent) travelling in Putney High Street are likely to meet this standard. In January 2012, the LEZ standards are tightened to Euro IV for PM (Phase 3). Although only 22% of the heavy duty vehicles in the study were found to be Euro IV for PM standard or higher, it is not known whether some of older vehicles already fitted with a particle trap or with eligible engines would also be compliant with the tighter standard.

76 percent of buses were found to be Euro III emission standard for PM. However, although measures by TfL have successfully reduced PM emissions, the NO\(_x\) emissions from the bus fleet are disproportionately high. TfL’s plans for all buses to meet the LEZ standards and to reduce the NO\(_x\) emissions from its fleet are outlined in Appendix D.

From January 2012, the MAQS sets out that taxi licenses will not be issued to those vehicles more than 15 years old (effectively Euro 1 vehicles). This study identified that ten percent of the taxi fleet are Euro 1 or older and therefore would not comply with this strategy.

\(^8\) http://www.london.gov.uk/sites/default/files/Air%20Quality%20Strategy%20v3.pdf
5 Further work

The current emissions assessment approach is considered to be an improvement to previous studies. However, the following areas of further work have been identified to improve the accuracy of the emissions calculations.

- To improve the accuracy of classifying the London buses and taxis in the fleet, it may be possible to obtain vehicle number plates from TfL with information on the Euro standard of each licensed vehicle. This could then be cross-referenced with the vehicles captured by the ANPR cameras.
- There may be scope to obtain better data on particle trap and catalytic converter failure rates rather than the assumed rates in the EFT. It is likely that this study under-estimated the failure rates, and therefore under-estimated emissions.
- Undertaking an instantaneous emissions modelling study by driving an instrumented vehicle along Putney High Street rather than this average speed approach would more accurately represent driving styles and the varying emissions during the day.
- An investigation of the influence on road traffic emissions due to the SCOOT traffic light system could be carried out to see how this system could be optimised when pedestrian crossings are activated.
References


<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADT</td>
<td>Average daily traffic (flow)</td>
</tr>
<tr>
<td>ANPR</td>
<td>Automatic Number Plate Recognition (camera)</td>
</tr>
<tr>
<td>ATC</td>
<td>Automatic traffic counter</td>
</tr>
<tr>
<td>AQMA</td>
<td>Air Quality Management Area</td>
</tr>
<tr>
<td>AQS</td>
<td>Air Quality Strategy</td>
</tr>
<tr>
<td>CSTP</td>
<td>Council Services Transport Plan</td>
</tr>
<tr>
<td>DfT</td>
<td>Department for Transport</td>
</tr>
<tr>
<td>DPF</td>
<td>Diesel particulate filter</td>
</tr>
<tr>
<td>DVLA</td>
<td>Driver and Vehicle Licensing Agency</td>
</tr>
<tr>
<td>EFT</td>
<td>Emission Factor Toolkit</td>
</tr>
<tr>
<td>GLA</td>
<td>Greater London Authority</td>
</tr>
<tr>
<td>GVW</td>
<td>Gross vehicle weight</td>
</tr>
<tr>
<td>HDV</td>
<td>Heavy duty vehicles</td>
</tr>
<tr>
<td>LAEI</td>
<td>London Atmospheric Emissions Inventory</td>
</tr>
<tr>
<td>LDV</td>
<td>Light duty vehicles</td>
</tr>
<tr>
<td>LEZ</td>
<td>Low Emission Zone</td>
</tr>
<tr>
<td>MAQS</td>
<td>Mayor’s Air Quality Strategy</td>
</tr>
<tr>
<td>NO₂</td>
<td>Nitrogen dioxide</td>
</tr>
<tr>
<td>NOX</td>
<td>Nitrogen oxides</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>Fine particulates (PM) less than 10μm in diameter</td>
</tr>
<tr>
<td>RPC</td>
<td>Reduced Pollution Certificate</td>
</tr>
<tr>
<td>SCOOT</td>
<td>Split cycle offset optimisation technique</td>
</tr>
<tr>
<td>SCR</td>
<td>Selective Catalytic Reduction</td>
</tr>
<tr>
<td>TfL</td>
<td>Transport for London</td>
</tr>
<tr>
<td>TRL</td>
<td>Transport Research Laboratory</td>
</tr>
<tr>
<td>TTR</td>
<td>Transport and Travel Research Ltd</td>
</tr>
</tbody>
</table>
Appendix A: Determination of Euro emission standards

This section provides an example of how the Euro standard was derived for a specific vehicle.

