Cambridge
Environmental
Research
Consultants Ltd

# Source Apportionment for Hillingdon, Hounslow and Spelthorne

Final Report

*Prepared for*
London Borough of Hillingdon

*21st March 2003*

C E R C

## Report Information

| | |
|---|---|
| CERC Job Number: | FM502 |
| Job Title: | Source Apportionment for Hillingdon, Hounslow and Spelthorne |
| Prepared for: | LB Hillingdon |
| Report Status: | Final |
| Report Reference: | FM502/R4S/03 |
| Issue Date: | 21/03/2003 |

| | |
|---|---|
| Author(s): | Matthew Williams, Sofia Girnary |

| | |
|---|---|
| Reviewer(s): | Sarah Wilkinson |

| Issue | Date | Comments |
|---|---|---|
| 1 | 14/10/02 | Draft report for source apportionment |
| 2 | 15/11/02 | Revised draft report for source apportionment |
| 3 | 17/12/02 | Final SA report |
| 4 | 21/03/03 | Changing to NOx as NO2 |

| | |
|---|---|
| Main File(s): | FM502_R4S_21Mar03.doc |

| Figures and Tables | Model Run Reference(s) |
|---|---|
| Table 3.1 | no2tothi, pmtothi |
| Figures 4.3a and 4.3b | gsards05, gsapts04, sa_oth05, gsaapt05, japvol05 |
| Figures 4.4a and 4.4b | sa_rds04, gsapts04, sa_oth04, gsaap04b, japol05 |
| Figures 5.3a and 5.3b | gsacar05, gsabus05, gsahgv05, gsalgv05 |
| Figures 5.4a and 5.4b | gsacar04, gsabus04, gsahgv04, gsalgv04 |
| Figures 6.4a and 6.4b | sa_ha05, sa_tfl05, sa_brd05 |
| Figures 6.5a and 6.5b | sa_ha04, sa_tfl04, sa_brd04 |
| Figures 7.4a and 7.4b | hr_rds05, nhr_rd05, gothrd05 |
| Figures 7.5a and 7.5b | hr_rds04, nhr_rd04, gothrd04 |
| Figures 8.3a to 8.4b | hr_rv05, hr_lin05, hr_hol05, hr_hea05, hr_ets05, hr_cpk05, hr_apu05, hr_all05 |
| Figues 9.1a to 9.2b | apv05_g.upl, apv05_m.upl, apv05_t.upl |

# Contents

# 1. Summary

A source apportionment study for emissions to air of $NO_x$ and $PM_{10}$ has been carried out using EMIT and ADMS-Urban. Emissions of $NO_x$ in 2005 and $PM_{10}$ in 2004 have been considered in the London Boroughs of Hillingdon and Hounslow and the Borough of Spelthorne.

An air quality modelling study was previously carried out for the area and is described in the report *Air quality modelling for West London: Hillingdon, Hounslow, Spelthorne and Slough*, dated 27th August 2002. This earlier work, and the source apportionment study described here, form part of the Stage 4 Review and Assessment of Air Quality.

Emissions data were taken from four different sources: the emissions inventory for Heathrow, 1998; the London Atmospheric Emissions Inventory (LAEI), supplied by the Greater London Authority (GLA), February 2002; the Surrey Traffic Model; and the February 2002 emissions inventory for Slough. Meteorological data from Heathrow for the year 1999 were used in the modelling. Background concentration data were obtained from rural monitoring sites and adjusted to be appropriate for the years 2004 and 2005.

The source apportionment exercise quantifies the relative contribution of each source group both (1) to the total emissions, and (2) to the resulting annual average ground level concentration at eleven receptor locations within Hillingdon. The emissions and annual average concentrations have been apportioned in the following ways:

- By major source group;
- Breakdown of traffic sources by vehicle type;
- Breakdown of traffic sources by road type, i.e. which organisation has responsibility;
- Breakdown of traffic sources into Heathrow and non-Heathrow traffic;
- Breakdown of Heathrow Airport sources; and
- Breakdown of Heathrow airborne aircraft sources by height.

The results of each of these are described in the following sections.

**Breakdown into major source groups**
The maximum contribution to the total emissions of $NO_x$ from within Hillingdon is from Heathrow Airport, which contributes 58%. The maximum contribution to the total emissions of $PM_{10}$ is also from Heathrow Airport, which contributes 40%.

At most of the receptor points, the major contribution to annual average $NO_x$ concentrations is from major roads. However, Heathrow Airport is the major contributor at Mendip Close and Bomber Close. For $PM_{10}$, the background concentration dominates the predicted concentrations.

**Breakdown of traffic by vehicle type**
The maximum contribution to the total emissions of $NO_x$ from traffic from within Hillingdon is from cars, which contribute 38%. The maximum contribution to the total emissions of $PM_{10}$ from traffic is from LGVs, which contribute 32%.

The contributions to the total annual average concentrations of $NO_x$ and $PM_{10}$ from traffic sources vary greatly depending on the receptor location considered, with the greatest contribution for both pollutants at the AURN site.

The percentage contribution of each traffic type to the annual average $NO_x$ concentration is approximately the same at each of the receptor points with the major contributions being from cars and HGVs. The situation for $PM_{10}$ is similar with cars, HGVs and LGVs all making major contributions to the concentrations.

**Breakdown of traffic by road type**

The $NO_x$ emissions from major roads within Hillingdon are fairly equally shared out amongst roads for which the Highways Agency and the local authority have responsibility, with the TfL roads contributing slightly less. There is a similar situation for $PM_{10}$.

The contribution to the annual average concentrations of $NO_x$ and $PM_{10}$ from each road group varies depending on the receptor location considered, as does the percentage contribution from each group.

**Breakdown into Heathrow and non-Heathrow traffic**

Emissions from Heathrow traffic make up 16% of the total emissions of $NO_x$ from major roads within Hillingdon. Non-Heathrow traffic contributes 60% with the remainder undefined. Heathrow traffic contributes 15% of the total emissions of $PM_{10}$ from major roads within Hillingdon. Non-Heathrow traffic contributes 58% with the remainder undefined

The contribution to the annual average concentrations of $NO_x$ and $PM_{10}$ from each road group varies depending on the receptor location considered, as does the percentage contribution from each group. For both pollutants the percentage contribution due to Heathrow traffic is greatest at Bomber Close where it reaches 26% of the total concentration resulting from traffic emissions.

**Breakdown of Heathrow Airport sources**

The maximum contribution to the emissions of $NO_x$ from Heathrow Airport is from airborne aircraft, which contribute 66%. The maximum contribution to the emissions of $PM_{10}$ is from taxiing and aircraft holding, which contribute 44%.

The contribution to the annual average concentrations of $NO_x$ and $PM_{10}$ from each airport source type varies depending on the receptor location considered.

At most of the receptor points, the major contribution to annual average $NO_x$ concentrations resulting from the airport emissions is from airborne aircraft. However, road vehicles are the major contributor at the AURN site. For $PM_{10}$, the percentage contribution varies depending on the receptor location considered with the major contributors being road vehicles and taxiing and aircraft holding.

**Breakdown of Heathrow airborne aircraft sources by height**

To determine the relative impacts of the aircraft at different heights, the volume sources used in the modelling have been divided into three sets according to the heights they represent (0 to 50m; 50m to 450m; and 450m to 1000m) and have been modelled separately. The maximum emissions of $NO_x$ and $PM_{10}$ are emitted from aircraft above a height of 450m, however, the impact of the emissions from different heights on ground level concentrations will vary depending on the distance from the ground and the area over which the pollutants are emitted.

The contribution of all the airborne aircraft to the annual average concentrations of $NO_x$ and $PM_{10}$ varies greatly depending on the receptor location.

In all cases the greatest contribution to the ground level concentrations comes from the aircraft closest to the ground, up to a height of 50m, which contribute between 82% and 97% of the total $NO_x$ and $PM_{10}$ concentration resulting from airborne aircraft. The impact of the aircraft above a height of 450m is very low, contributing at most 3% of the total $NO_x$ and $PM_{10}$ concentration resulting from airborne aircraft emissions. The greatest percentage contribution from aircraft above a height of 450m occurs at sites away from the airport, where the overall contribution to the ground level concentrations from airborne aircraft is smallest.

# 2. Introduction

Cambridge Environmental Research Consultants Ltd (CERC) has been commissioned by the London Boroughs of Hillingdon and Hounslow and the Borough of Spelthorne to carry out a source apportionment study for the area covered by the three boroughs using EMIT and ADMS-Urban, for $PM_{10}$ and $NO_x$.

An air quality modelling study was previously carried out for the area and is described in the report *Air quality modelling for West London: Hillingdon, Hounslow, Spelthorne and Slough*, dated 27th August 2002. This earlier work, and the source apportionment study described here, form part of the Stage 4 Review and Assessment of Air Quality.

The source apportionment exercise quantifies the relative contribution of each source group both (1) to the total emissions, and (2) to the resulting annual average ground level concentration at eleven receptor locations within Hillingdon. The emissions and annual average concentrations have been apportioned in the following ways:

- By major source group;
- Breakdown of traffic sources by vehicle type;
- Breakdown of traffic sources by road type, i.e. which organisation has responsibility;
- Breakdown of traffic sources into Heathrow and non-Heathrow traffic;
- Breakdown of Heathrow Airport sources; and
- Breakdown of Heathrow airborne aircraft sources by height.

# 3. Source apportionment

The pollutant concentrations occurring at any location are the result of emissions from a wide range of sources of different types and at different locations. The modelling carried out for the London Boroughs of Hillingdon and Hounslow and the Borough of Spelthorne considered all the emission sources within the London area and took into account the effect of emissions from outside the area by using rural background concentration data.

The source apportionment exercise reported here quantifies the relative contribution of each source group both to the total emissions, and to the resulting annual average ground level concentration at eleven receptor locations within the borough. The emissions and concentrations have been apportioned in the following ways:

- By major source group;
- Breakdown of traffic sources by vehicle type;
- Breakdown of traffic sources by road type, i.e. which organisation has responsibility;
- Breakdown of traffic sources into Heathrow and non-Heathrow traffic;
- Breakdown of Heathrow Airport sources; and
- Breakdown of Heathrow airborne aircraft sources by height.

The source apportionment work has been carried out for the predicted emissions and concentrations in 2004 for $PM_{10}$ and 2005 for $NO_x$. These are the years by which the Air Quality Strategy Objective values are required to be achieved and, to aid the decision making process involved in the Stage 4 Review and Assessment of Air Quality, it is most useful to have estimates of source apportionment for these years.

The Air Quality Strategy defines objective values for $NO_2$, while emissions from the modelled sources are given in terms of $NO_x$. A proportion of the emitted $NO_x$ is in the form of $NO_2$ and a further proportion will be converted to $NO_2$ during its time in the atmosphere. The amount of $NO_2$ created will depend on many factors including emissions from other sources in the area. Therefore the total $NO_2$ concentration cannot be broken down simply into concentrations resulting from different sources, as for $PM_{10}$, as it will depend on emissions from the other sources in the area. The source apportionment study has therefore been carried out using $NO_x$ concentrations, assuming that all $NO_x$ is $NO_2$. These give an indication of which sources are contributing most to the concentrations of $NO_2$ although the results should be treated with caution because, for example, a 10% reduction in $NO_x$ concentrations will not bring about a 10% reduction in $NO_2$ concentrations.

## 3.1 Emissions

Emissions data were taken from four different sources: the emissions inventory for Heathrow, 1998; the London Atmospheric Emissions Inventory (LAEI), supplied by the Greater London Authority (GLA), February 2002; the Surrey Traffic Model; and the February 2002 emissions inventory for Slough. Traffic emissions were calculated from the traffic flows given in the inventories using the latest set of emission factors, released in February 2002.

Emissions for sources other than road and industrial sources are given in the form of a set of 1km square grid cells covering the whole of London.

For each source apportionment exercise the emissions were broken down into source groups. For each source group total emissions from within Hillingdon; from within the study area comprising Hillingdon, Hounslow and Spelthorne (referred to as Hi/Ho/Sp); and from the entire area covered by the emission inventories have been presented.

## 3.2 Concentrations

As well as dividing the emissions into different source groups, the ground level concentrations resulting from each source group have been calculated at a set of receptor points within the borough. Details of the receptor locations within Hillingdon for which the source apportionment exercise were carried out are given in Table 3.1 together with the total annual average $NO_2$ and $PM_{10}$ concentrations predicted at each of the locations. The locations are shown in Figure 3.1.

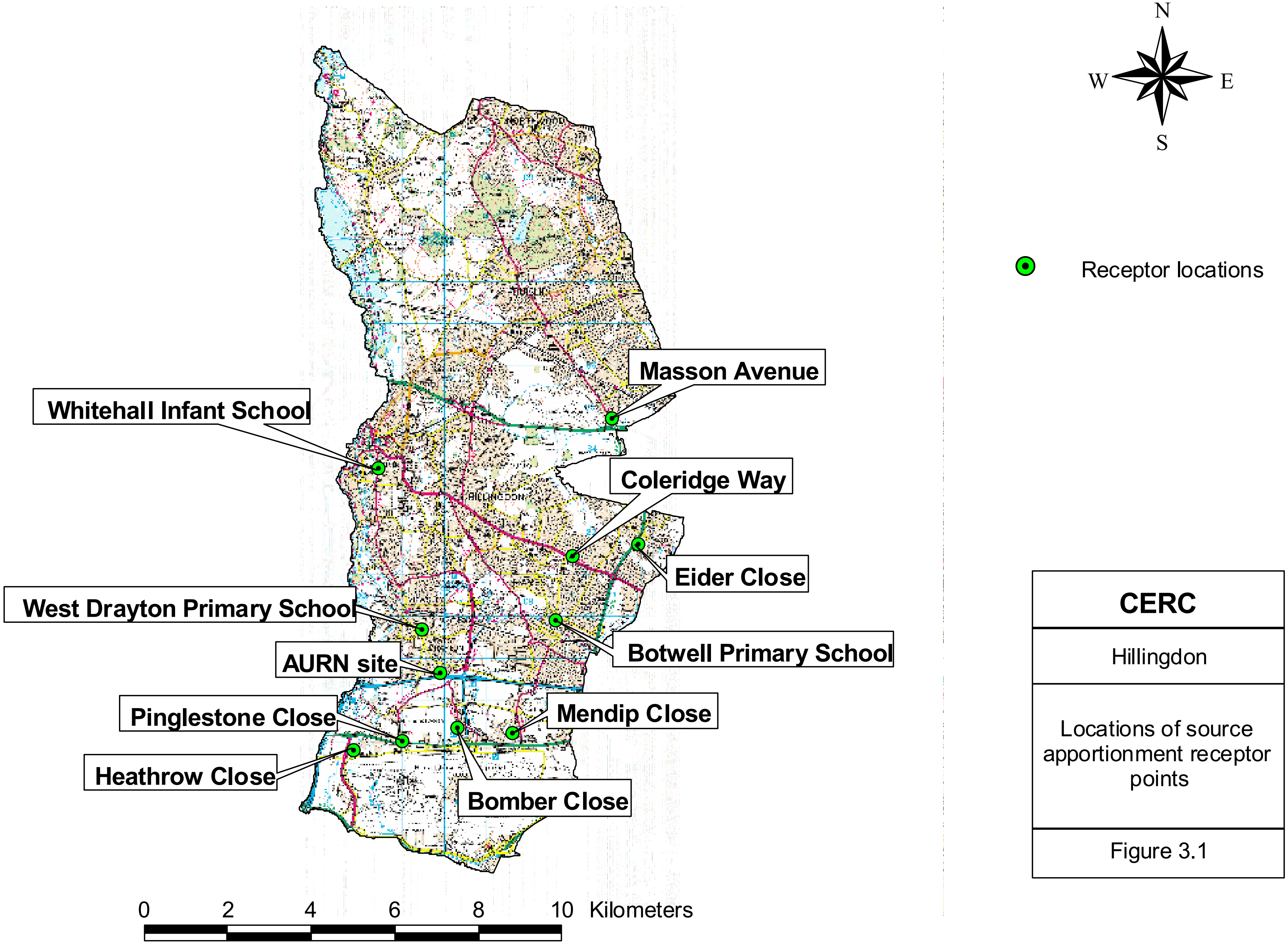
***Table 3.1: Source apportionment receptor point locations within Hillingdon***

