Air Quality Monitoring at the High Street, Wootton Bassett September 2006 – February 2007

Document Control

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Document Status and Review Schedule

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1	13/03/07	Final Report	Prof. Duncan Laxen
2			
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Contents

1 Introduction

1.1 This report presents measurements of nitrogen dioxide and PM_{10} made on the High Street, Wootton Bassett in the winter of 2006/2007. It is one of a series of reports commissioned by North Wiltshire District Council over a number of years, which have presented and analysed data from monitoring sites across the District (e.g. Marner and Welch, 2006). In order to place the measurements in context, they have been compared with data collected at other monitoring sites in the region over the same period.

2 The Monitoring

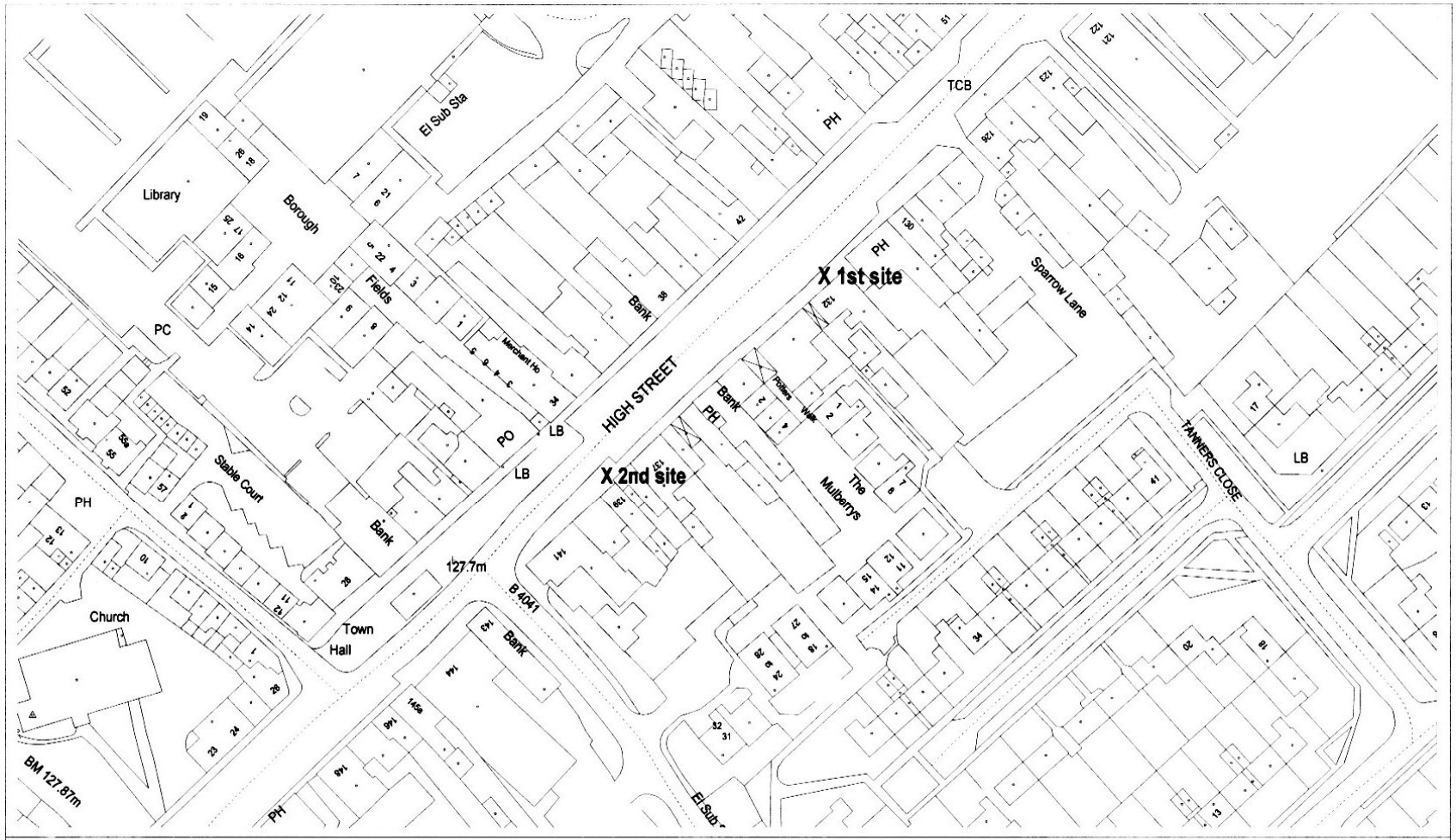
2.1 Air quality monitoring was carried out at a roadside site on the High Street in Wootton Bassett between the 8th of September and 29th October 2006, and between the 16th January and 20th February 2007. The monitor was initially positioned on the High Street, adjacent to 132 High Street, between the junctions with Sparrow Lane and Station Road, but was moved for the second monitoring period around 70 m south west, to a location adjacent to 139 High Street, closer to the junction with Station Road. The sites are shown in Figure 1. Both sites were selected by officers of the Environmental Health Services Department. The monitoring station comprised a self-contained air-conditioned unit equipped with a Met One BAM 1020 Dust Monitor without a heated inlet for measuring PM_{10} concentrations and a chemiluminescence monitor (API M200A) for measuring nitrogen dioxide concentrations.

2.2 Reports prepared prior to 2006 for North Wiltshire District Council have compared measurements with those from the monitoring station at Bristol Centre which was part of the UK Government's Automatic Urban and Rural Network of monitoring sites. For the 2006 report, whilst the Bristol Centre site was being relocated, nitrogen dioxide data were compared with the roadside AURN station at Bristol Old Market. The urban centre monitoring site has now been relocated, however, the site is now in an urban background location, and a full dataset is not available for 2006. For these two reasons, the nitrogen dioxide concentrations measured at the Wootton Bassett monitoring site, presented in this report, have once again been compared with those measured at the Bristol Old Market site, which is an established roadside site. PM_{10} concentrations are not measured at the Bristol site, and so PM_{10} measurements have again been compared with those from a rural site at Harwell. Data from both AURN sites have been obtained from Defra (2007a).

2.3 The AURN site at Harwell measures PM_{10} concentrations using a TEOM analyser with a heated inlet that results in loss of the volatile component of the particulate matter. In consequence, the TEOM systematically under-reads in comparison with a gravimetric sampler. Current advice from the Government is to multiply TEOM results by a default adjustment factor of 1.3 to approximate gravimetric results. This has been done in the present study. It should be recognised, however, that this 1.3 factor will vary from site to site and from one period to another. It is nevertheless considered to be near worst-case.

2.4 Conversely, BAM analysers with unheated inlets are known to systematically over-predict gravimetric PM_{10} concentrations. Advice from Defra (2007b) is to divide the annual mean from un-heated BAMs by 1.2 to estimate gravimetric concentrations. This has been done in the present study.