Each observed vehicle number plate was compiled into a table with the format shown in Table A.1.

Table A.1. Example of vehicle information in TRL database.

<table>
<thead>
<tr>
<th>Column header</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID number</td>
<td>1</td>
</tr>
<tr>
<td>In Site</td>
<td>North Entry</td>
</tr>
<tr>
<td>In Type</td>
<td>LV</td>
</tr>
<tr>
<td>In Plate</td>
<td>Number plate</td>
</tr>
<tr>
<td>In Arrival</td>
<td>00:00:05</td>
</tr>
<tr>
<td>Hour</td>
<td>0</td>
</tr>
<tr>
<td>Formatted including errors</td>
<td>Number plate corrected</td>
</tr>
<tr>
<td>Day</td>
<td>Thursday</td>
</tr>
<tr>
<td>TaxClass</td>
<td>Petrol cars – CO₂ private</td>
</tr>
<tr>
<td>Fuel Type</td>
<td>Petrol</td>
</tr>
<tr>
<td>Body Type</td>
<td>Cars</td>
</tr>
<tr>
<td>Make</td>
<td>Ford</td>
</tr>
<tr>
<td>Model</td>
<td>Focus Studio</td>
</tr>
<tr>
<td>Date First Registered</td>
<td>29/12/2005</td>
</tr>
<tr>
<td>Gross Weight</td>
<td>0</td>
</tr>
<tr>
<td>No of Seats</td>
<td>4</td>
</tr>
<tr>
<td>Wheel Plan</td>
<td>2 AXLE RIGID BODY</td>
</tr>
<tr>
<td>Engine Capacity</td>
<td>1388</td>
</tr>
<tr>
<td>Unladen Weight</td>
<td>0</td>
</tr>
<tr>
<td>Vehicle category type</td>
<td>M1</td>
</tr>
<tr>
<td>Euro Standard</td>
<td>E4</td>
</tr>
<tr>
<td>Emission modelling category</td>
<td>Car</td>
</tr>
</tbody>
</table>

For this example vehicle the following criteria were applied to the number plate to identify the vehicle type and derive the Euro emission standard.

1. The 'Body type' was defined from the categories: Cars, Buses, Coaches, Goods-Light, Goods-Heavy, Motorcycles, Mopeds & Scooters, Taxis and Other. For this vehicle, the body type was classed as Cars.

2. The 'Vehicle category type' was determined from M1, M2, M3, N1, N2, N3, L1, L3. For this vehicle, the category was M1 (cars).

3. The date first registered. This vehicle was registered on 29/12/2005.

4. Given this information on the body type 'cars', vehicle category 'M1' and first registered 29/12/2005, the standard of Euro 4 was selected (referring to Table 3 where Euro 4 cars came into legislation from 1/1/2005).
Appendix B: Issues with Euro standards

Changes in taxi category
Taxis (London Hackney Cabs) are not specifically vehicle category type ‘M1’ as shown in the DVLA database, but N1 class 3 for Euro 1 to 4 compliance and M1 for Euro 5 and the pending Euro 6. Therefore taxis of different ages are classified in a different manner.

Buses
Some buses are categorised as M1, M2, M3, NI, N2 and N3\(^9\). Hence a system was required in order to determine an appropriate emissions category based on gross vehicle weight and seating capacity.

- M1 buses, have no more than eight seats in addition to the driving seat, were re-categorised as ‘cars’.
- M2 buses (passenger vehicles >8 seats with a mass of <5t) were re-categorised as having LGV emission standards similar to that of large vans.
- M3 buses (passenger vehicles >8 seats with a mass of >5t) were categorised as having HGV emissions standards.
- N1 buses (goods vehicles having a maximum mass not exceeding 3.5 tonnes) where re-categorised as having LGV emission standards similar to that of large vans. A single N1 vehicle remained as a bus having 33 seats and a GVW of 8.2t.
- N2 buses (goods vehicles having a maximum mass exceeding 3.5 tonnes but not exceeding 12t) were re-categorised as having LGV emission standards similar to that of large vans.
- N3 buses retained HGV emissions standards.