| ID | Description | Location | Annual average $NO_2$ concentration (µg/m³) | Annual average $PM_{10}$ concentration (µg/m³) |
|---|---|---|---|---|
| 1 | Masson Avenue | 511019, 184714 | 39.3 | 23.7 |
| 2 | Eider Close | 511642, 181709 | 40.4 | 23.7 |
| 3 | Coleridge Way | 510073, 181410 | 35.4 | 23.2 |
| 4 | Botwell Primary School | 509681, 179870 | 40.5 | 23.7 |
| 5 | Mendip Close | 508640, 177199 | 47.0 | 23.8 |
| 6 | Bomber Close | 507307, 177301 | 45.0 | 23.8 |
| 7 | Pinglestone Close | 505996, 177006 | 45.6 | 23.7 |
| 8 | Heathrow Close | 504842, 176789 | 42.1 | 23.8 |
| 9 | West Drayton Primary School | 506473, 179674 | 37.7 | 23.4 |
| 10 | AURN site | 506900, 178620 | 51.9 | 25.4 |
| 11 | Whitehall Infant School | 505432, 183532 | 36.8 | 23.4 |

The annual average $NO_2$ concentrations are predicted to exceed the AQS objective value of 40µg/m³ at seven of the eleven receptor points considered. The annual average $PM_{10}$ concentrations are not predicted to exceed the AQS objective value of 40µg/m³ at any of the receptor locations.

$NO_x$ emissions from outside London and $PM_{10}$ emissions both from outside London and from sources not represented in the emissions inventory (the "coarse component") are represented in the modelling by background concentrations. The background values used are the same as those used in the modelling study for the area and are described fully in the report *Air quality modelling for West London: Hillingdon, Hounslow, Spelthorne and Slough*.

Note that the concentrations due to each source group have been predicted from the emissions over the entire area covered by the emissions inventories.


N
W
E
S
Receptor locations
Masson Avenue
Whitehall Infant School
Coleridge Way
Eider Close
West Drayton Primary School
Botwell Primary School
AURN site
Mendip Close
Pinglestone Close
Heathrow Close
Bomber Close
0
2
4
6
8
10
Kilometers
CERC
Hillingdon
Locations of source apportionment receptor points
Figure 3.1

# 4. Apportionment by source group

The emissions from all the sources in the borough have been divided according to their source type. The total emissions from each source group from within the borough, from within the study area and from the entire area covered by the emissions inventories have been calculated. The contributions to the ground level concentrations from each source group, due to emissions from the entire inventory area, have been calculated at each of the receptor locations. The source types used are:

- Major road sources;
- Heathrow Airport sources, including airborne aircraft, taxiing and aircraft holding, heating, and on-site traffic, car parks and taxi ranks;
- Industrial, including Part As, Part Bs and boilers rated greater than 2MW; and
- Other sources, including other transport sources and commercial and domestic fuel use.

When predicting concentrations from each of these source groups, the major roads and major industrial sources were modelled explicitly and the remaining industrial sources and other source groups were modelled as $1km^2$ gridded emissions.

## 4.1 Emissions

Tables 4.1 and 4.2 show the emissions of $NO_x$ and $PM_{10}$, respectively, from within Hillingdon, from within the study area comprising Hillingdon, Hounslow and Spelthorne (referred to as HI/Ho/Sp), and from the entire area covered by the emissions inventories (referred to as EI area), broken down into the major source groups.

***Table 4.1: $NO_x$ emissions broken down by source type (tonnes/year)***

| | **Major roads** | **Airport** | **Industrial** | **Other** | **Total** |
|---|---|---|---|---|---|
| **Hillingdon** | 1541 | 3750 | 243 | 906 | 6440 |
| **Hi/Ho/Sp** | 3843 | 5004 | 293 | 1680 | 10820 |
| **EI area** | 25759 | 9089 | 25609 | 36130 | 96587 |

***Table 4.2: $PM_{10}$ emissions broken down by source type (tonnes/year)***

| | **Major roads** | **Airport** | **Industrial** | **Other** | **Total** |
|---|---|---|---|---|---|
| **Hillingdon** | 60 | 72 | 27 | 22 | 181 |
| **Hi/Ho/Sp** | 149 | 81 | 60 | 37 | 327 |
| **EI area** | 1130 | 96 | 1061 | 1056 | 3344 |

Figures 4.1 and 4.2 show the emissions of $NO_x$ and $PM_{10}$, respectively, from within Hillingdon.

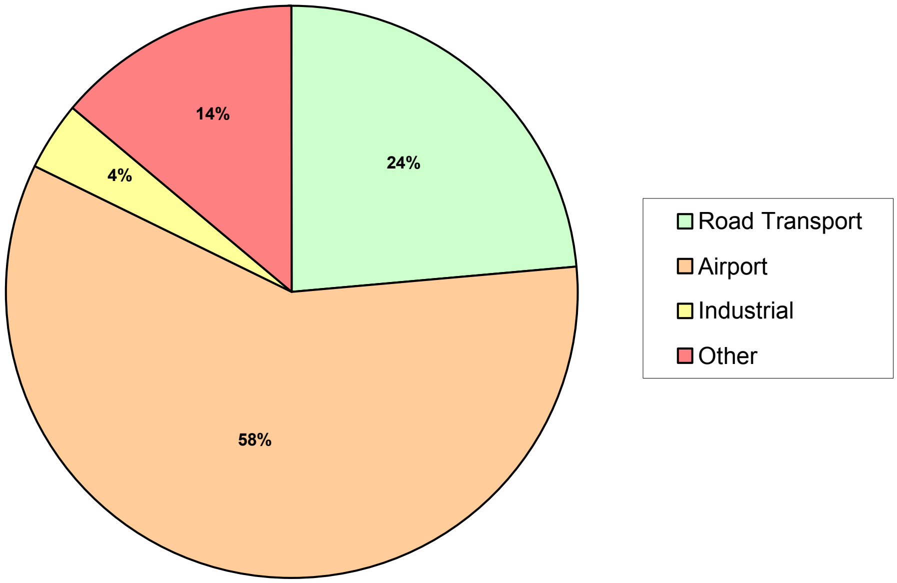



***Figure 4.1: $NO_x$ emissions from within Hillingdon***

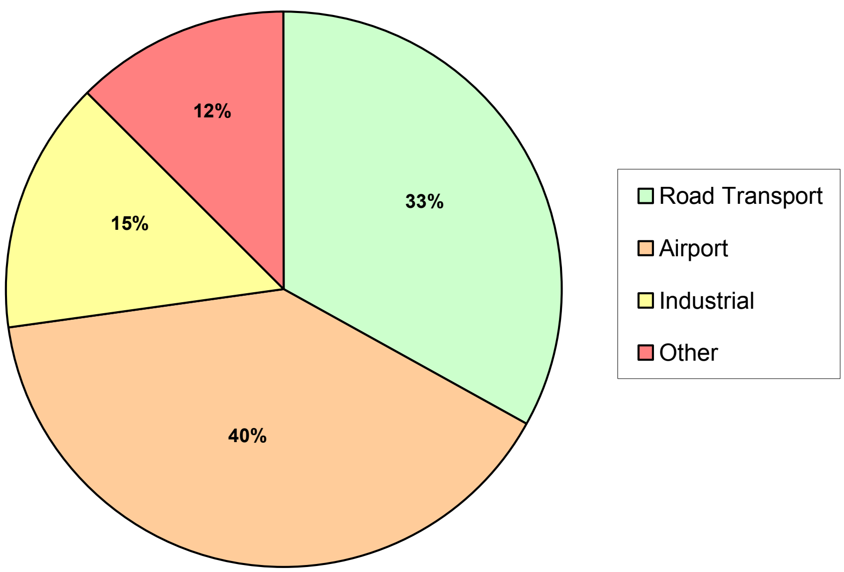



***Figure 4.2: $PM_{10}$ emissions from within Hillingdon***

The maximum contribution to the total emissions of $NO_x$ within Hillingdon is from Heathrow Airport, which contributes 58%. Road traffic contributes 24% to the total emissions of $NO_x$ within Hillingdon.

The maximum contribution to the total emissions of $PM_{10}$ is also from the airport, which contributes 40%. Road traffic contributes 33% to the total emissions of $PM_{10}$ within the borough.

## 4.2 Concentrations

The annual average $NO_x$ concentrations resulting from emissions from each source type have been calculated at each of the receptor points. Figure 4.3a shows the contributions of each of the source groups to these predicted concentrations. Figure 4.3b shows these values as percentages of the totals. Note that the concentrations presented are those resulting from emissions over the whole of the area covered by the emissions inventories, not just from within Hillingdon. Figures 4.4a and 4.4b show the equivalent information for $PM_{10}$; note the change of scale in Figure 4.4a.

At most of the receptor points, the major contribution to annual average $NO_x$ concentrations is from major roads. However, Heathrow Airport is the major contributor at Mendip Close and Bomber Close. For $PM_{10}$, the background concentration dominates the predicted concentrations.

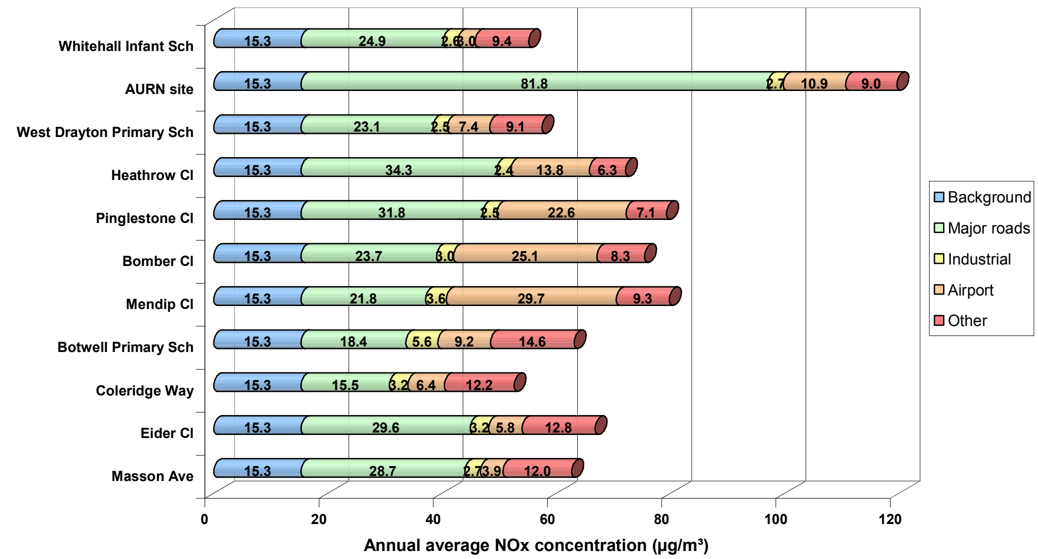



*Figure 4.3a: Contribution of major source groups to annual average $NO_x$ concentrations*

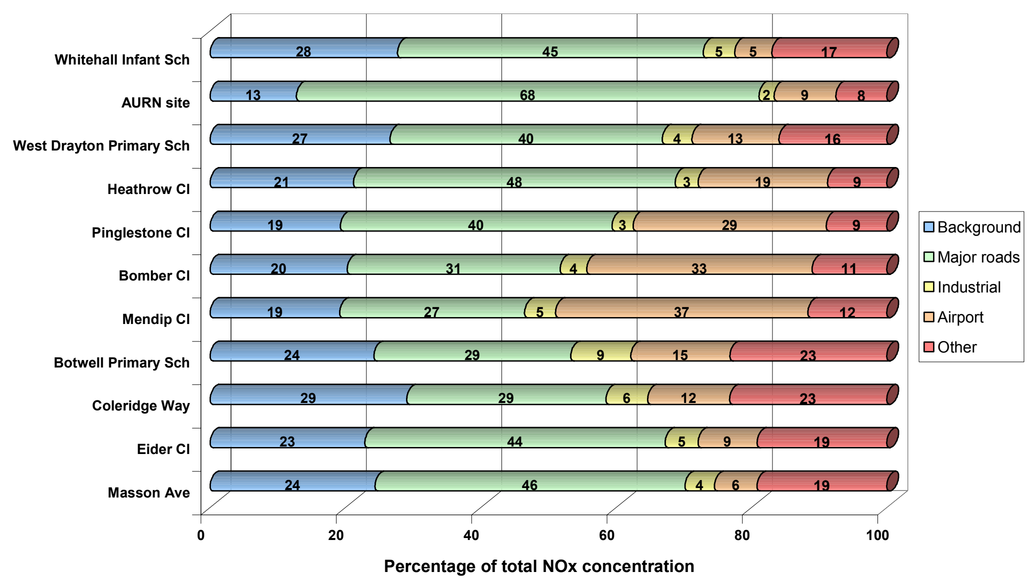



*Figure 4.3b: Percentage contribution of major source groups to annual average $NO_x$ concentrations*