2.5 To validate the data, calibration factors were applied to the raw data. Nitrogen dioxide and nitrogen oxide concentrations were then converted from ppb to $\mu g/m^3$ (assuming standard temperature and pressure, i.e. 1 ppb = 1.913 $\mu g/m^3$). The concentration data were plotted as a time series and a visual examination was carried out. A comparison with monitoring data from the closest national automatic network monitoring sites (Bristol Old Market, Bath Roadside, Oxford Centre Roadside and Harwell) was made to determine any erroneous data, which were removed.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HIGH STREET
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Merchant Ho
Stable Court
The Mulberrys
Church
Town Hall
127.7m
B 4041
BM 127.87m
Monitoring sites, High Street, Wootton Bassett
SCALE: 1:1250
Figure 1: Positions of the Automatic Monitors
8/3/2007
North Wiltshire District Council
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3 Results for the Monitoring Period

3.1 The results of the monitoring over concurrent periods at the High Street, Wootton Bassett, Bristol Old Market and Harwell monitoring sites are summarised in Tables 1 and 2, and shown as plots in Figures 2 – 17. The Bristol and Harwell data have been verified by the Network managers, but have not been fully ratified by the QA/QC unit. There may therefore be small changes once ratification has taken place.

Table 1: September – October 2006 Data Summary

Pollutant	NOx		NO_2		PM_{10} [a]	
	Wootton Bassett	Bristol	Wootton Bassett	Bristol	Wootton Bassett	Harwell
Period mean (µg/m^3)	74	180	33	66	24	21
Maximum hourly mean (µg/m^3)	318	1028	115	178	na	na
No 1-h >200 µg/m^3	na	na	0	0	na	na
24-h Max (µg/m^3)	na	na	na	na	59	53
No 24-h >50 µg/m^3	na	na	na	na	3	1
Date capture	100%	99%	100%	100%	100%	100%

[a] Values expressed as gravimetric equivalent.

Table 2: January – February 2007 Data Summary

Pollutant	NOx		NO_2		PM_{10} [a]	
	Wootton Bassett	Bristol	Wootton Bassett	Bristol	Wootton Bassett	Harwell
Period mean (µg/m^3)	128	214	49	70	25	20
Maximum hourly mean (µg/m^3)	1040	831	203	191	na	na
No 1-h >200 µg/m^3	na	na	2	0	na	na
24-h Max (µg/m^3)	na	na	na	na	48	36
No 24-h >50 µg/m^3	na	na	na	na	0	0
Date capture	99%	93%	99%	93%	100%	96%

[a] Values expressed as gravimetric equivalent.

Nitrogen Dioxide and Nitrogen Oxides

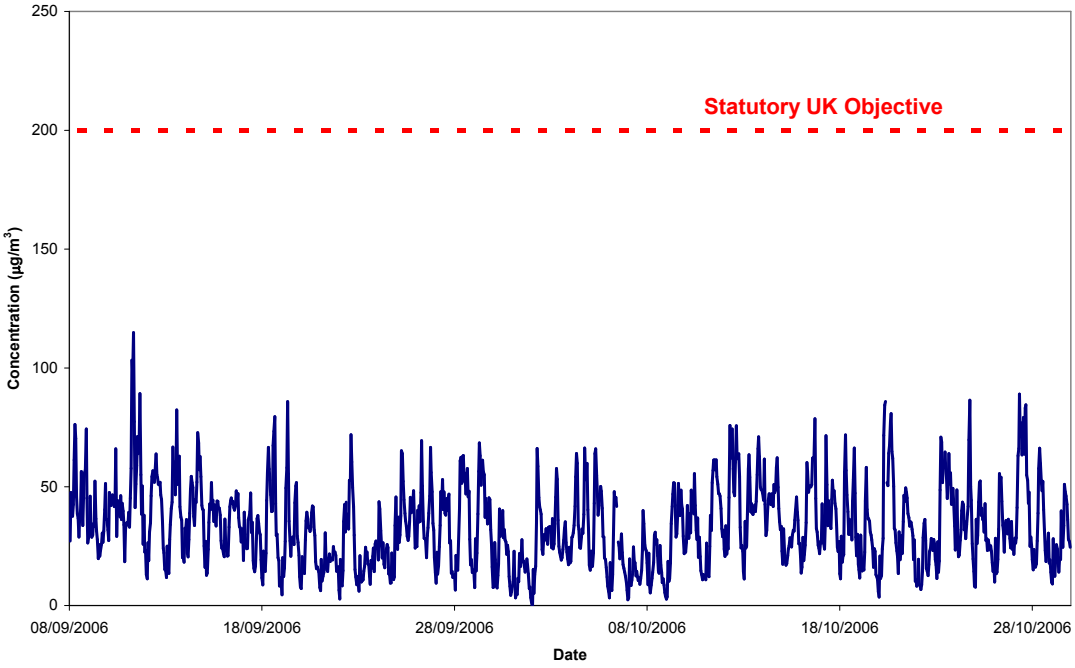

Figure 2: 1-hour Mean Nitrogen Dioxide Concentrations at High Street, 1st Site, September – October 2006

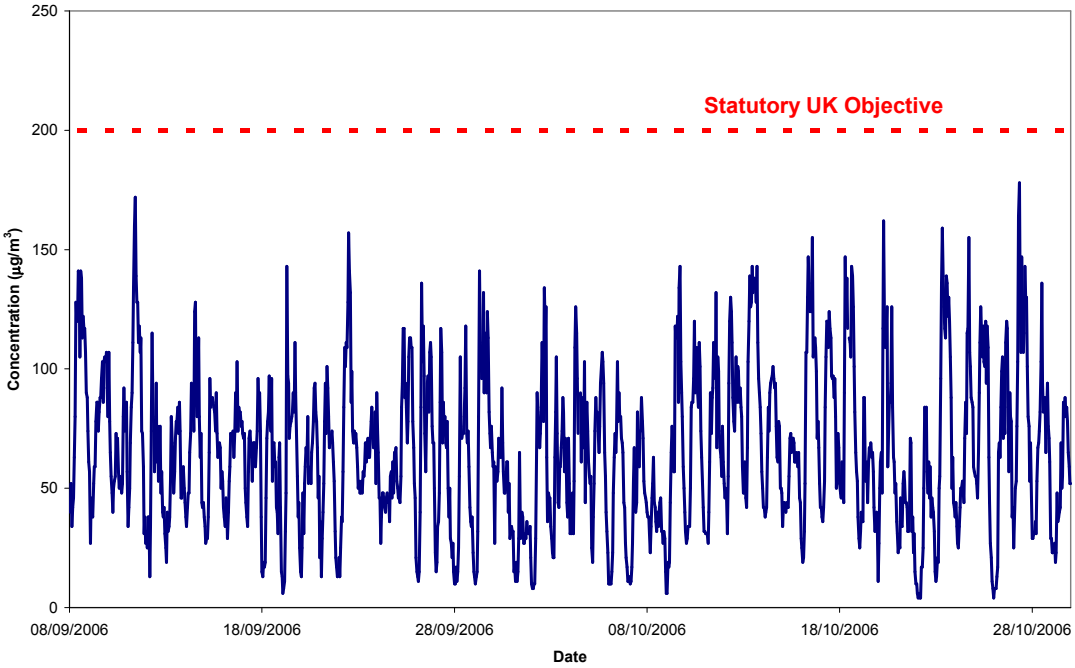

Figure 3: 1-hour Mean Nitrogen Dioxide Concentrations at Bristol Old Market, September – October 2006