Communication with TfL confirmed that of the seven bus routes operating along Putney High Street, their emission standards were either Euro III (with DPF) or Euro IV (with selective catalytic reduction (SCR) technology).\(^{10}\)

Uncategorised plates for bus type vehicles

- Uncategorised bus type vehicles (i.e. those not indicated as being M1, 2, 3 and N1, 2, 3 categories) having more than 8 seats and less than 18 seats, with a mass of five tonnes or less and an engine size of < 3lt were re-categorised as LGVs (i.e. similar to M2).
- All remaining uncategorised bus-type vehicles exceeded 23 seats and a vehicle mass of 8t or greater, and were given HGV emissions standards.

Vehicle meets a higher Euro standard than given by date of registration
This could include cases where manufacturers produce vehicles that are “early adopters” of Euro standards or have “eligible engines”. These have not been identified in this study.


\(^{10}\)Nicola Cheetham and Anna Rickard, Surface Transport, TfL
Vehicles with an approved abatement device fitted

HGVs and buses can be fitted with an approved abatement device (e.g. diesel particulate filter - DPF) and gain an RPC. This information is given in the DVLA database and has been used in the emissions calculations within the EFT (for PM emissions only). As seen in Table B1, there were 124 unique buses with RPCs and 59 unique HGVs in the dataset.

**Table B1: Numbers of captured vehicles with reduced pollution certificates.**

<table>
<thead>
<tr>
<th>Vehicle type</th>
<th>Euro I</th>
<th>Euro II</th>
<th>Euro III</th>
<th>Euro IV</th>
<th>Euro V</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buses</td>
<td>0</td>
<td>7 (35)</td>
<td>101 (3759)</td>
<td>16 (298)</td>
<td>0</td>
<td>124 (4092)</td>
</tr>
<tr>
<td>HGVs</td>
<td>2 (2)</td>
<td>6 (10)</td>
<td>8 (11)</td>
<td>22 (32)</td>
<td>21 (29)</td>
<td>59 (84)</td>
</tr>
</tbody>
</table>
### Appendix C: Hourly traffic flows by vehicle type

#### Table C1: Southbound traffic flows.

<table>
<thead>
<tr>
<th>Hour</th>
<th>Car</th>
<th>Taxi</th>
<th>LGV</th>
<th>HGV</th>
<th>Bus</th>
<th>Coach</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thurs 0h</td>
<td>164</td>
<td>59</td>
<td>16</td>
<td>1</td>
<td>46</td>
<td>1</td>
<td>287</td>
</tr>
<tr>
<td>Thurs 1h</td>
<td>109</td>
<td>51</td>
<td>19</td>
<td>0</td>
<td>19</td>
<td>0</td>
<td>198</td>
</tr>
<tr>
<td>Thurs 2h</td>
<td>66</td>
<td>29</td>
<td>11</td>
<td>2</td>
<td>11</td>
<td>0</td>
<td>120</td>
</tr>
<tr>
<td>Thurs 3h</td>
<td>60</td>
<td>14</td>
<td>18</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>102</td>
</tr>
<tr>
<td>Thurs 4h</td>
<td>75</td>
<td>6</td>
<td>28</td>
<td>3</td>
<td>10</td>
<td>0</td>
<td>121</td>
</tr>
<tr>
<td>Thurs 5h</td>
<td>76</td>
<td>5</td>
<td>29</td>
<td>8</td>
<td>14</td>
<td>0</td>
<td>132</td>
</tr>
<tr>
<td>Thurs 6h</td>
<td>184</td>
<td>4</td>
<td>85</td>
<td>14</td>
<td>32</td>
<td>0</td>
<td>320</td>
</tr>
<tr>
<td>Thurs 7h</td>
<td>362</td>
<td>3</td>
<td>91</td>
<td>20</td>
<td>42</td>
<td>1</td>
<td>519</td>
</tr>
<tr>
<td>Thurs 8h</td>
<td>286</td>
<td>8</td>
<td>110</td>
<td>23</td>
<td>46</td>
<td>0</td>
<td>472</td>
</tr>
<tr>
<td>Thurs 9h</td>
<td>261</td>
<td>19</td>
<td>113</td>
<td>21</td>
<td>51</td>
<td>0</td>
<td>466</td>
</tr>
<tr>
<td>Thurs 10h</td>
<td>271</td>
<td>10</td>
<td>126</td>
<td>25</td>
<td>47</td>
<td>1</td>
<td>480</td>
</tr>
<tr>
<td>Thurs 11h</td>
<td>241</td>
<td>3</td>
<td>109</td>
<td>19</td>
<td>44</td>
<td>0</td>
<td>416</td>
</tr>
<tr>
<td>Thurs 12h</td>
<td>241</td>
<td>8</td>
<td>93</td>
<td>20</td>
<td>36</td>
<td>0</td>
<td>397</td>
</tr>
<tr>
<td>Thurs 13h</td>
<td>205</td>
<td>5</td>
<td>80</td>
<td>16</td>
<td>13</td>
<td>0</td>
<td>320</td>
</tr>
<tr>
<td>Thurs 14h</td>
<td>335</td>
<td>17</td>
<td>113</td>
<td>20</td>
<td>30</td>
<td>0</td>
<td>514</td>
</tr>
<tr>
<td>Thurs 15h</td>
<td>314</td>
<td>18</td>
<td>121</td>
<td>15</td>
<td>39</td>
<td>0</td>
<td>507</td>
</tr>
<tr>
<td>Thurs 16h</td>
<td>333</td>
<td>23</td>
<td>152</td>
<td>8</td>
<td>28</td>
<td>0</td>
<td>543</td>
</tr>
<tr>
<td>Thurs 17h</td>
<td>342</td>
<td>24</td>
<td>74</td>
<td>6</td>
<td>42</td>
<td>0</td>
<td>488</td>
</tr>
<tr>
<td>Thurs 18h</td>
<td>416</td>
<td>20</td>
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Appendix D: The Mayor’s Air Quality Strategy