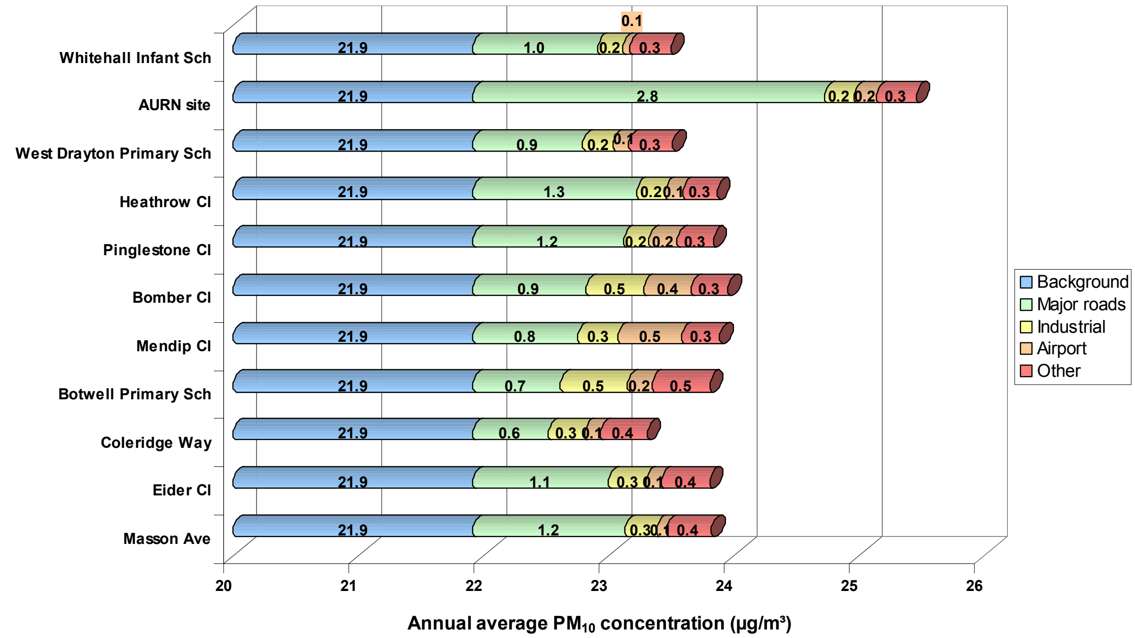



*Figure 4.4a: Contribution of major source groups to annual average $PM_{10}$ concentrations*

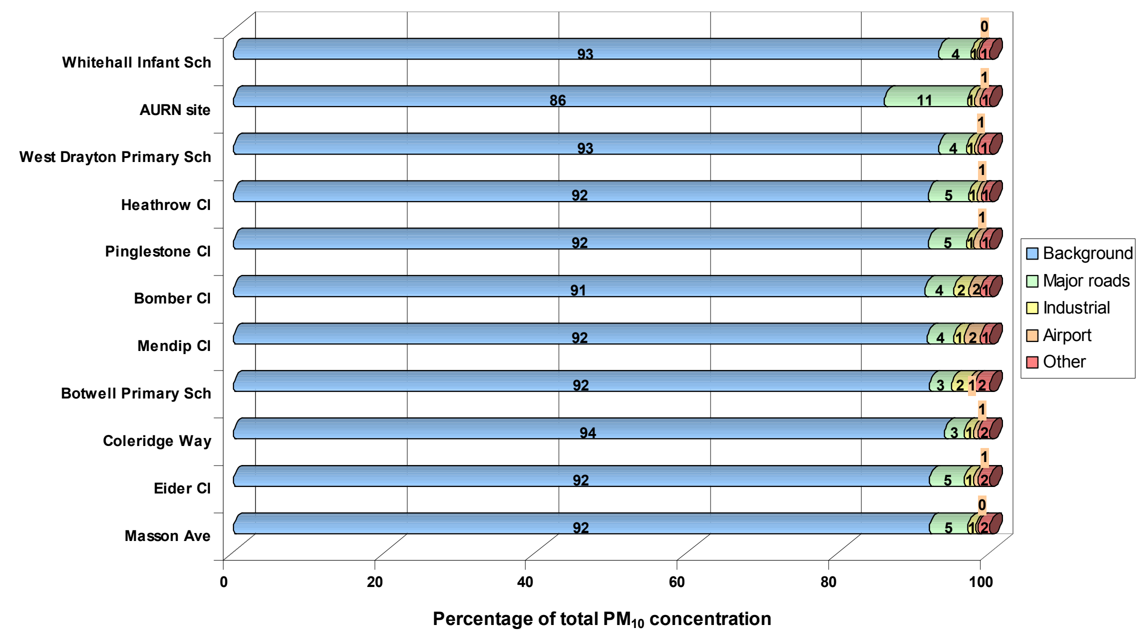



*Figure 4.4b: Percentage contribution of major source groups to annual average $PM_{10}$ concentrations*

# 5. Breakdown of traffic emissions by vehicle type

The emissions from the major roads have been broken down into emissions from the different types of vehicles. The total emissions from each vehicle type from within the borough, the study area and the entire inventory area have been calculated. The contributions to the ground level concentrations from each vehicle type, due to emissions from the entire inventory area, have been calculated at each of the receptor locations. The vehicle categories used are:

- Cars & motorcycles;
- Light Goods Vehicles (LGVs);
- Heavy Goods Vehicles (HGVs); and
- Buses & coaches.

## 5.1 Emissions

Tables 5.1 and 5.2 show the breakdown of traffic emissions of $NO_x$ and $PM_{10}$, respectively, from within Hillingdon, from within the study area comprising Hillingdon, Hounslow and Spelthorne, and from within the whole emissions inventory area. Figures 5.1 and 5.2 show pie charts of the emissions from within the borough.

***Table 5.1: Emissions of $NO_x$ from different vehicle types***

| | **Cars** | | **LGV** | | **HGV** | | **Bus** | |
|---|---|---|---|---|---|---|---|---|
| | **T/yr** | **%** | **T/yr** | **%** | **T/yr** | **%** | **T/yr** | **%** |
| **Hillingdon** | 600 | 38 | 152 | 10 | 563 | 37 | 227 | 15 |
| **Hi/Ho/Sp** | 1439 | 37 | 373 | 10 | 1419 | 37 | 612 | 16 |
| **EI area** | 9154 | 36 | 2780 | 11 | 10495 | 41 | 3332 | 13 |

***Table 5.2: Emissions of $PM_{10}$ from different vehicle types***

| | **Cars** | | **LGV** | | **HGV** | | **Bus** | |
|---|---|---|---|---|---|---|---|---|
| | **T/yr** | **%** | **T/yr** | **%** | **T/yr** | **%** | **T/yr** | **%** |
| **Hillingdon** | 17 | 29 | 19 | 32 | 17 | 28 | 7 | 11 |
| **Hi/Ho/Sp** | 42 | 28 | 45 | 30 | 42 | 28 | 19 | 13 |
| **EI area** | 383 | 34 | 327 | 29 | 350 | 31 | 70 | 6 |

The maximum contribution to the total emissions of $NO_x$ from traffic within Hillingdon is from cars, which contribute 38%. The maximum contribution to the total emissions of $PM_{10}$ from traffic is from LGVs, which contribute 32%.

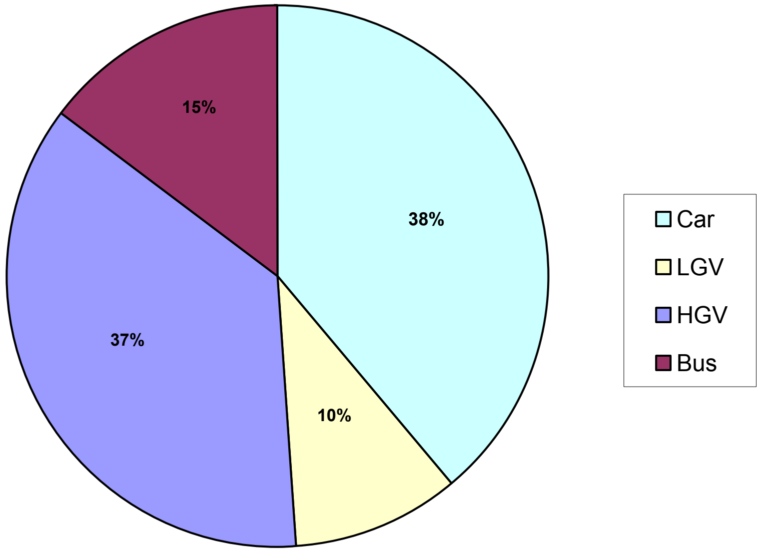



***Figure 5.1: $NO_x$ emissions from different vehicle types within Hillingdon***

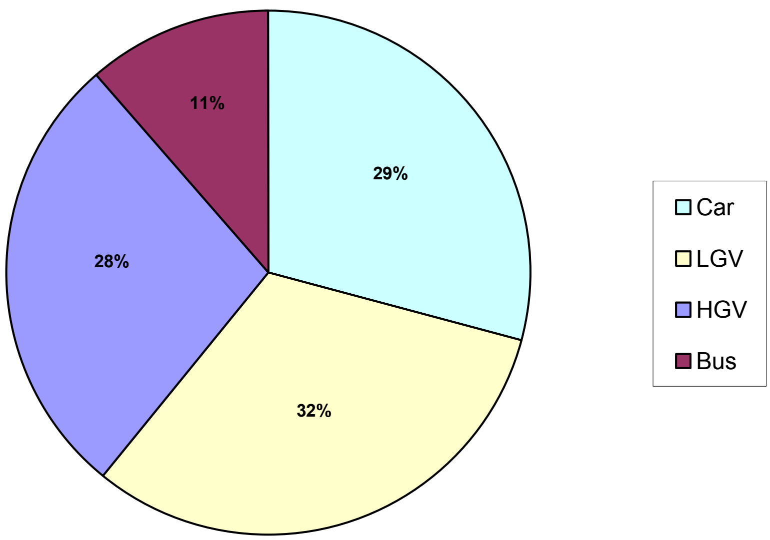



***Figure 5.2: $PM_{10}$ emissions from different vehicle types within Hillingdon***

## 5.2 Concentrations

The annual average $NO_x$ concentrations resulting from each vehicle type have been calculated at each of the receptor points and these are shown in Figure 5.3a. Figure 5.3b shows the percentage contribution of each source group to the total annual average $NO_x$ concentration resulting from traffic emissions. Note that the concentrations presented are those resulting from emissions over the whole of the area covered by the emissions inventories, not just from within Hillingdon. Figures 5.4a and 5.4b show the equivalent contributions to the annual average $PM_{10}$ concentrations.

The contribution to the annual average concentrations of $NO_x$ and $PM_{10}$ from traffic sources varies depending on the receptor location considered. For both pollutants the greatest contribution occurs at the AURN site.

The percentage contribution of each traffic type to the annual average $NO_x$ concentration is approximately the same at each of the receptor points. Cars and HGVs each contribute between 33% and 44% of the total concentration resulting from traffic emissions at each of the receptor points. The situation is similar for $PM_{10}$ with cars, HGVs and LGVs each contributing between 23% and 36% to the total concentration resulting from traffic emissions.

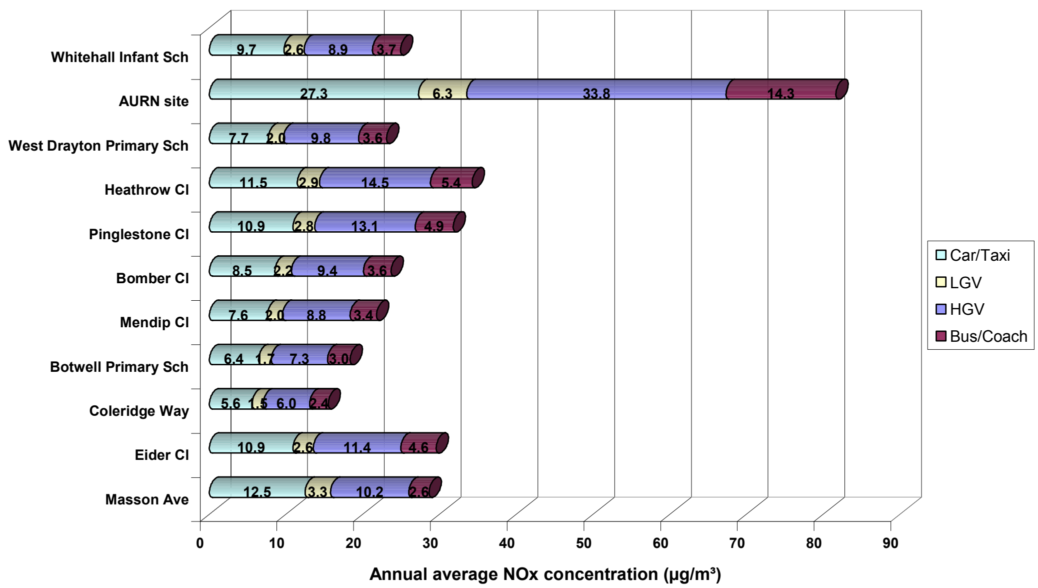



***Figure 5.3a: Contribution of different vehicle types to annual average $NO_x$ concentrations***

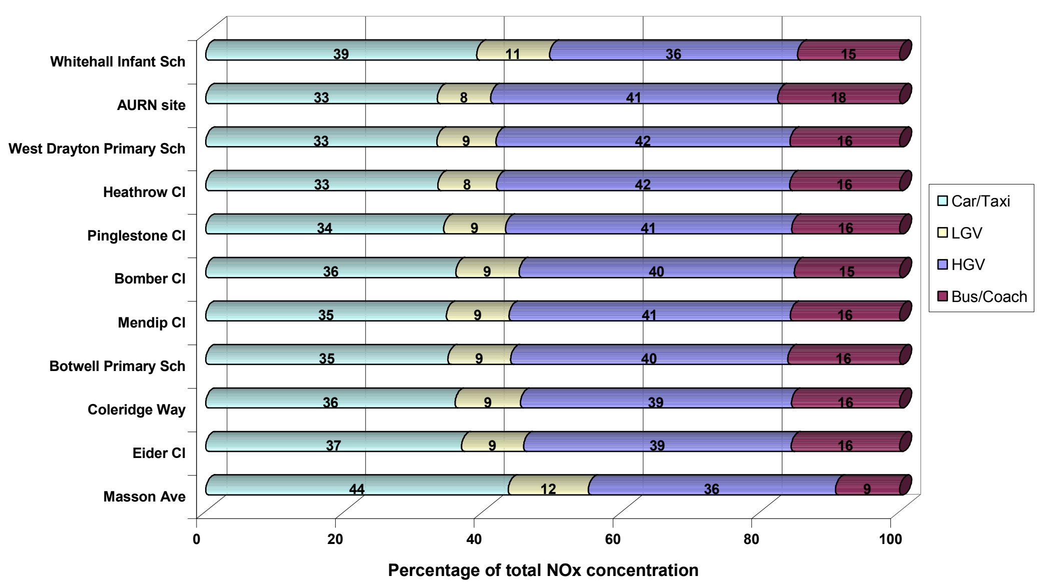



***Figure 5.3b: Percentage contribution of different vehicle types to annual average $NO_x$ concentrations resulting from traffic emissions***