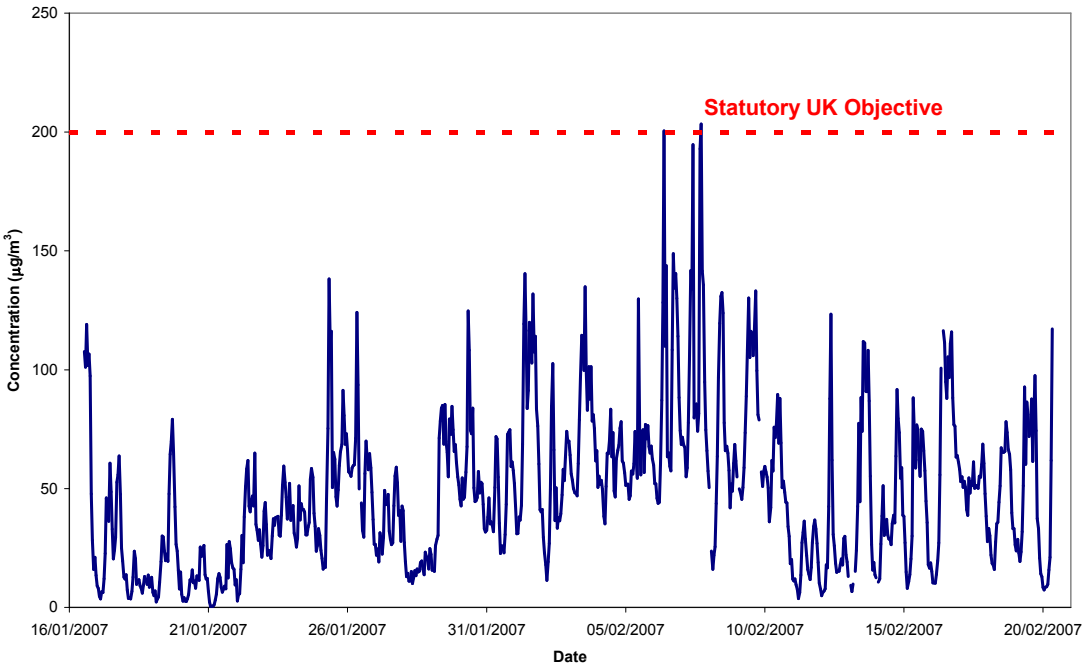

Figure 4: 1-hour Mean Nitrogen Dioxide Concentrations at High Street, 2nd Site, January – February 2007

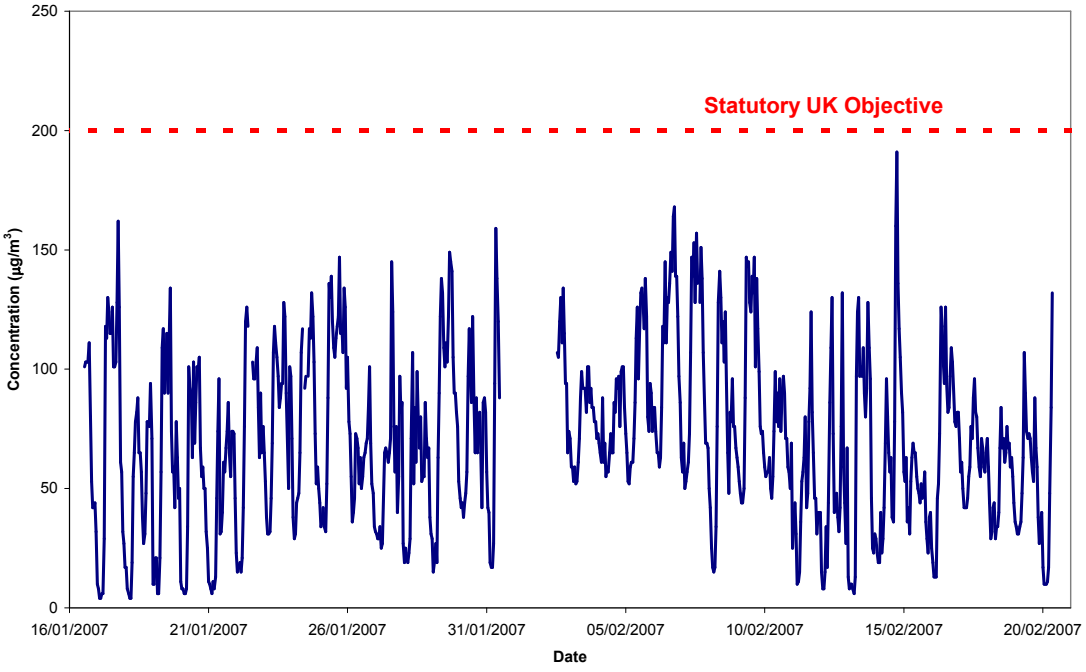

Figure 5: 1-hour Mean Nitrogen Dioxide Concentrations at Bristol Old Market, January – February 2007

3.2 On average, nitrogen dioxide levels at the High Street, Wootton Bassett Site 1 were lower than those at Bristol Old Market. Figures 2 and 3 show that concentrations at both sites were relatively

stable throughout the September – October 2006 period. Figures 3 and 4, however, show that, whilst average concentrations at the High Street, Wootton Bassett Site 2 were lower than those measured at Bristol Old Market during January – February 2007, the Wootton Bassett site experienced an elevated period of concentrations at the beginning of February. Concentrations at Bristol Old Market were relatively uniform, with no exceedences of the 200 µg/m^3 hourly objective, whilst the Wootton Bassett site experienced two exceedences during the elevated period.

3.3 In order to examine the factors driving these differences, the time series for each monitoring site have been plotted against each other in Figures 6 and 7. If the concentrations measured at the two sites were the same, then the data would lie on the 1:1 line. For those hours when the concentration measured in Wootton Bassett was greater than the concentration measured in Bristol, the data lie above the 1:1 line. The hours when Bristol measured the higher concentrations are shown below the 1:1 line. There is clearly a wide spread over both periods, with the majority of points lying below the line in each case. Very few points lie on the 1:1 line, which shows that periods of peak concentration at each site were not replicated at the other. This indicates that local factors, such as emissions from the nearby roads, drove the trends measured at each site.