In 2010, the Mayor of London produced a new Air Quality Strategy\textsuperscript{11} setting out policies and proposals to reduce air pollution in Greater London. The overall aim of the strategy is to work to achieve the EU limit values for particulate matter (PM\textsubscript{10} and PM\textsubscript{2.5}) and NO\textsubscript{2}.

**LEZ**

One of the most high profile policies in the Strategy is the London Low Emission Zone (LEZ), which was introduced in 2008 as a means to reduce particulate matter (PM) emissions from the most polluting vehicles driving in London. The LEZ covers most of Greater London and has a daily charge for vehicles that do not meet certain Euro emission standards. Owners of vehicles not meeting the standard who do not pay the charge are liable to be fined.

The LEZ is currently in Phase 2, for which an emission standard applies to diesel vehicles over 3.5 tonnes GWV (\textit{e.g.} lorries, caravans, refuse trucks, horse boxes, fire engines) and buses and coaches over five tonnes GVW. These vehicle types are required to meet the Euro III emission standard for PM which came into force in October 2000. From 3 January 2012, the standard for these vehicles will be tightened to the Euro IV for PM standard (this standard came into force in October 2005). In addition, diesel vehicles between 1.205 and 3.5 tonnes GVW (including larger vans and 4x4 utility vehicles) and minibuses up to five tonnes GVW will be required to meet the Euro 3 standard for PM (which came into force between 2000 and 2001).

As well as purchasing a new vehicle to meet these standards, owners can fit an approved PM abatement device (such as a particle filter). There are also some vehicles which have been manufactured to meet an emission standard earlier than it legally came into force. These vehicles are either known as “early adopters” or have “eligible engines”.

**Buses**

The Mayor has introduced specific policies for dealing with emissions from public transport, primarily tackling London buses and registered taxis. In addition to ensuring that all buses meet the LEZ standards, the Mayor aims for all buses to meet the Euro IV standard for NO\textsubscript{x} by 2015. In 2012, 900 buses will be fitted with SCR technology to meet this standard\textsuperscript{12}. Transport for London (TfL) is trialling alternative-fuelled buses including diesel hybrid buses, with a target for 300 hybrid buses to be in service by the end of 2012. Several hydrogen fuel cell buses are also being tested in the fleet.