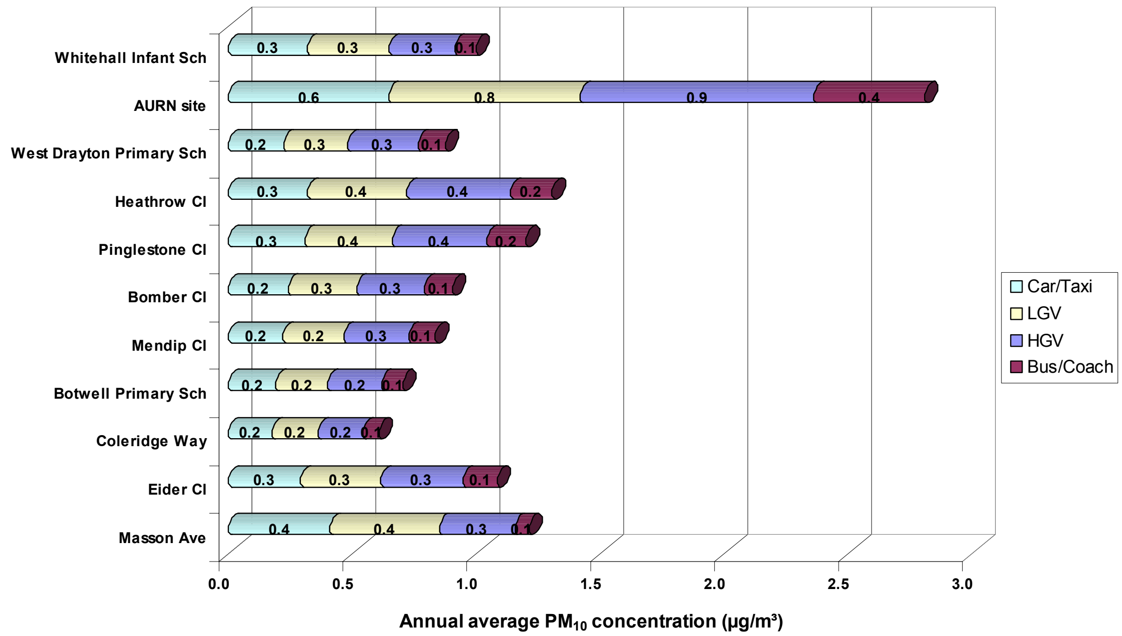



***Figure 5.4a: Contribution of different vehicle types to annual average $PM_{10}$ concentrations***

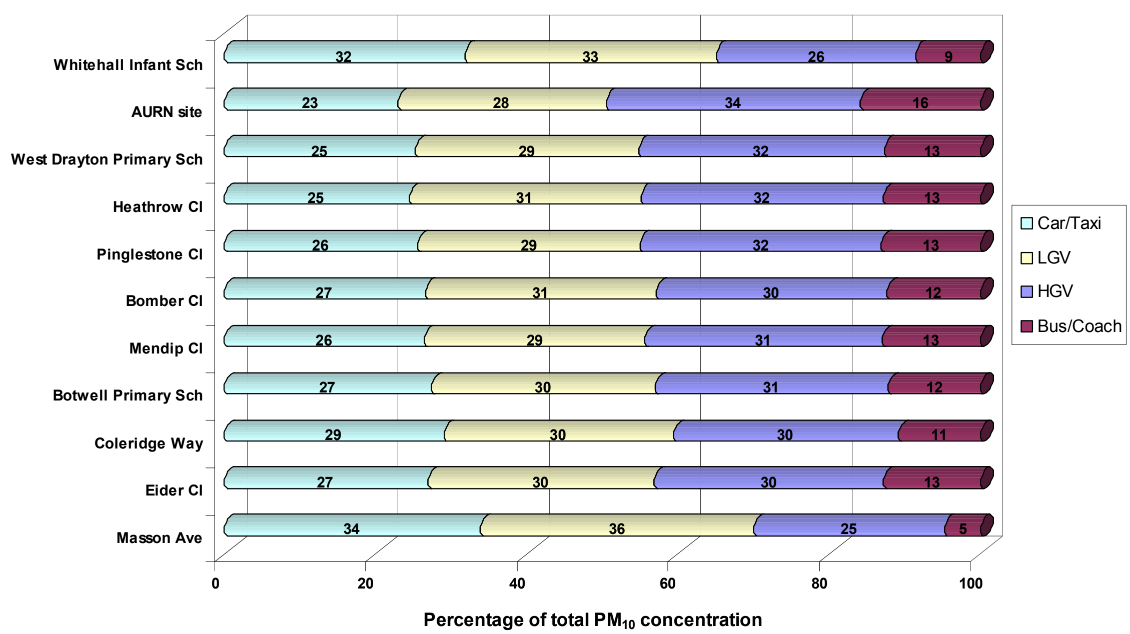



***Figure 5.4b: Percentage contribution of different vehicle types to annual average $PM_{10}$ concentrations resulting from traffic emissions***

# 6. Breakdown of traffic emissions by road type

The major roads in the West London area are the responsibility of one of the following organisations:

- the Highways Agency;
- Transport for London (TfL); or
- the Local Authority.

The emissions from each group of roads have been considered separately and the annual average concentrations resulting from each group have been calculated at each of the receptor points considered. The roads included in each group are shown in Figure 6.1. Note that only the emissions from roads within the study area, comprising Hillingdon, Hounslow and Spelthorne, have been included in the modelling for this section.

## 6.1 Emissions

Tables 6.1 and 6.2 show the emissions of $NO_x$ and $PM_{10}$, respectively, from each of the three road groups, including each as a percentage of the total emissions from these three groups. Figures 6.2 and 6.3 show pie charts of the breakdown of emissions within the borough.

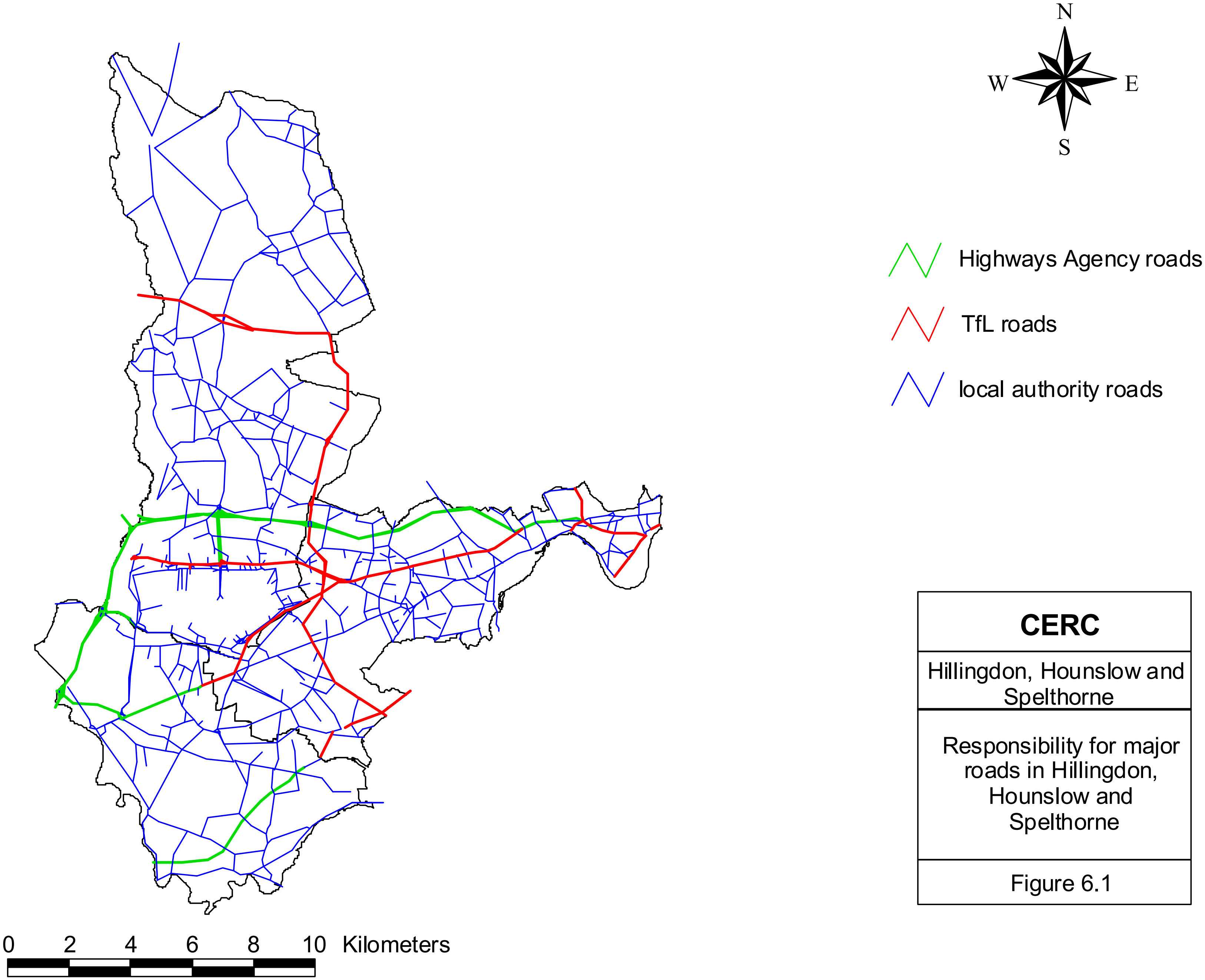
***Table 6.1: $NO_x$ emissions from different road types***

| | Highways Agency | | TfL | | Local Authority | |
|---|---|---|---|---|---|---|
| | **T/yr** | **%** | **T/yr** | **%** | **T/yr** | **%** |
| **Hillingdon** | 1017 | 38 | 691 | 26 | 975 | 36 |
| **Hi/Ho/Sp** | 2270 | 39 | 1293 | 22 | 2270 | 39 |

***Table 6.2: $PM_{10}$ emissions from different road types***

| | Highways Agency | | TfL | | Local Authority | |
|---|---|---|---|---|---|---|
| | **T/yr** | **%** | **T/yr** | **%** | **T/yr** | **%** |
| **Hillingdon** | 24 | 35 | 18 | 26 | 27 | 39 |
| **Hi/Ho/Sp** | 55 | 36 | 34 | 23 | 63 | 41 |

The $NO_x$ emissions from major roads within Hillingdon are fairly equally shared out amongst roads for which the Highways Agency and the local authority have responsibility, with the TfL roads contributing slightly less. There is a similar situation for $PM_{10}$.


N
W
E
S
Highways Agency roads
TfL roads
local authority roads
CERC
Hillingdon, Hounslow and Spelthorne
Responsibility for major roads in Hillingdon, Hounslow and Spelthorne
Figure 6.1
0 2 4 6 8 10 Kilometers

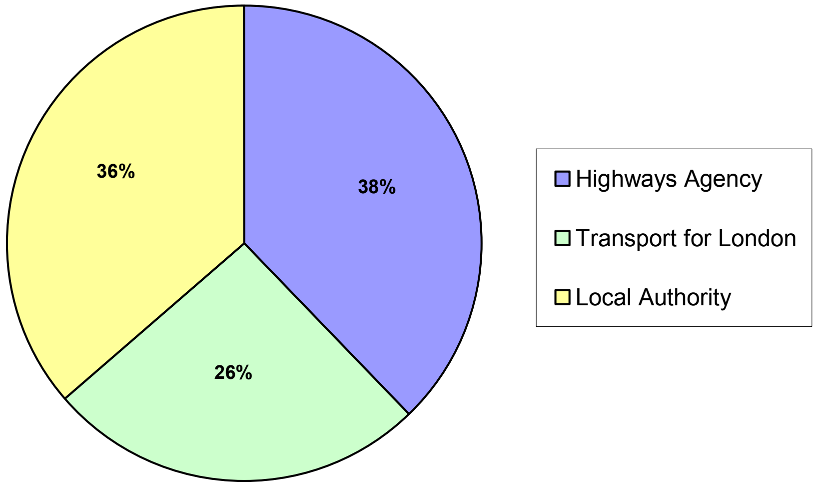



***Figure 6.2: $NO_x$ emissions from different road types in Hillingdon***

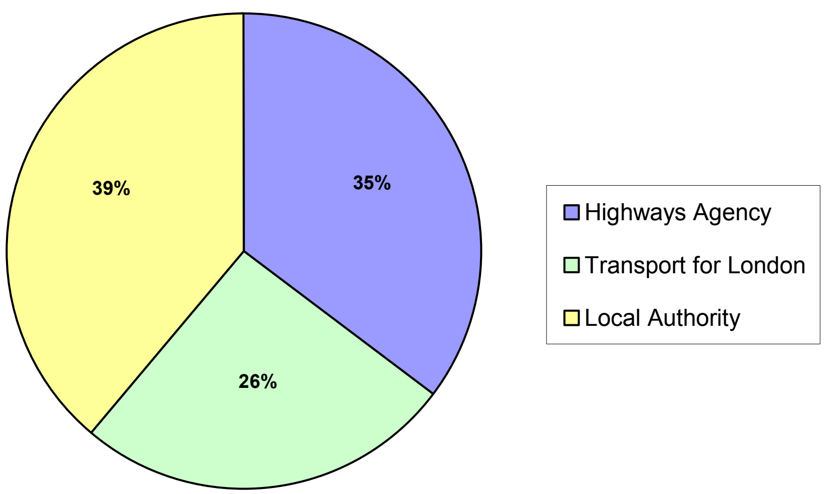



***Figure 6.3: $PM_{10}$ emissions from different road types in Hillingdon***

## 6.2 Concentrations

The annual average concentrations of $NO_x$ resulting from emissions from each road group have been predicted at the receptor points in the borough. Note that the concentrations presented are those resulting from emissions within Hillingdon, Hounslow and Spelthorne, not just from within Hillingdon.

Figure 6.4a shows the contribution of each road type to the total and Figure 6.4b shows these contributions as percentages of the total concentration resulting from traffic emissions. Figures 6.5a and 6.5b show the equivalent information for $PM_{10}$.

The contribution to the annual average concentrations of $NO_x$ and $PM_{10}$ from each road group varies depending on the receptor location considered.

For both $NO_x$ and $PM_{10}$ the greatest percentage contribution from Highways Agency roads is at the AURN site. The greatest percentage contribution from TfL roads is at Eider Close, and the greatest percentage contribution from local authority roads is at Whitehall Infant School.