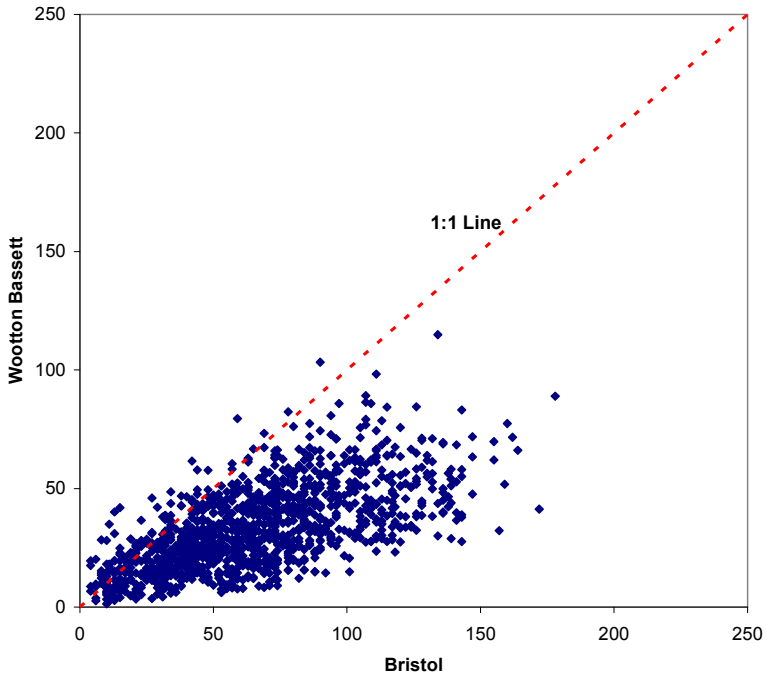

Figure 6: 1-hour Mean Nitrogen Dioxide at Wootton Bassett (Site 1) vs Bristol Old Market (µg/m^3), September – October 2006.

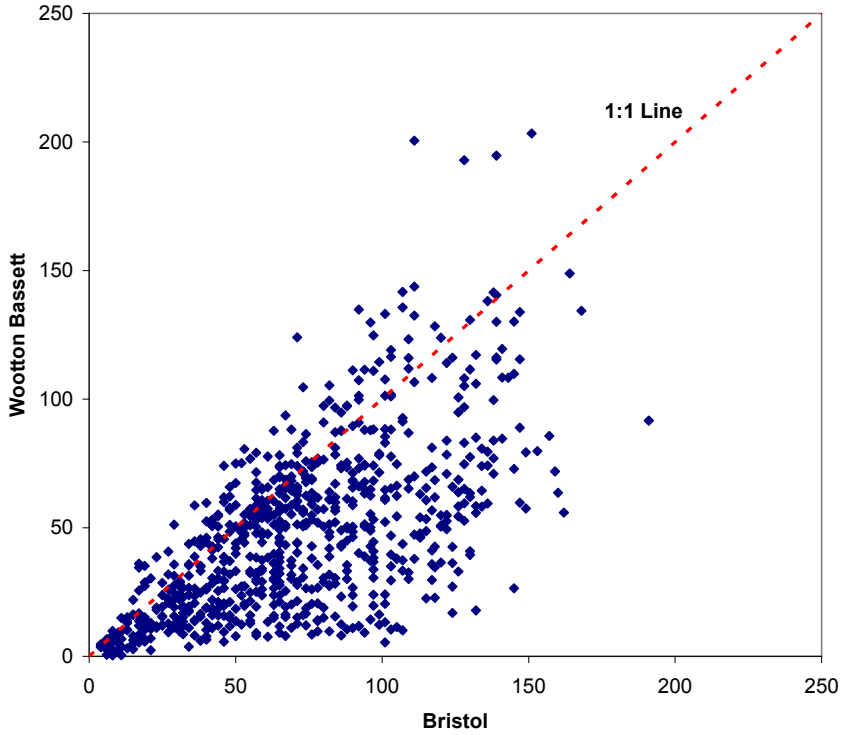

Figure 7: 1-hour Mean Nitrogen Dioxide at Wootton Bassett (Site 2) vs Bristol Old Market (µg/m^3), January – February 2007.

3.4 The relative importance of local emissions can be inferred from the ratio of nitrogen dioxide concentration to the total nitrogen oxides (NOx) concentration. This is because while some nitrogen dioxide is emitted directly, most is emitted as nitric oxide and subsequently converted to nitrogen dioxide in the atmosphere. Although the speed of this reaction depends on very many factors and is difficult to judge, the difference between nitrogen dioxide and nitrogen oxides gives an indication of the relative "age" of the air pollution. The nitrogen dioxide to NOx ratios for each hour of measurements from the Wootton Bassett sites are shown in Figures 8 and 9. Figures 10 and 11 show the corresponding data for the Bristol site. As noted in Tables 1 and 2, the maximum NOx concentration measured at each site was greater than 700 µg/m^3, but the horizontal scales have been truncated for the sake of clarity.

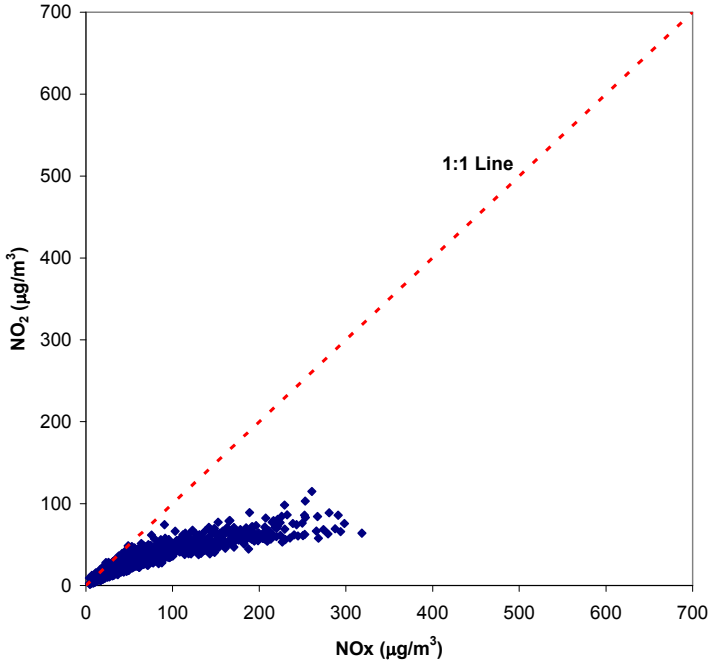

Figure 8: 1-hour Mean Nitrogen Oxides vs Nitrogen Dioxide at Wootton Bassett (Site 1), September - October 2006.