**Taxis**

The Mayor introduced his taxi emission strategy in 2006 with the aim of all taxis meeting the Euro III emission standard for PM and NO\textsubscript{x}. Since June 2008, licences were only renewed for taxis meeting this standard. However, in the Mayor’s most recent strategy, the initiative is now for a rolling age limit on taxis. From the 1 January 2012, no licence will be issued for black cabs over 15 years in age (effectively Euro 1) and all new taxis entering the fleet from 1 April 2012 will meet the Euro 5 standard. For private hire vehicles (minicabs), this age limit will be set at ten years from January 2012, and new

\textsuperscript{11} http://www.london.gov.uk/sites/default/files/Air%20Quality%20Strategy%20v3.pdf

\textsuperscript{12} Personal communication with Nicola Cheetham (TfL, Surface Transport)
vehicles (or newly licensed vehicles) in April 2012 will need to meet the Euro IV standard.
## Appendix E: Emission rates by vehicle type

### Table E1: NO\textsubscript{x} emission rate by vehicle type (southbound).

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<tr>
<th>Hour</th>
<th>Car</th>
<th>Taxi</th>
<th>LGV</th>
<th>HGV</th>
<th>Bus</th>
<th>Coach</th>
<th>Total</th>
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Table E2: NO\(_x\) emission rate by vehicle type (northbound).

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**Total** 7,002 2,161 3,121 3,954 35,299 118 51,653

**Average hourly** 97.3 30.0 43.3 54.9 490.3 1.6 717.4
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| Sat 2h | 3.6 | 2.8 | 0.9 | 2.0 | 3.4 | 0.0 | 13 |
| Sat 3h | 2.5 | 1.3 | 2.0 | 0.2 | 2.8 | 0.0 | 9 |
| Sat 4h | 2.7 | 0.9 | 2.8 | 0.7 | 2.3 | 0.0 | 9 |
| Sat 5h | 3.7 | 1.0 | 2.6 | 0.7 | 3.1 | 0.0 | 11 |
| Sat 6h | 3.8 | 0.9 | 4.7 | 1.9 | 4.2 | 0.0 | 15 |
| Sat 7h | 7.2 | 1.5 | 7.0 | 2.6 | 5.4 | 0.0 | 24 |
| Sat 8h | 10.1 | 2.9 | 6.1 | 1.8 | 7.7 | 0.0 | 29 |
| Sat 9h | 13.7 | 3.2 | 5.4 | 2.4 | 9.1 | 0.0 | 34 |
| Sat 10h | 16.0 | 3.4 | 6.4 | 2.3 | 7.9 | 0.0 | 36 |
| Sat 11h | 15.3 | 2.9 | 5.7 | 0.6 | 8.6 | 0.0 | 33 |
| Sat 12h | 13.6 | 2.3 | 5.6 | 0.8 | 8.1 | 0.2 | 31 |
| Sat 13h | 14.7 | 1.7 | 3.6 | 0.7 | 9.2 | 0.4 | 30 |
| Sat 14h | 14.6 | 3.7 | 3.4 | 1.1 | 8.7 | 0.0 | 32 |
| Sat 15h | 12.9 | 3.7 | 6.7 | 0.5 | 7.1 | 0.2 | 31 |
| Sat 16h | 15.3 | 2.7 | 4.1 | 0.4 | 8.0 | 0.2 | 31 |</p>
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The aim of this project was to determine the vehicle emission sources in Putney High Street in London Borough of Wandsworth. This street was chosen because kerbside measured nitrogen dioxide (NO2) concentrations are some of the highest in London, exceeding both the annual and hourly mean Air Quality Strategy Objective by a large margin.

A combination of automatic number plate recognition (ANPR) cameras and video traffic counts were employed to characterise the vehicle fleet and determine emissions from each vehicle type for each hour of the day. Recommendations for further work to overcome some of the limitations of this study are provided in the report.

The headline results from the study showed that buses contributed over two-thirds of NOx-emissions and 21 percent of particulate (PM) emissions in Putney High Street despite making up only ten percent of vehicle flow. Overall, cars made up two-thirds of the total vehicle flow in the street and contributed to 14 percent of NOx emissions and 35 percent of PM emissions. Emission rates were similar on weekdays and Saturday and the diurnal profile reflected that of the hourly NO2 concentrations measured at the kerbside monitoring site.

The majority of the fleet met either Euro 3/III or Euro 4/IV emissions standard, i.e. were 10 years old or newer. 93 percent of heavy goods vehicles, buses and coaches were found to meet the required standard of Phase 2 of the London Low Emission Zone scheme.

Other titles from this subject area

PPR490 The acoustic durability of timber noise barriers on England’s strategic road network. P A Morgan. 2010
PPR485 The performance of quieter surfaces over time. M Muirhead, L Morris and R E Stait. 2010
PPR394 An examination of the monetised benefit of proposed changes to type approved noise limits for tyres. M Muirhead, P G Abbott and M Burdett. 2009