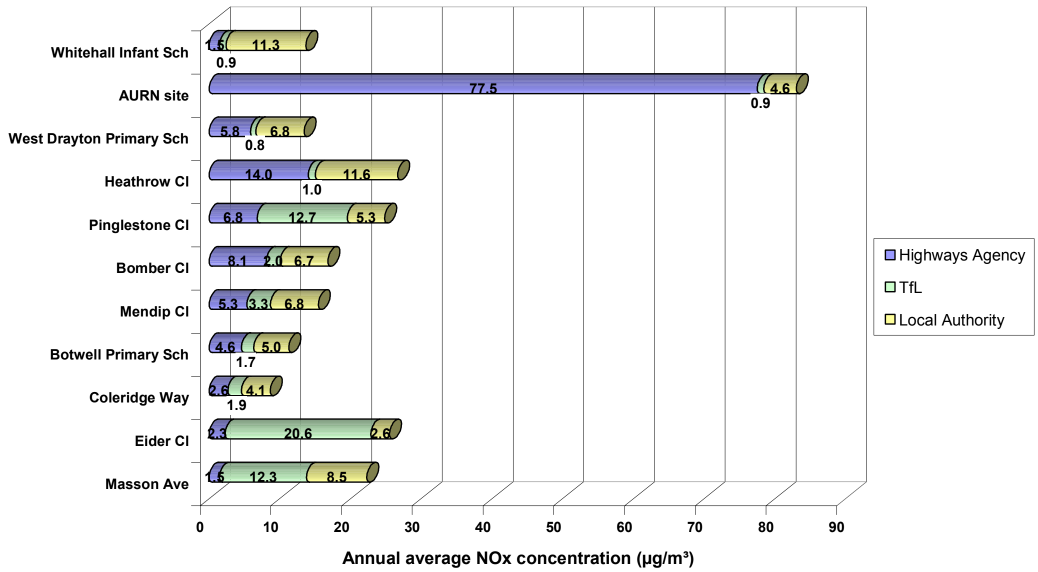



*Figure 6.4a: Contribution of different road types to annual average $NO_x$ concentrations*

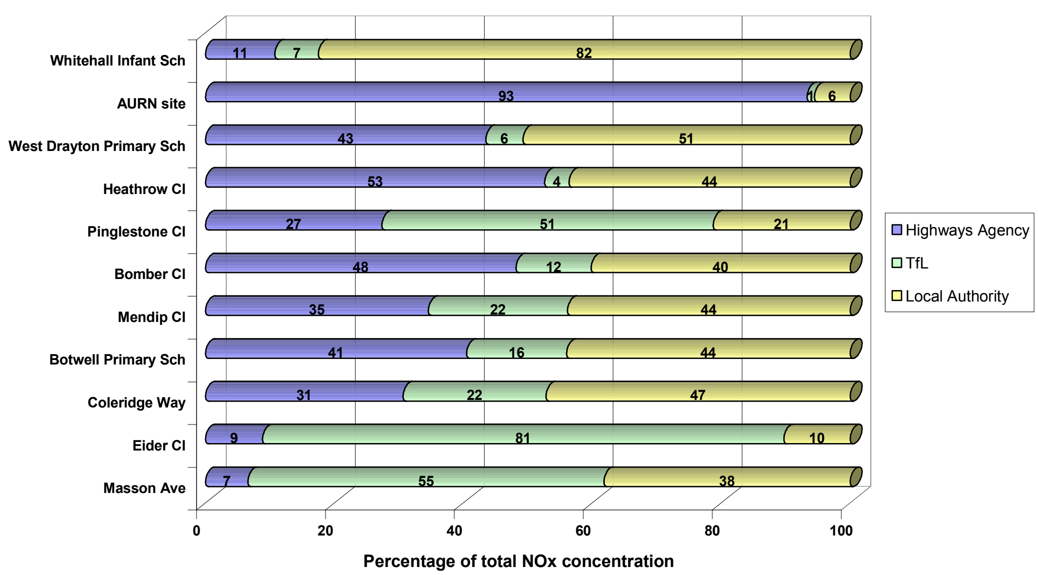



*Figure 6.4b: Percentage contribution of different road types to annual average $NO_x$ concentrations from major roads*

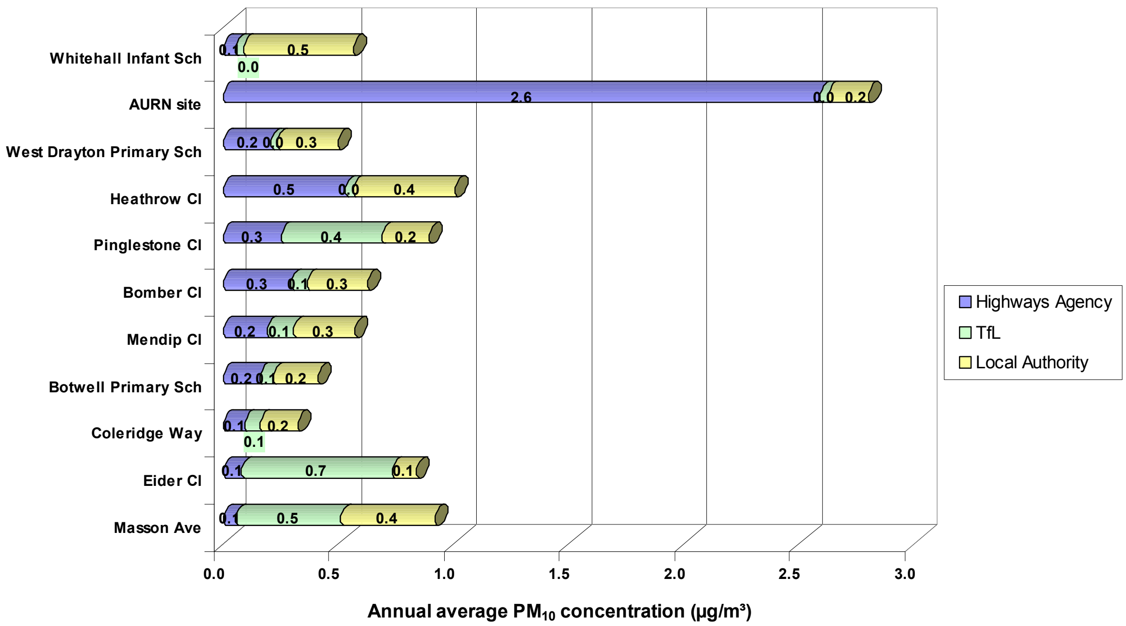



*Figure 6.5a: Contribution of different road types to annual average $PM_{10}$ concentrations*

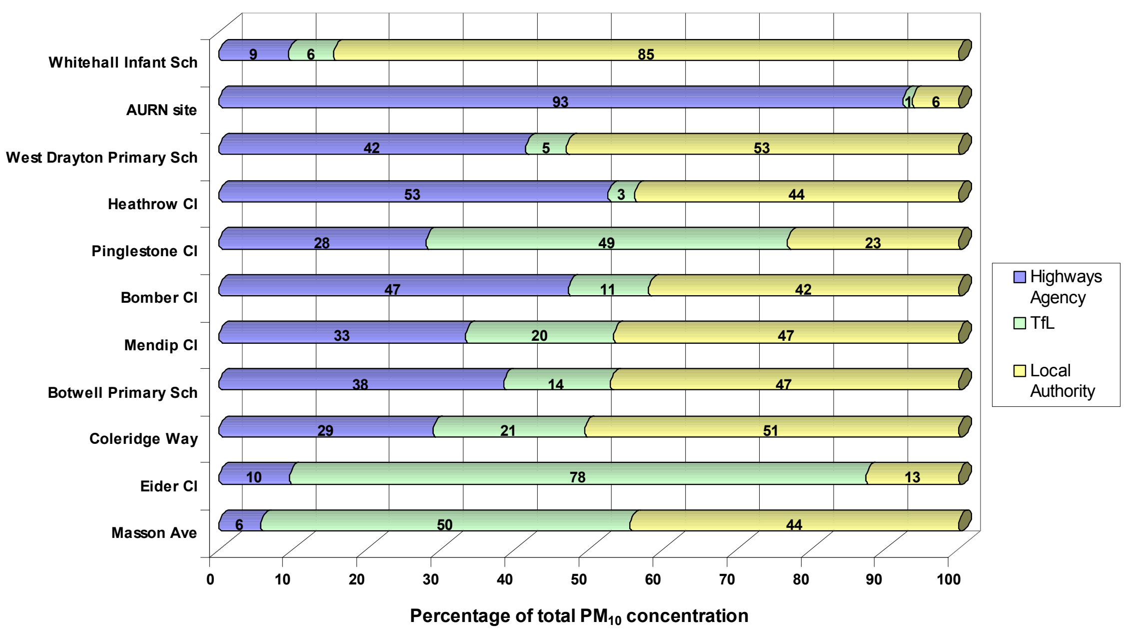



*Figure 6.5b: Percentage contribution of different road types to annual average $PM_{10}$ concentrations from major roads*

# 7. Breakdown into Heathrow & non-Heathrow traffic

The Heathrow Emissions Inventory gives a total traffic flow and a flow due to Heathrow traffic for each road covered by the inventory. The emissions for the roads in the inventory have been broken down into the following groups:

- Heathrow traffic;
- Non-Heathrow traffic; and
- Traffic on roads for which no Heathrow/non-Heathrow split is available (referred to as "other roads")

The emissions from each group have been considered separately and the annual average concentrations resulting from each group have been calculated at each of the receptor points considered. The roads for which the Heathrow/non-Heathrow split is available are shown in Figure 7.1.

## 7.1 Emissions

Tables 7.1 and 7.2 show the emissions of $NO_x$ and $PM_{10}$, respectively, from the different road groups, including each as a percentage of the total major road emissions. Figures 7.2 and 7.3 show pie charts of the breakdown of emissions within the borough.

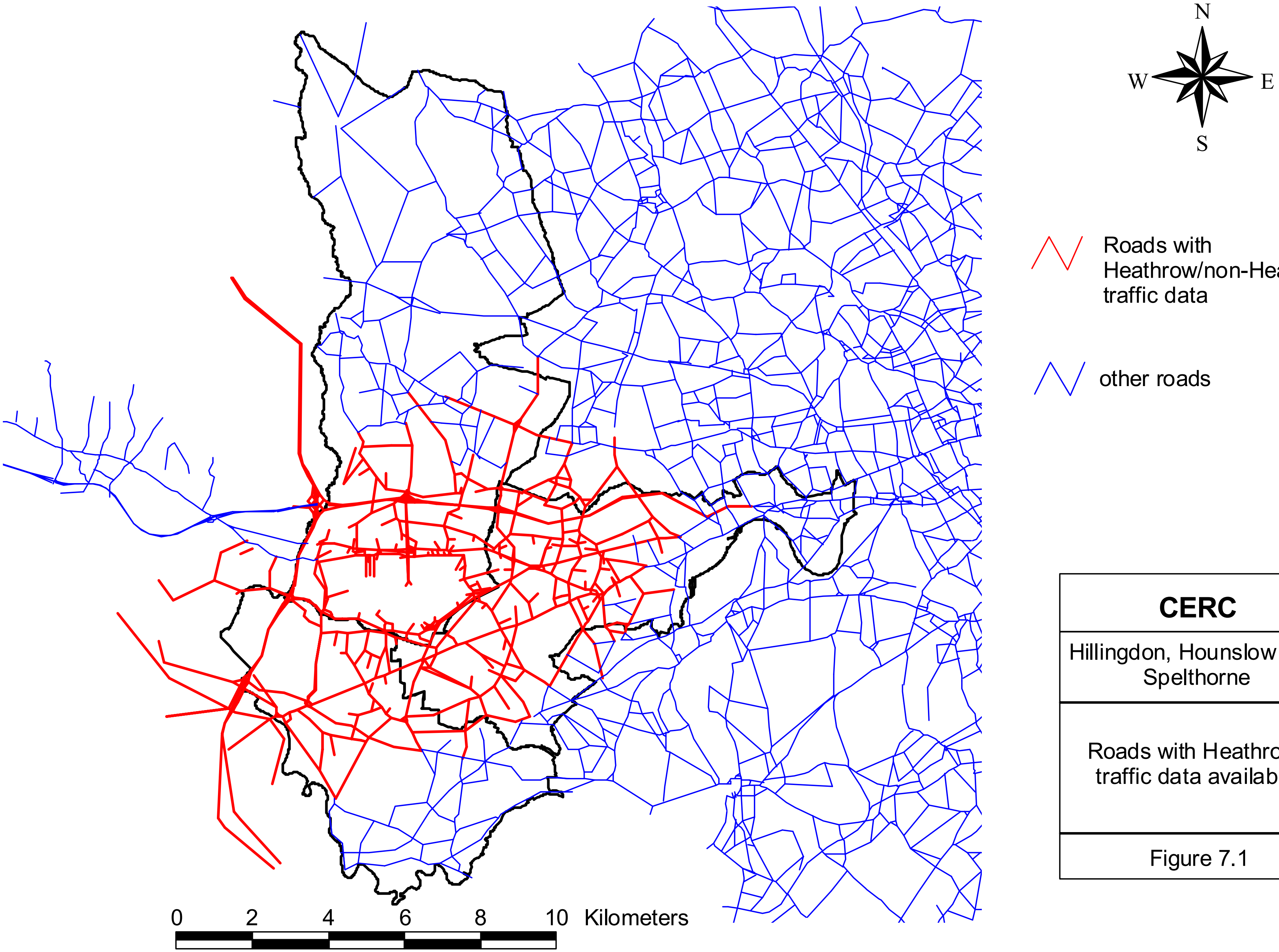
***Table 7.1: $NO_x$ emissions from Heathrow & non-Heathrow traffic***

| | **Heathrow traffic** | | **Non-Heathrow traffic** | | **Other roads** | |
|---|---|---|---|---|---|---|
| | **T/yr** | **%** | **T/yr** | **%** | **T/yr** | **%** |
| **Hillingdon** | 455 | 16 | 1768 | 60 | 704 | 24 |
| **Hi/Ho/Sp** | 631 | 12 | 3032 | 60 | 1386 | 27 |

***Table 7.2: $PM_{10}$ emissions from Heathrow & non-Heathrow traffic***

| | **Heathrow traffic** | | **Non-Heathrow traffic** | | **Other roads** | |
|---|---|---|---|---|---|---|
| | **T/yr** | **%** | **T/yr** | **%** | **T/yr** | **%** |
| **Hillingdon** | 16 | 15 | 64 | 58 | 30 | 27 |
| **Hi/Ho/Sp** | 23 | 12 | 111 | 57 | 60 | 31 |

Heathrow traffic contributes 16% of the total $NO_x$ traffic emissions within Hillingdon. Non-Heathrow traffic contributes 60%, with the remainder undefined. Heathrow traffic contributes 15% of the total $PM_{10}$ traffic emissions within Hillingdon. Non-Heathrow traffic contributes 58% with the remainder undefined.