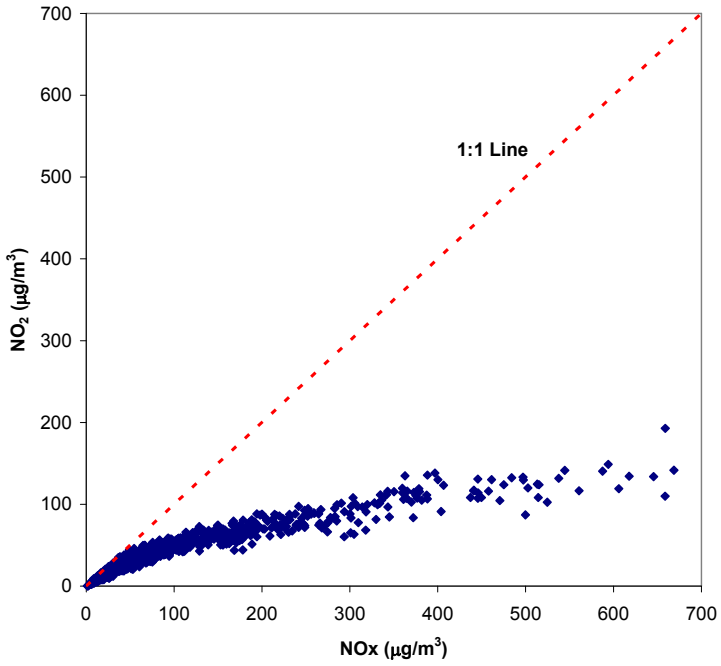

Figure 9: 1-hour Mean Nitrogen Oxides vs Nitrogen Dioxide at Wootton Bassett (Site 2), January – February 2007. (Horizontal scale truncated at 700 for the sake of clarity).

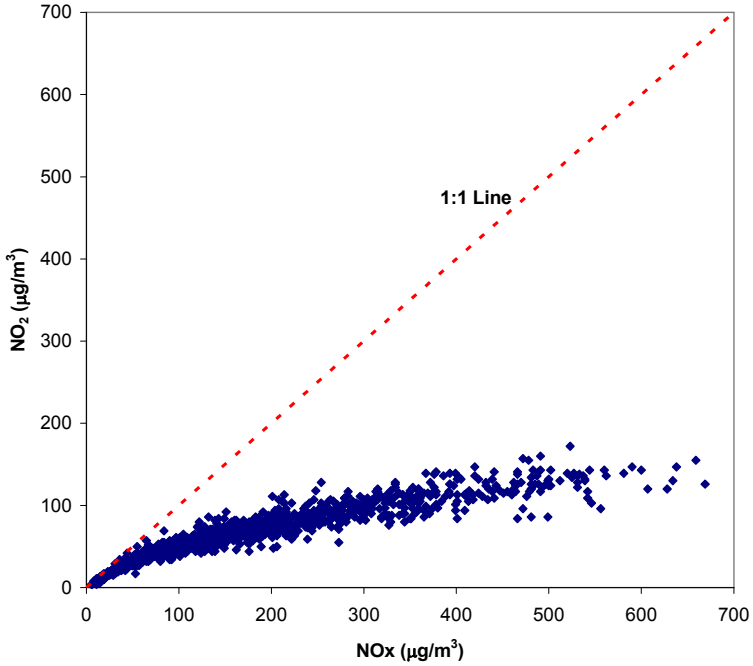

Figure 10: 1-hour Mean Nitrogen Oxides vs Nitrogen Dioxide at Bristol Old Market, September – October 2006. (Horizontal scale truncated at 700 for the sake of clarity).

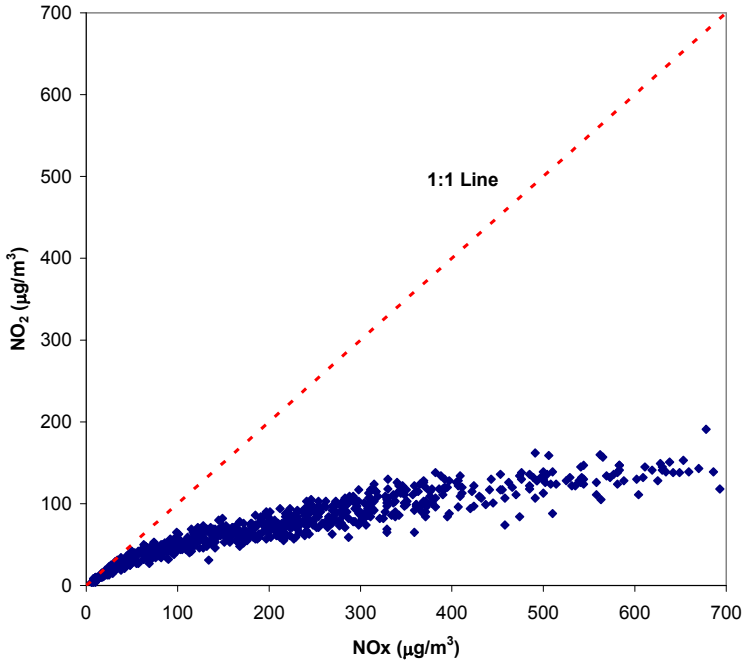

Figure 11: 1-hour Mean Nitrogen Oxides vs Nitrogen Dioxide at Bristol Old Market, January – February 2007. (Horizontal scale truncated at 700 for the sake of clarity).

3.5 All of the sites (both High Street, Wootton Bassett sites, and the Bristol Old Market site during both monitoring periods) exhibit NOx concentrations well in excess of the concurrent nitrogen dioxide

concentrations, which is only to be expected and shows that local emissions are frequently important at each site. Vertical scatter at all sites is quite limited, which indicates that all periods of high nitrogen dioxide concentration are driven by large NOx concentrations, and thus very local emissions.

3.6 In summary, periods of peak concentration at all sites tend to be driven by emissions from local roads.

PM_{10}

3.7 On average, concentrations at the two Wootton Bassett sites were slightly higher than those measured at Harwell. This is to be expected as the Harwell monitor is at a rural location, well away from busy roads. Figures 12 and 13 show the 24-hour mean concentrations measured at the Wootton Bassett sites during both monitoring periods. Figures 14 and 15 show the same data for the Harwell site. Both the Wootton Bassett site and the Harwell site experienced two peaks in 24-hour mean on the 16th September and between the 15th and 17th October. These peaks are likely to have been primarily driven by regional trends, as they affected both sites. This is highlighted in Figures 16 and 17, which plot the corresponding Harwell data against those from Wootton Bassett. As would be expected, concentrations at the rural Harwell site never exceeded the concurrent concentrations at Wootton Bassett by any great amount. Concentrations at Wootton Bassett, however, did show isolated peaks (most evident in Figure 17 which plots the data from the second monitoring site location), which are likely to reflect the influence of local emissions.

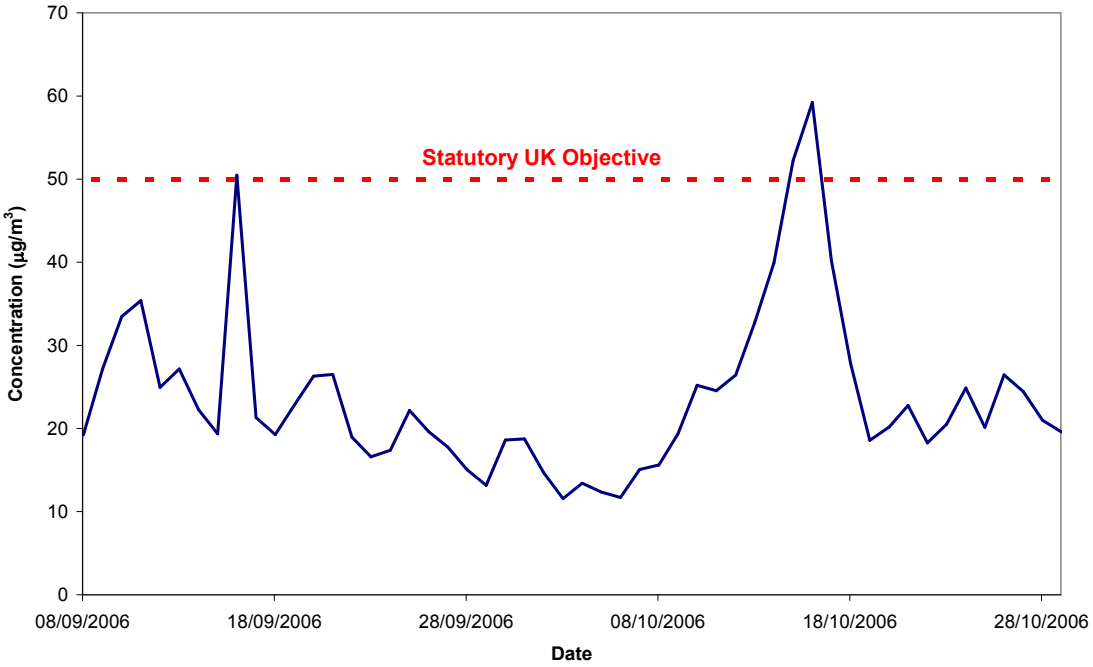

Figure 12: 24-hour Mean PM_{10} Concentrations at Wootton Bassett (Site 1), September – October 2006.

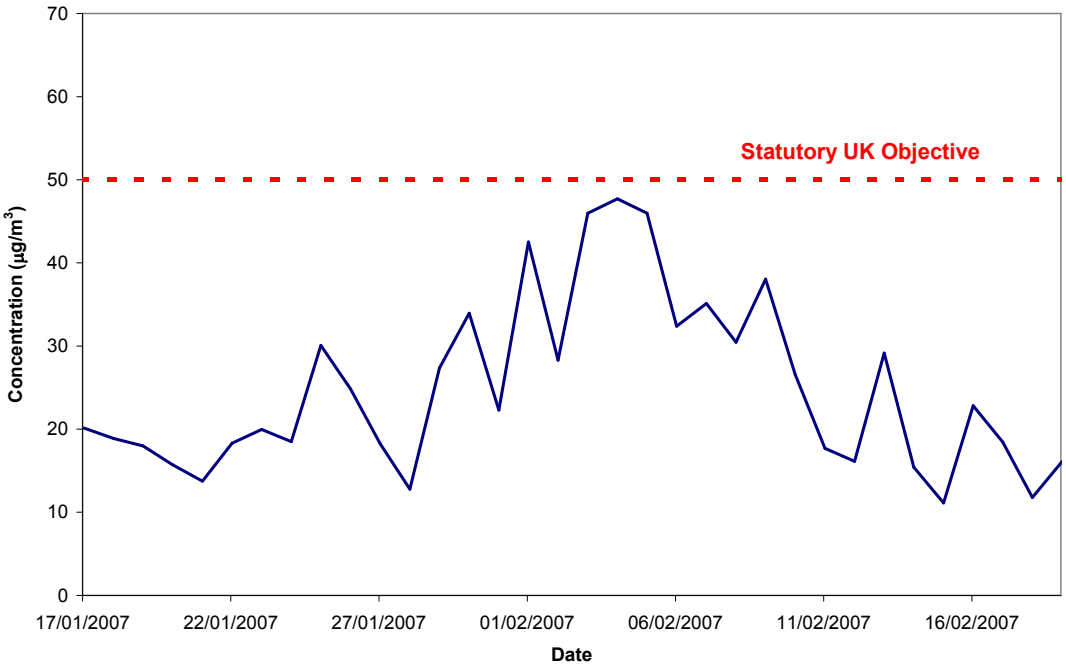

Figure 13: 24-hour Mean PM_{10} Concentrations at Wootton Bassett (Site 2), January – February 2007.

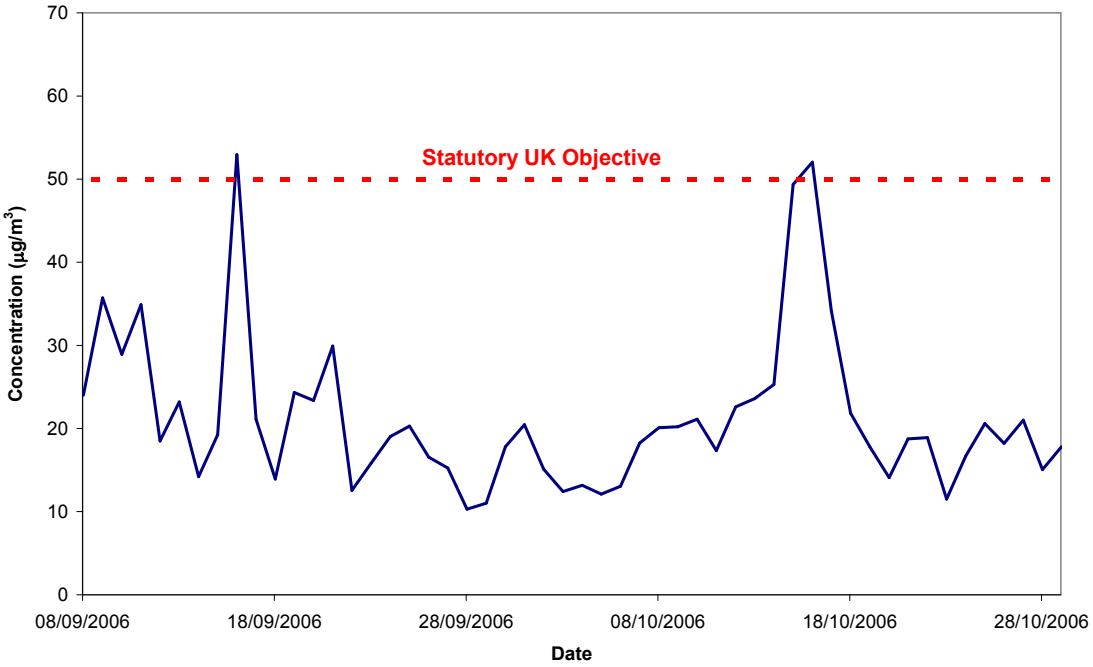

Figure 14: 24-hour Mean PM_{10} Concentrations at Harwell, September – October 2006.