Roads with Heathrow/non-Heathrow traffic data

other roads

**CERC**

Hillingdon, Hounslow and Spelthorne

Roads with Heathrow traffic data available

Figure 7.1

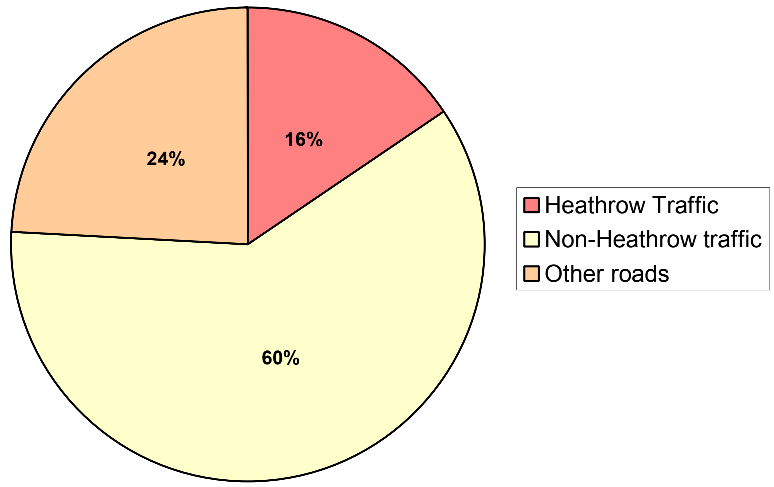



***Figure 7.2: $NO_x$ emissions from different road types in Hillingdon***

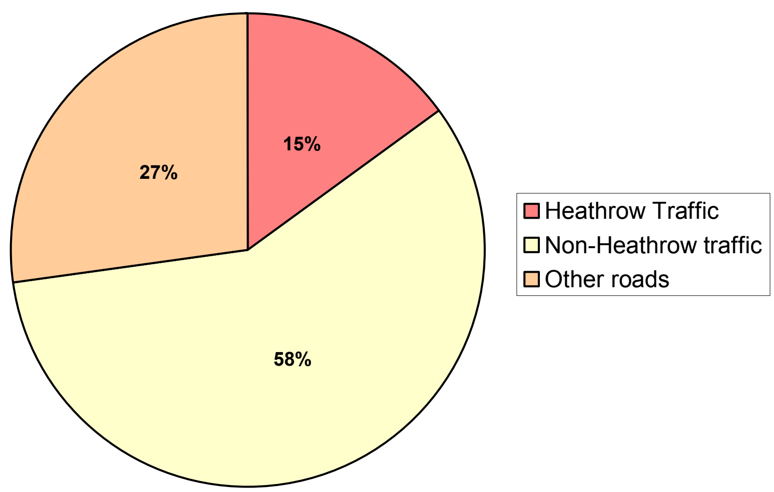



***Figure 7.3: $PM_{10}$ emissions from different road types in Hillingdon***

## 7.2 Concentrations

The annual average concentrations of $NO_x$ resulting from emissions from Heathrow and non-Heathrow traffic have been predicted at the receptor points in the borough. Note that the concentrations presented are those resulting from emissions over the whole of the area covered by the emissions inventory, not just from within Hillingdon.

Figure 7.4a shows the contribution of each road type to the total and Figure 7.4b shows these contributions as percentages of the total concentrations resulting from traffic emissions. Figures 7.5a and 7.5b show the equivalent information for $PM_{10}$.

The contribution of each road group to the annual average $NO_x$ and $PM_{10}$ concentration varies depending on the receptor location considered, as does the percentage contribution of each group. For both pollutants the percentage contribution due to Heathrow traffic is greatest at Bomber Close where it reaches 26% of the total concentration resulting from traffic emissions.

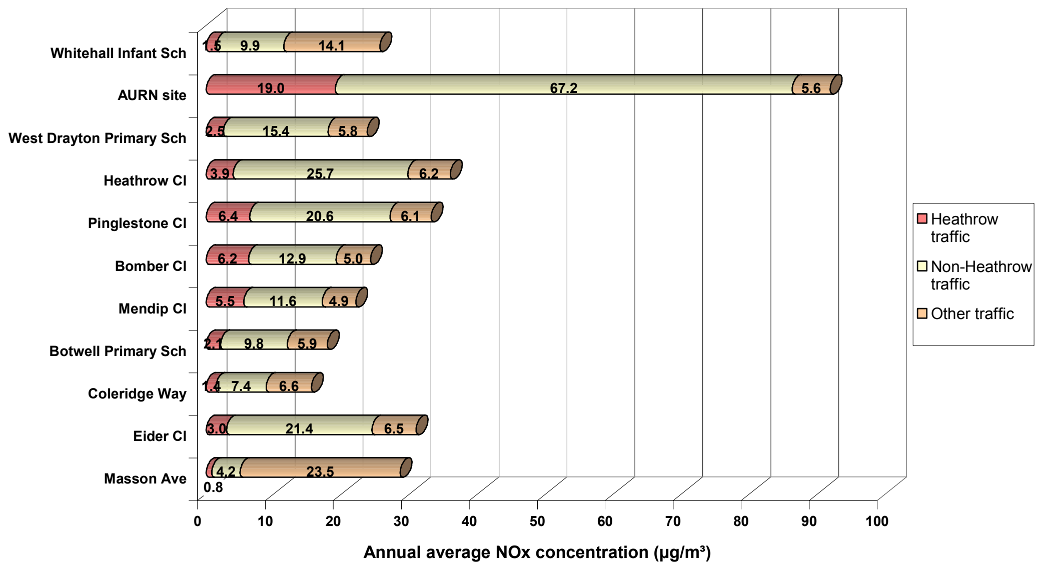



*Figure 7.4a: Contribution of Heathrow traffic to annual average $NO_x$ concentrations*

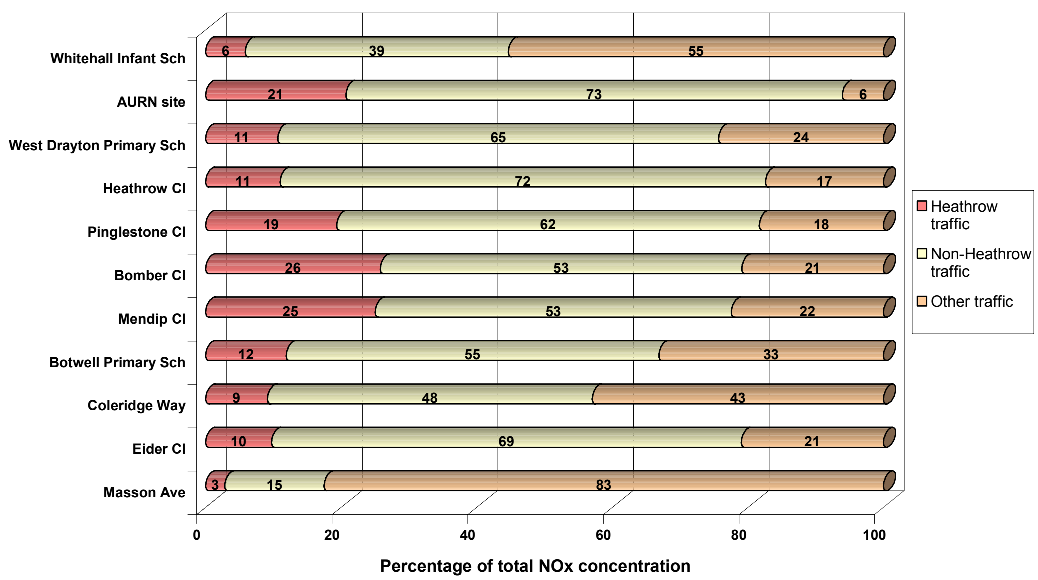



*Figure 7.4b: Percentage contribution of Heathrow traffic to annual average $NO_x$ concentrations from major roads*

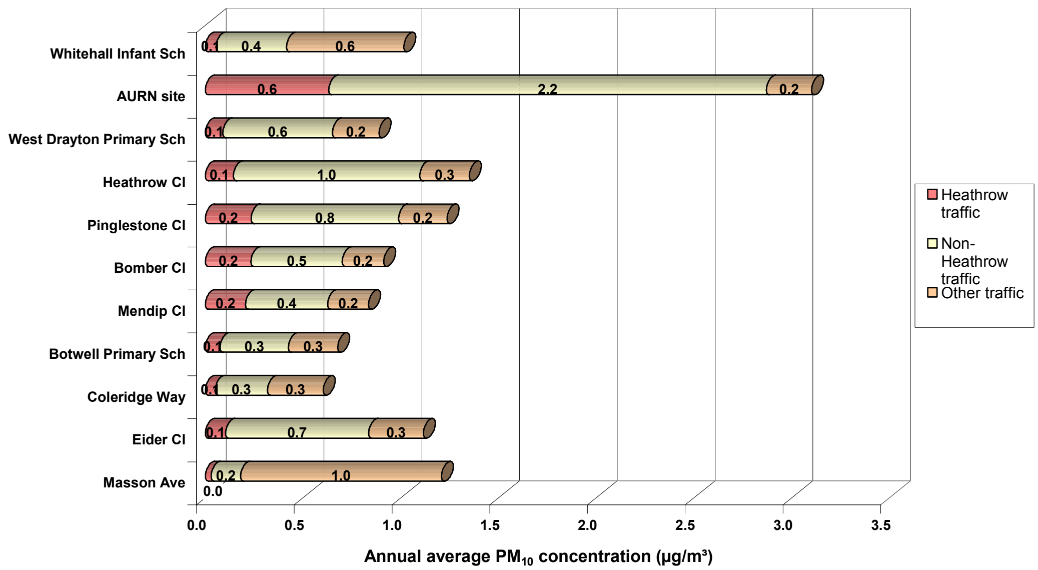



*Figure 7.5a: Contribution of Heathrow traffic to annual average $PM_{10}$ concentrations*

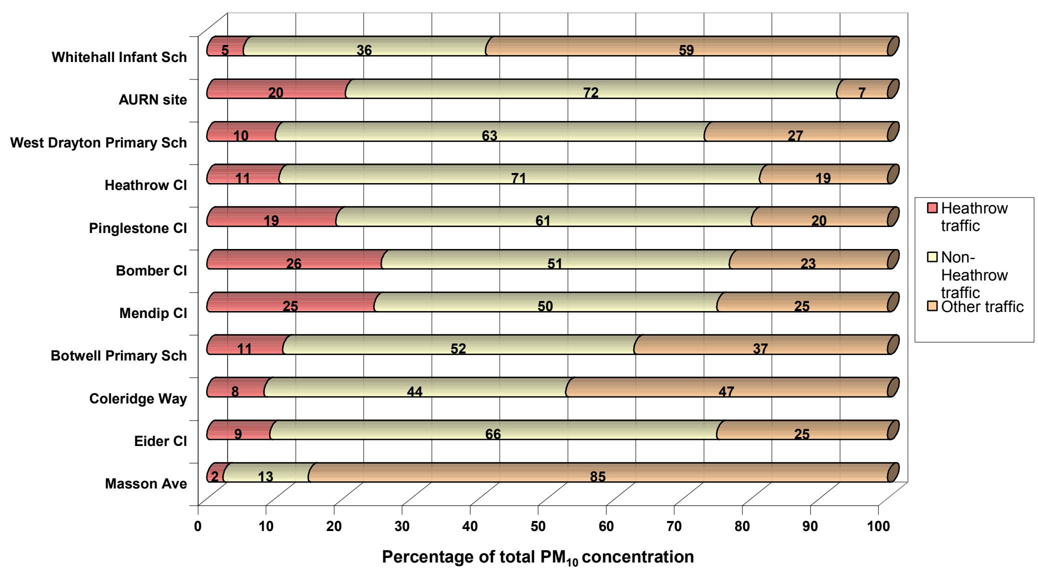



*Figure 7.5b: Percentage contribution of Heathrow traffic to annual average $PM_{10}$ concentrations from major roads*

# 8. Breakdown of Heathrow Airport emissions

Emissions from Heathrow Airport have been broken down according to the following source types:

- Emissions from road vehicles, including Heathrow traffic, on-site traffic, car parks and taxi ranks;
- Emissions from airborne aircraft;
- Emissions from aircraft taxiing and holding;
- Emissions from heating; and
- Other emissions.

The emissions from airborne aircraft have been modelled as a set of volume sources, shown in plan and elevation in Figures 8.1 and 8.2 respectively. These volume sources are considered in more detail in Section 9. The traffic emissions were modelled explicitly, and the remaining road vehicle sources, aircraft taxiing and holding, heating, and other emissions were modelled as 1km$^2$ gridded emissions.

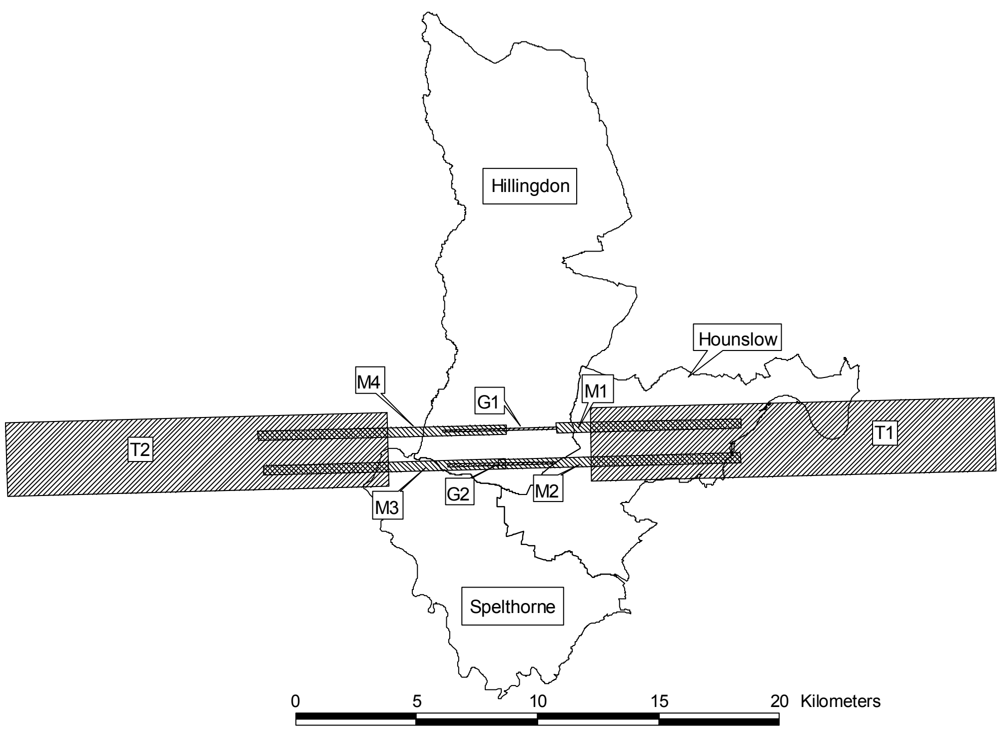



***Figure 8.1: Diagram showing the aircraft volume sources in plan***

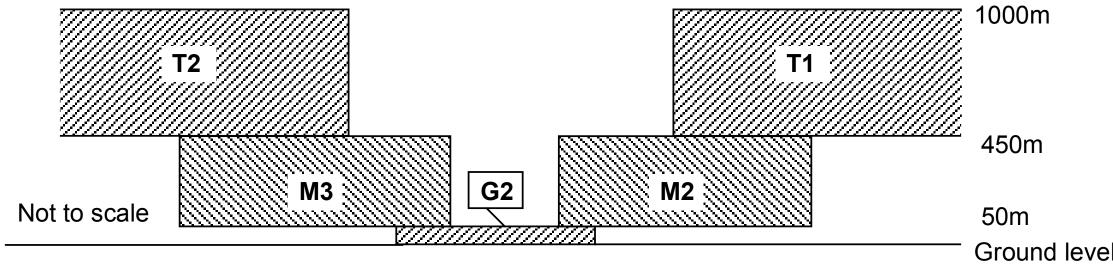



***Figure 8.2: Diagram showing the aircraft volume sources in elevation (view from south)***

## 8.1 Emissions

Tables 8.1 and 8.2 show the emissions of $NO_x$ and $PM_{10}$, respectively, from the different Heathrow Airport source groups. Figures 8.3 and 8.4 show pie charts of the breakdown of emissions within the borough. Note that the road vehicles group includes the "Heathrow traffic" shown earlier, as well as on-site traffic including car parks and taxi ranks.