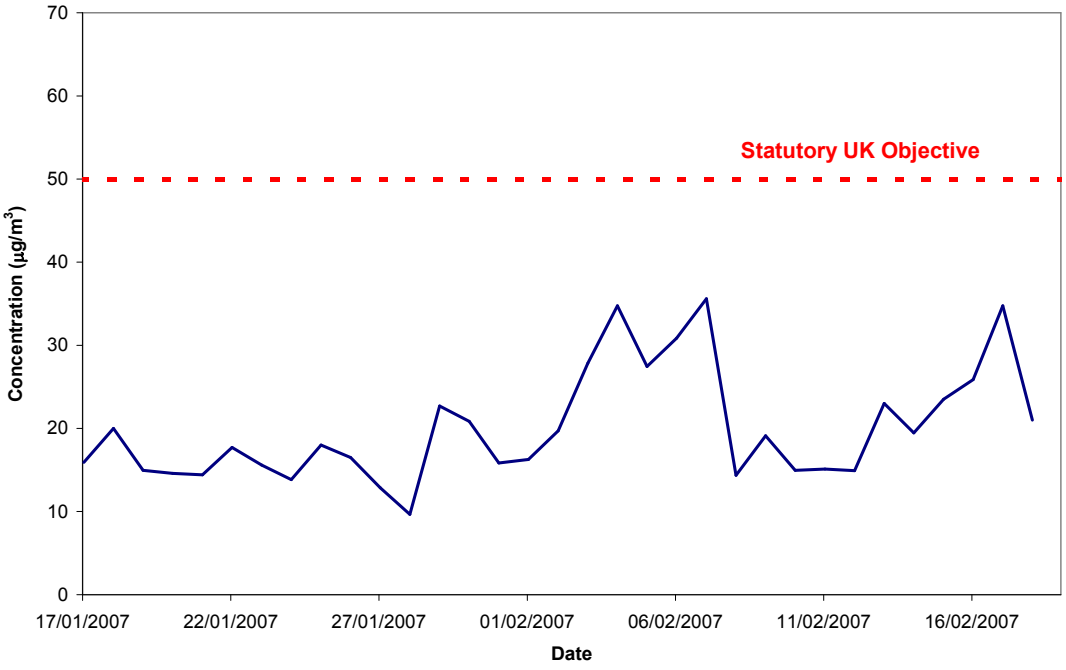

Figure 15: 24-hour Mean PM_{10} Concentrations at Harwell, January – February 2007.

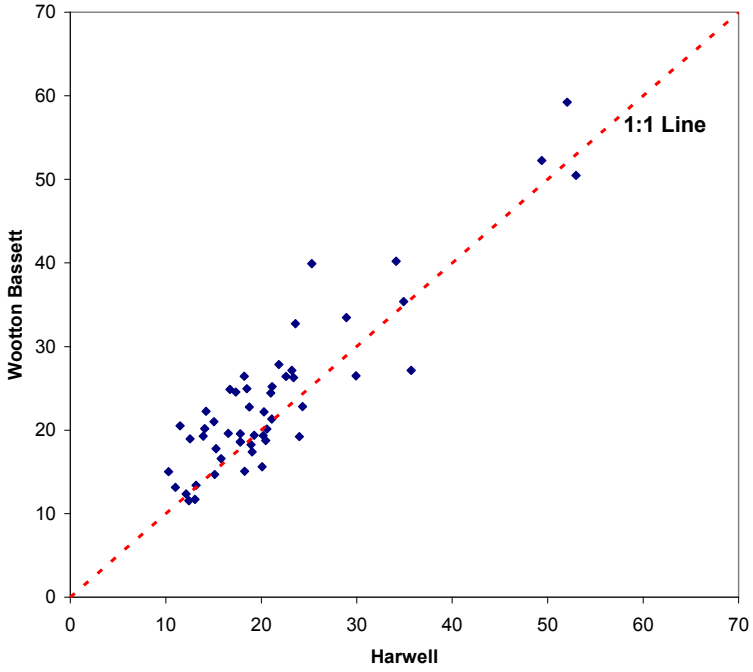

Figure 16: 24-hour Mean PM_{10} Concentrations at Wootton Bassett (Site 1) vs Harwell, September – October 2006. (µg/m^3; gravimetric equivalent).

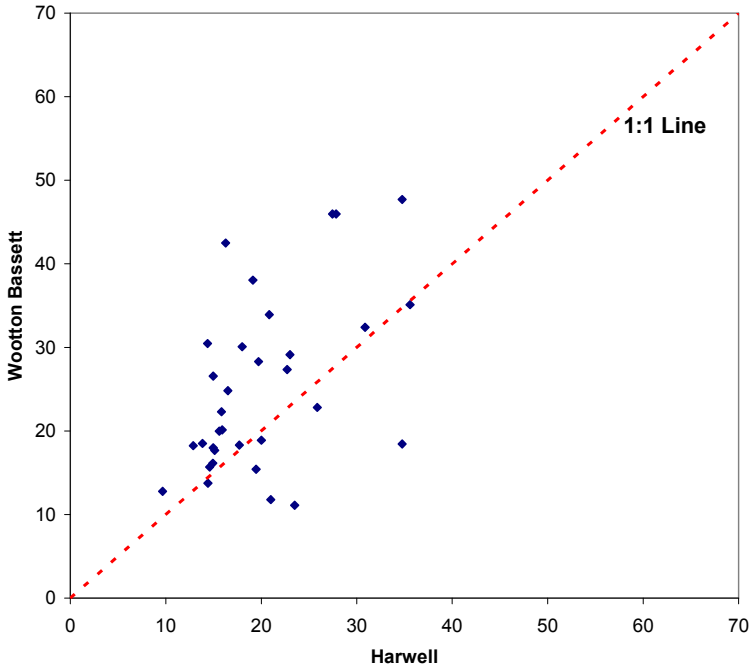

Figure 17: 24-hour Mean PM_{10} Concentrations at Wootton Bassett (Site 2) vs Harwell, January – February 2007. (µg/m^3; gravimetric equivalent).

4 Comparison with the Air Quality Objectives

The Air Quality Objectives

4.1 The Government has established a set of air quality standards and objectives to protect human health. The 'standards' are set as concentrations below which effects are unlikely even in sensitive population groups, or below which risks to public health would be exceedingly small. They are based purely upon the scientific and medical evidence of the effects of an individual pollutant. The 'objectives' set out the extent to which the Government expects the standards to be achieved by a certain date. They take account of the costs, benefits, feasibility and practicality of achieving the standards. The objectives for use by local authorities are prescribed within the Air Quality Regulations, 2000 (Stationery Office, 2000) and the Air Quality (England) (Amendment) Regulations 2002, (Stationery Office, 2002). The relevant objectives for this assessment are provided in Table 3.