***Table 8.1: $NO_x$ emissions from Heathrow***

| | Road vehicles | Airborne aircraft | Taxiing & aircraft holding | Heating | Other |
|---|---|---|---|---|---|
| **Hillingdon** | 487 | 2607 | 533 | 251 | 342 |
| **Hi/Ho/Sp** | 663 | 3861 | 533 | 251 | 342 |

***Table 8.2: $PM_{10}$ emissions from Heathrow***

| | Road vehicles | Airborne aircraft | Taxiing & aircraft holding | Heating | Other |
|---|---|---|---|---|---|
| **Hillingdon** | 18 | 11 | 44 | 9 | 6 |
| **Hi/Ho/Sp** | 24 | 20 | 44 | 9 | 6 |

The maximum contribution to the emissions of $NO_x$ from Heathrow Airport is from airborne aircraft, which contribute 66%. The maximum contribution to the emissions of $PM_{10}$ is from taxiing and aircraft holding, which contribute 44%.

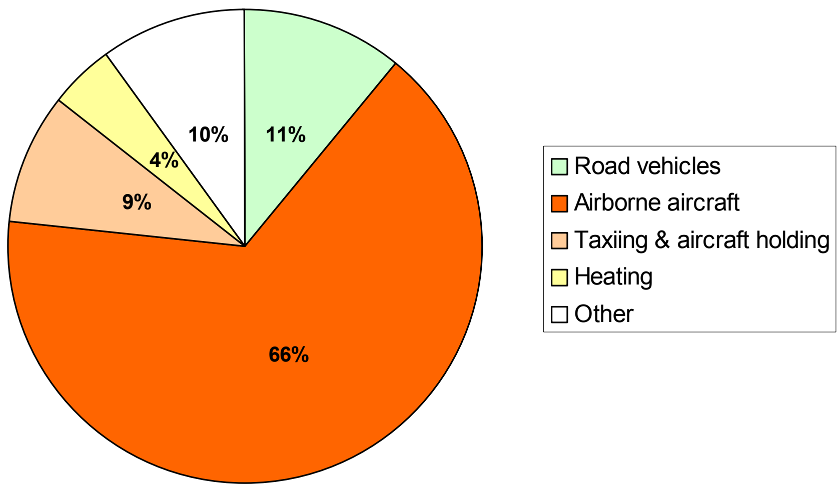



***Figure 8.3: $NO_x$ emissions from different Heathrow source groups in Hillingdon***

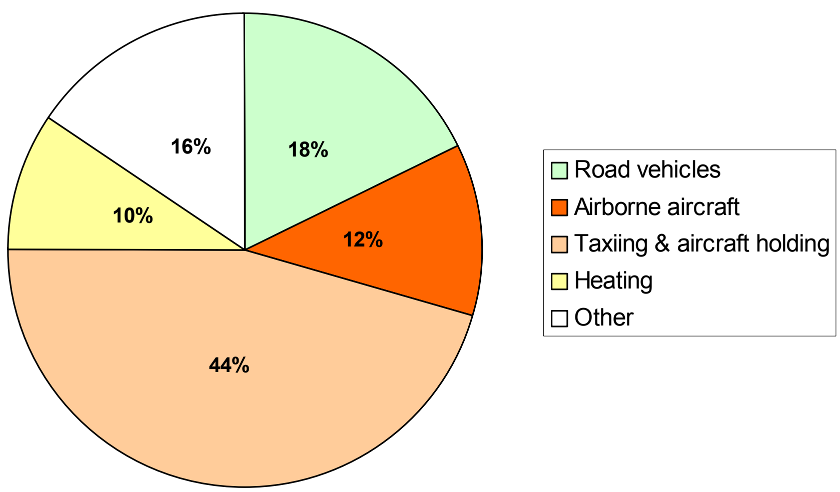



***Figure 8.4: $PM_{10}$ emissions from different Heathrow source groups in Hillingdon***

## 8.2 Concentrations

The annual average concentrations of $NO_x$ resulting from emissions from each airport source type have been predicted at the receptor points in the borough. Figure 8.5a shows the contribution of each source type to the total and Figure 8.5b shows these contributions as percentages of the total concentrations resulting from Heathrow emissions. Figures 8.6a and b show the equivalent information for $PM_{10}$.

The contribution to the annual average concentrations of $NO_x$ and $PM_{10}$ from each airport source type varies depending on the receptor location considered.

At most of the receptor points, the major contribution to annual average $NO_x$ concentrations from the airport is from airborne aircraft. However, road vehicles are the major contributor at the AURN site. For $PM_{10}$, the percentage contribution varies depending on the receptor location considered.

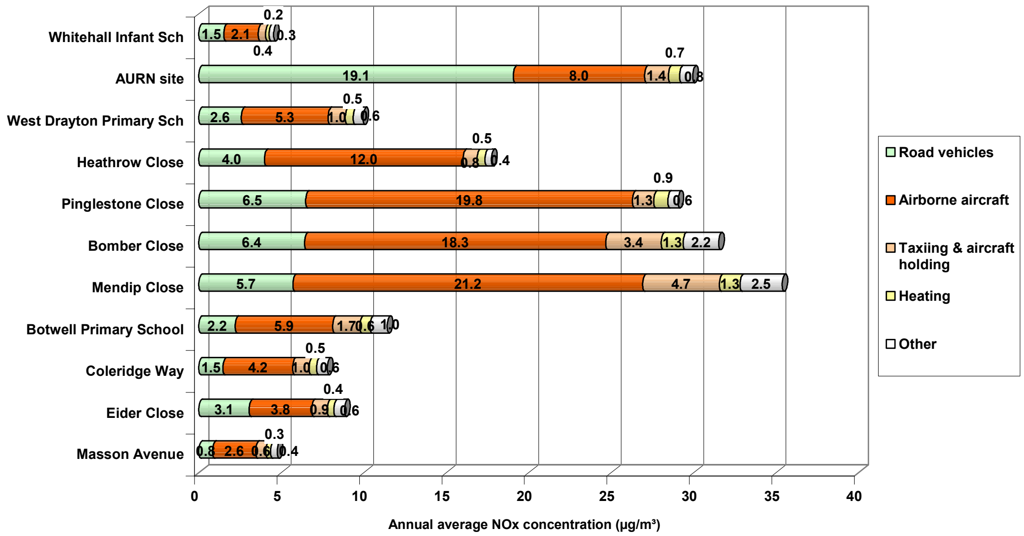



***Figure 8.5a: Contribution of Heathrow sources to annual average $NO_x$ concentrations***

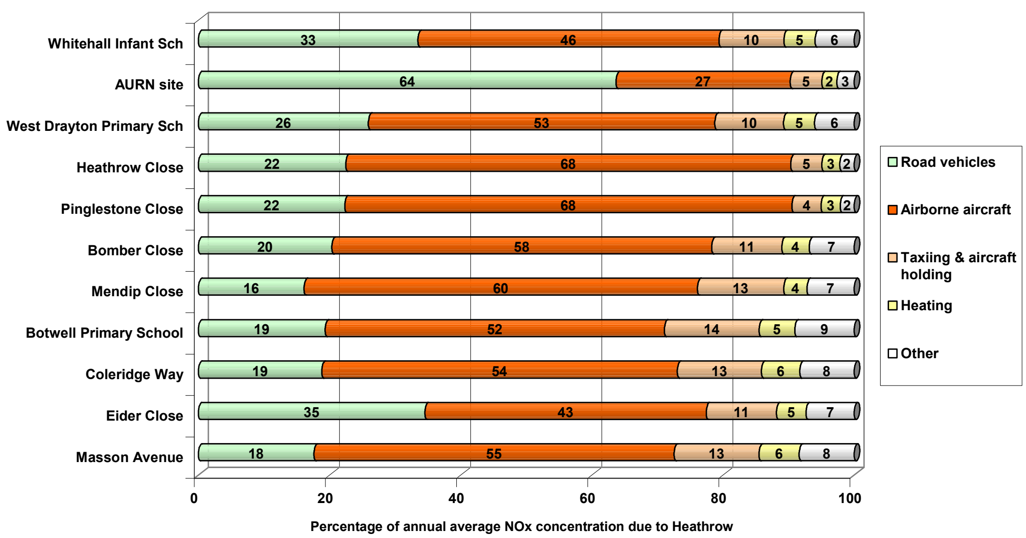



***Figure 8.5b: Percentage contribution of Heathrow sources to annual average $NO_x$ concentrations from Heathrow***

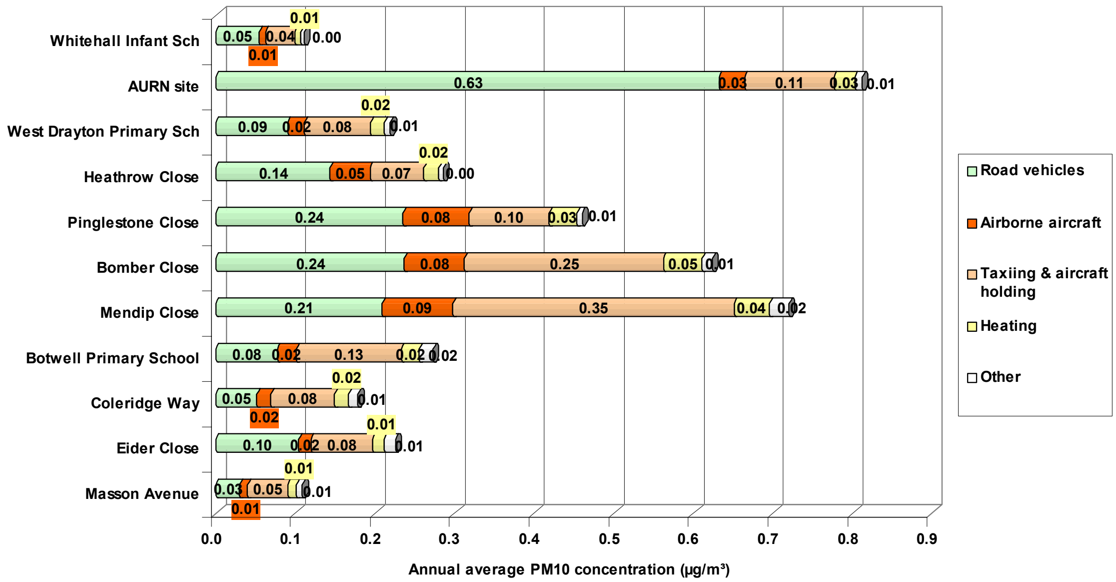



*Figure 8.6a: Contribution of Heathrow sources to annual average $PM_{10}$ concentrations*

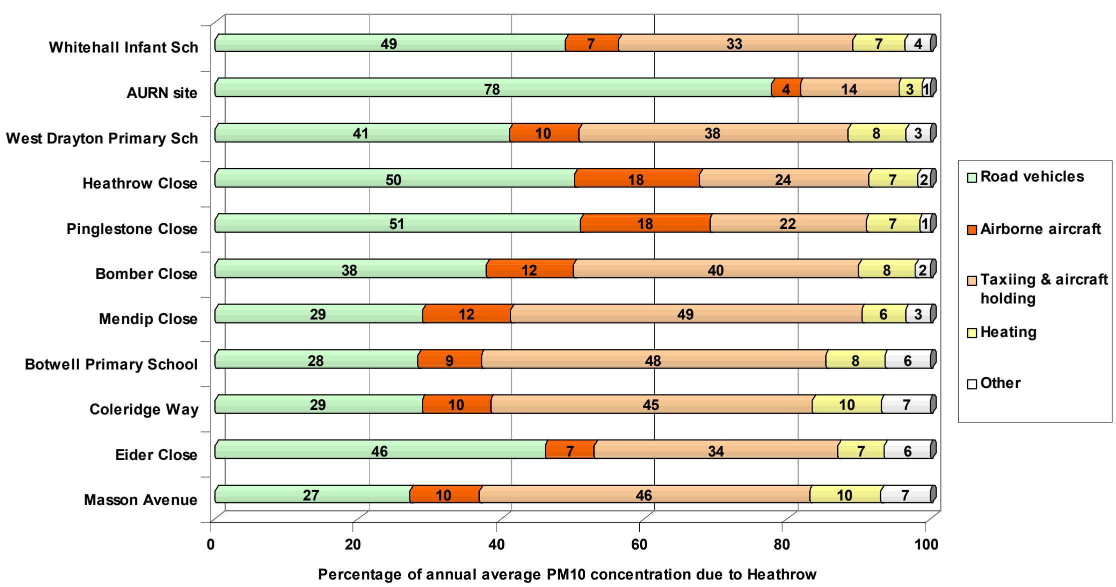



*Figure 8.6b: Percentage contribution of Heathrow sources to annual average $PM_{10}$ concentrations from Heathrow*

# 9. Breakdown of Heathrow airborne aircraft sources by height

Detailed information on the emission rates of aircraft in different stages of the Landing and Take-Off (LTO) cycle were given in the Heathrow Emissions Inventory. For the purposes of the modelling this information was used to define a set of volume sources, of different dimensions and with different emission rates, to represent the airborne aircraft emissions.

To determine the relative impacts of the aircraft at different heights, the volume sources used in the modelling have been divided into three sets according to the heights they represent (0 to 50m; 50m to 450m; and 450m to 1000m) and have been modelled separately. No airborne aircraft sources above a height of 1000m have been included in the modelling. The modelled volume sources are shown in plan and elevation in Figures 8.1 and 8.2 respectively.

## 9.1 Emissions

Table 9.1 shows the dimensions and emission rates of each of the modelled volume sources and Figures 8.1 and 8.2 show the dimensions of the volume sources in plan and elevation.

***Table 9.1: Explicitly modelled Heathrow Airport volume sources***

| Source | Base height (m) | Top height (m) | Length (m) | Width (m) | $NO_x$ emission rate (T/yr) | $NO_x$ emission rate ($g/m^3/s$) | $PM_{10}$ emission rate (T/yr) | $PM_{10}$ emission rate ($g/m^3/s$) |
|---|---|---|---|---|---|---|---|---|
| **G1** | 0 | 50 | 4701 | 100 | 713 | 9.62E-07 | 3.1 | 4.23E-09 |
| **G2** | 0 | 50 | 4456 | 100 | 981 | 1.40E-06 | 3.6 | 5.16E-09 |
| **M1** | 50 | 450 | 7633 | 400 | 117 | 3.04E-09 | 2.1 | 5.40E-11 |
| **M2** | 50 | 450 | 9995 | 400 | 566 | 1.12E-08 | 3.4 | 6.80E-11 |
| **M3** | 50 | 450 | 10261 | 400 | 808 | 1.56E-08 | 2.4 | 4.65E-11 |
| **M4** | 50 | 450 | 10021 | 400 | 800 | 1.58E-08 | 3.2 | 6.33E-11 |
| **T1** | 450 | 1000 | 16695 | 3000 | 1112 | 1.28E-09 | 7.7 | 8.85E-12 |
| **T2** | 450 | 1000 | 15759 | 3000 | 2848 | 3.47E-09 | 8.7 | 1.07E-11 |
| **Total** | | | | | **7945** | | **34.3** | |

Table 9.1 shows that more $NO_x$ and $PM_{10}$ are emitted from aircraft above a height of 450m than from those close to ground level. However, the impact of the emissions from different heights on ground level concentrations will vary due to the distance from the ground and the area over which the pollutants are emitted.