Table 3: Relevant Air Quality Objectives

Pollutant	Time Period	Objective	To be achieved by[a]
Nitrogen Dioxide	1-hour mean	200 μg/m^3 not to be exceeded more than 18 times a year	2005
	Annual mean	40 μg/m^3	2005
Fine Particles (PM_{10})[b]	24-hour mean	50 μg/m^3 not to be exceeded more than 35 times a year	2004
	Annual mean	40 μg/m^3	2004

[a] The achievement dates for the UK objectives are the end of the specified year.
[b] Measured by the gravimetric method.

4.2 The objectives for nitrogen dioxide and PM_{10} were to have been achieved by 2005 and 2004 respectively, and will continue to apply in all future years thereafter. The Air Quality Strategy Addendum (Defra, 2003a) proposed a set of more stringent provisional objectives for PM_{10} to be achieved by 2010. However, the recent review of the Air Quality Strategy (Defra, 2006) indicates that these provisional PM_{10} objectives will not be brought into Regulation. There is thus no requirement to assess air quality against them and they are not discussed further.

4.3 The European Union has also set limit values for both nitrogen dioxide and PM_{10}. Achievement of these values is a national obligation rather than a local one. The limit values for nitrogen dioxide are the same levels as the UK objectives, and are to be achieved by 2010. The limit values for

PM_{10} are also the same level as the UK statutory objectives, and were to be achieved by 2005. The objectives are the same as, or more stringent than, the limit values, thus it is appropriate to focus the assessment on the objectives.

Calculation of the Annual Mean Equivalent Data

4.4 In order to compare the monitoring data with the air quality objectives, factors have been calculated and applied to each period mean to give a 2006 annual mean equivalent value. These factors were calculated as the ratio of concentrations over the full 2006 calendar year at three sites where long-term continuous monitoring data are available (Defra, 2007a), to those during the monitoring periods of interest (Sept – Oct 2006 and Jan – Feb 2007). The Harwell, Reading New Town and Cwmbran sites have been used to determine factors for the PM_{10} monitoring data, whilst the Harwell, Bournemouth and Cwmbran sites have been used to determine factors to adjust the NO_2 data. These sites have been used for this purpose because they have reliable long term datasets (data capture >90%) and are Background sites, however only the Harwell site is within 50 miles of the Wootton Bassett monitoring station (LAQM.TG(03) Box 6.5 (Defra, 2003b)). Tables 4 and 5 summarise these calculations.

Table 4: Calculation of Factors to Adjust Short-Term Period Nitrogen Dioxide Means to 2006 Annual Mean Equivalent

Period Mean Concentration ($\mu g/m^3$)	Harwell	Bournemouth	Cwmbran	Overall Factor
2006	11.5	17.1	13.8	-
8/9/06 – 29/10/06	10.3	14.1	12.7	-
Adjustment Factor	**1.111**	**1.212**	**1.081**	**1.135**
16/1/07 – 20/2/07	19.5	26.8	21.7	-
Adjustment Factor	**0.589**	**0.639**	**0.634**	**0.620**

Table 5: Calculation of Factors to Adjust Short-Term Period PM_{10} Means to 2006 Annual Mean Equivalent

Period Mean Concentration (µg/m^3)	Harwell	Reading New Town	Cwmbran	Overall Factor
2006	21.7	23.0	19.4	-
8/9/06 – 29/10/06	21.3	23.7	18.7	-
Adjustment Factor	**1.022**	**0.968**	**1.037**	**1.009**
16/1/07 – 20/2/07	20.1	24.4	17.3	-
Adjustment Factor	**1.083**	**0.942**	**1.118**	**1.048**

4.5 Table 6 sets out the annual mean equivalent data from both periods of monitoring at the two monitoring sites in the High Street, Wootton Bassett. The number of exceedences of the 24-hour PM_{10} objective has been estimated according to the relationship with the annual mean concentration set out by Defra (2003b). Measurements from across the country have shown that the 1-hour nitrogen dioxide objective is unlikely ot be exceeded unless the annual mean nitrogen dioxide concentration is greater than 60 µg/m^3 (Laxen and Marner, 2003).

Table 6: 2006 Annual Mean Equivalent Nitrogen Dioxide and PM_{10} Concentrations at the High Street, Wootton Bassett Sites for each Monitoring Period

	NO_2	PM_{10} [a]	
	Annual Mean Equivalent (µg/m^3)	**Annual Mean Equivalent (µg/m^3)**	**No 24-hour >50 µg/m^3**
Sept – Oct 2006	37.7	23.9	10[b]
Jan – Feb 2007	30.1	25.9	15[b]
Statutory Objective	**40**	**40**	**35**

[a] Values expressed as gravimetric equivalent.
[b] Estimated from the relationship between the annual mean concentration and the number of exceedences of the objective as described in LAQM.TG(03) (Defra, 2003b).

4.6 None of the statutory objectives for nitrogen dioxide or PM_{10} are expected to be exceeded at the High Street, Wootton Bassett. The statutory PM_{10} objectives are likely to be achieved by a very substantial margin. The annual mean equivalent PM_{10} concentrations calculated for each of the monitoring periods, at the two sites in the High Street are similar in value. However, the annual mean equivalent nitrogen dioxide concentrations differ by over 7 µg/m^3. This may reflect the differences between the two locations but may also reflect the limitations of estimating annual means at roadside sites from a one-month period.

5 Summary and Conclusions

5.1 Monitoring for nitrogen dioxide and PM_{10} has been carried out at two roadside locations within the High Street, Wootton Bassett between September and October 2006, and January and February 2007. To assist data interpretation, comparisons have been made with monitoring carried out at a roadside site in Bristol and a rural site in Harwell. Annual mean equivalent concentrations have been calculated to allow comparison with the relevant air quality objectives.

5.2 Nitrogen dioxide concentrations at the Wootton Bassett sites were generally lower than those at the Bristol site over the same periods. Patterns in the Wootton Bassett nitrogen dioxide data were driven mainly by local emissions, most likely the adjacent roads. PM_{10} concentrations at the Wootton Bassett site were generally higher than those at the Harwell rural site over the same periods. Patterns in the Wootton Bassett data were driven by both regional and local factors.

5.3 None of the statutory air quality objectives for nitrogen dioxide or PM_{10} are likely to be exceeded at either of the sites in the High Street, Wootton Bassett.

6 References

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7 Glossary

Standards A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal.

Objectives A nationally defined set of health-based concentrations for nine pollutants, seven of which are incorporated in Regulations, setting out the extent to which the standards should be achieved by a defined date, taking into account costs, benefits, feasibility and practicality. There are also vegetation-based objectives for sulphur dioxide and nitrogen oxides.

Exceedence A period of time where the concentration of a pollutant is greater than the appropriate air quality objective.

PM_{10} Small airborne particles, more specifically particulate matter less than 10 micrometers in aerodynamic diameter.

NO_2 Nitrogen dioxide.

$\mu g/m^3$ Microgrammes per cubic metre.