## 9.2 Concentrations

To determine the relative impacts of the aircraft at different heights, the volume sources at heights of 0 to 50m; 50m to 450m; and 450m to 1000m have each been modelled separately. The annual average concentrations of $NO_x$ resulting from emissions from each set of sources have been predicted at each of the receptor points in the borough. Figure 9.1a shows the contribution of each set to the total and Figure 9.1b shows these contributions as percentages of the total concentrations resulting from airborne aircraft emissions. Figures 9.2a and b show the equivalent information for $PM_{10}$.

The contribution of all the airborne aircraft to the annual average concentrations of $NO_x$ and $PM_{10}$ varies greatly depending on the receptor location, although in all cases the greatest contribution comes from the aircraft closest to the ground. These emissions contribute between 82% and 97% of the total $NO_x$ and $PM_{10}$ concentration resulting from airborne aircraft. The impact of the aircraft above a height of 450m is very low, contributing at most 3% of the total $NO_x$ and $PM_{10}$ concentrations resulting from airborne aircraft emissions. The greatest percentage contribution from aircraft above a height of 450m occurs at sites away from the airport, where the overall contribution to the ground level concentrations from airborne aircraft is smallest.

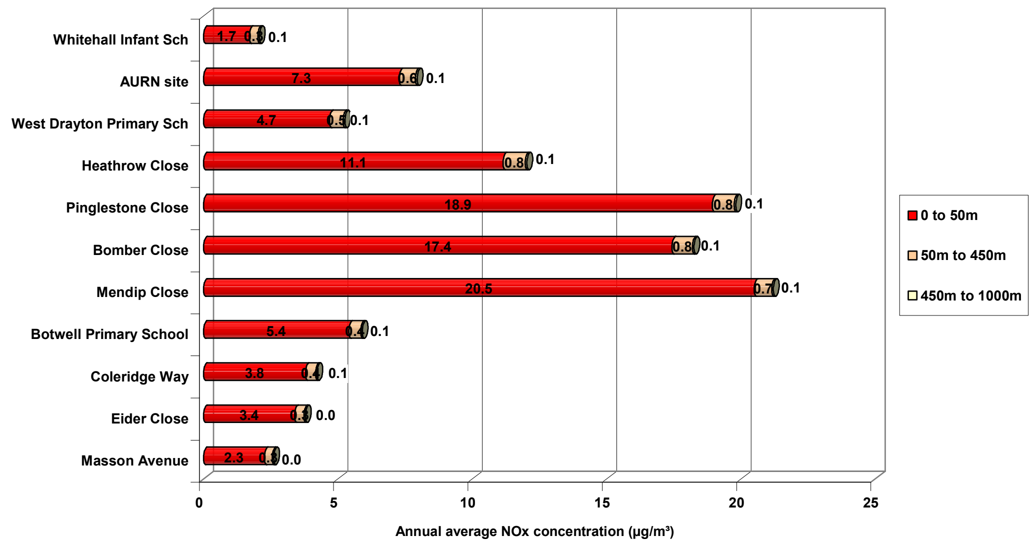



***Figure 9.1a: Contribution of aircraft at different heights to annual average $NO_x$ concentrations***

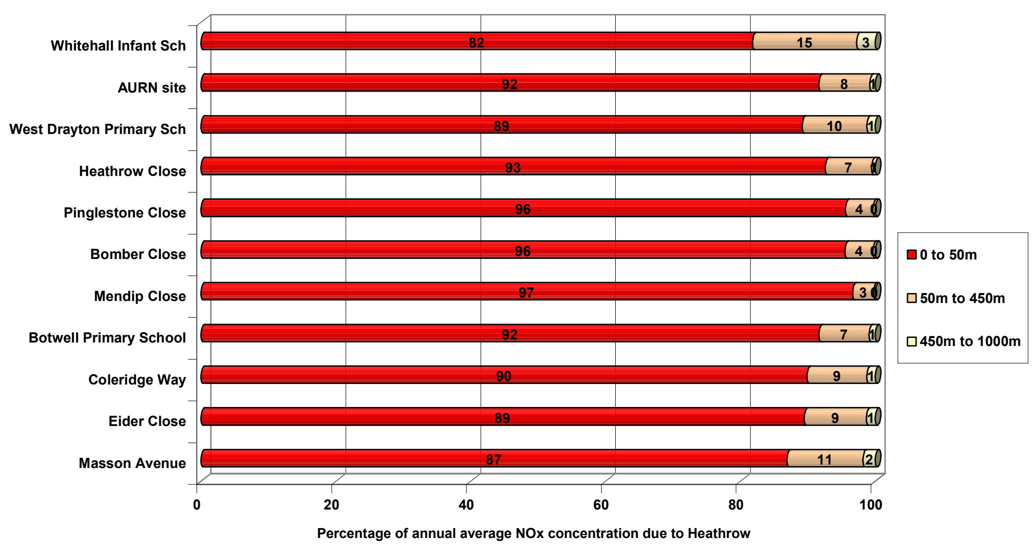



***Figure 9.1b: Percentage contribution of aircraft at different heights to annual average $NO_x$ concentrations from airborne aircraft***

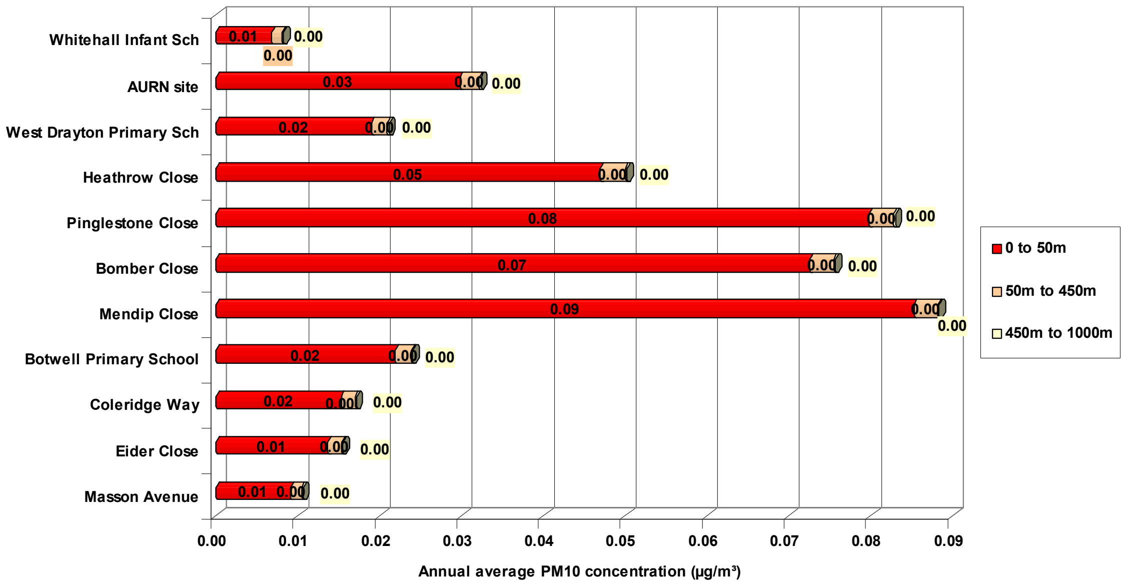



*Figure 9.2a: Contribution of aircraft at different heights to annual average $PM_{10}$ concentrations*

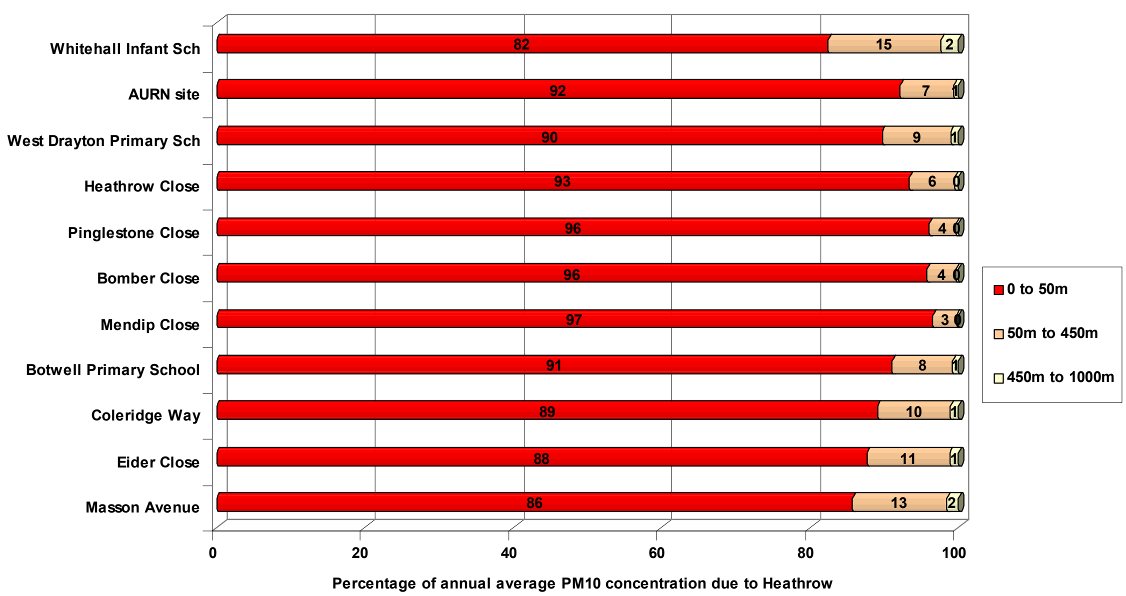



*Figure 9.2b: Percentage contribution of aircraft at different heights to annual average $PM_{10}$ concentrations from airborne aircraft.*

# 10. Discussion

The predicted emissions of $NO_x$, in 2005, and $PM_{10}$, in 2004, from within Hillingdon and from the rest of the area covered by the emissions inventories, have been broken down in the following ways:

- By major source group;
- Breakdown of traffic sources by vehicle type;
- Breakdown of traffic sources by road type, i.e. which organisation has responsibility;
- Breakdown of traffic sources into Heathrow and non-Heathrow traffic;
- Breakdown of Heathrow Airport sources; and
- Breakdown of Heathrow airborne aircraft sources by height.

The source apportionment exercise has quantified the relative contribution of each source group both (1) to the total emissions, and (2) to the resulting annual average ground level concentration at eleven receptor locations within Hillingdon.

The results for each part of the exercise are described in the following sections.

**Breakdown into major source groups**
The maximum contribution to the total emissions of $NO_x$ from within Hillingdon is from Heathrow Airport, which contributes 58%. The maximum contribution to the total emissions of $PM_{10}$ is also from Heathrow Airport, which contributes 40%.

At most of the receptor points, the major contribution to annual average $NO_x$ concentrations is from major roads. However, Heathrow Airport is the major contributor at Mendip Close and Bomber Close. For $PM_{10}$, the background concentration dominates the predicted concentrations.

**Breakdown of traffic by vehicle type**
The maximum contribution to the total emissions of $NO_x$ from traffic from within Hillingdon is from cars, which contribute 38%. The maximum contribution to the total emissions of $PM_{10}$ from traffic is from LGVs, which contribute 32%.

The contributions to the total annual average concentrations of $NO_x$ and $PM_{10}$ from traffic sources vary greatly depending on the receptor location considered, with the greatest contribution for both pollutants at the AURN site.

The percentage contribution of each traffic type to the annual average $NO_x$ concentration is approximately the same at each of the receptor points with the major contributions being from cars and HGVs. The situation for $PM_{10}$ is similar with cars, HGVs and LGVs all making major contributions to the concentrations.

**Breakdown of traffic by road type**

The $NO_x$ emissions from major roads within Hillingdon are fairly equally shared out amongst roads for which the Highways Agency and the local authority have responsibility, with the TfL roads contributing slightly less. There is a similar situation for $PM_{10}$.

The contribution to the annual average concentrations of $NO_x$ and $PM_{10}$ from each road group varies depending on the receptor location considered, as does the percentage contribution from each group.

**Breakdown into Heathrow and non-Heathrow traffic**

Emissions from Heathrow traffic make up 16% of the total emissions of $NO_x$ from major roads within Hillingdon. Non-Heathrow traffic contributes 60% with the remainder undefined. Heathrow traffic contributes 15% of the total emissions of $PM_{10}$ from major roads within Hillingdon. Non-Heathrow traffic contributes 58% with the remainder undefined

The contribution to the annual average concentrations of $NO_x$ and $PM_{10}$ from each road group varies depending on the receptor location considered, as does the percentage contribution from each group. For both pollutants the percentage contribution due to Heathrow traffic is greatest at Bomber Close where it reaches 26% of the total concentration resulting from traffic emissions.

**Breakdown of Heathrow Airport sources**

The maximum contribution to the emissions of $NO_x$ from Heathrow Airport is from airborne aircraft, which contribute 66%. The maximum contribution to the emissions of $PM_{10}$ is from taxiing and aircraft holding, which contribute 44%.

The contribution to the annual average concentrations of $NO_x$ and $PM_{10}$ from each airport source type varies depending on the receptor location considered.

At most of the receptor points, the major contribution to annual average $NO_x$ concentrations resulting from the airport emissions is from airborne aircraft. However, road vehicles are the major contributor at the AURN site. For $PM_{10}$, the percentage contribution varies depending on the receptor location considered with the major contributors being road vehicles and taxiing and aircraft holding.

**Breakdown of Heathrow airborne aircraft sources by height**

To determine the relative impacts of the aircraft at different heights, the volume sources used in the modelling have been divided into three sets according to the heights they represent (0 to 50m; 50m to 450m; and 450m to 1000m) and have been modelled separately. The maximum emissions of $NO_x$ and $PM_{10}$ are emitted from aircraft above a height of 450m, however, the impact of the emissions from different heights on ground level concentrations will vary depending on the distance from the ground and the area over which the pollutants are emitted.

The contribution of all the airborne aircraft to the annual average concentrations of $NO_x$ and $PM_{10}$ varies greatly depending on the receptor location.

In all cases the greatest contribution to the ground level concentrations comes from the aircraft closest to the ground, up to a height of 50m, which contribute between 82% and 97% of the total $NO_x$ and $PM_{10}$ concentration resulting from airborne aircraft. The impact of the aircraft above a height of 450m is very low, contributing at most 3% of the total $NO_x$ and $PM_{10}$ concentration resulting from airborne aircraft emissions. The greatest percentage contribution from aircraft above a height of 450m occurs at sites away from the airport, where the overall contribution to the ground level concentrations from airborne aircraft is smallest.