South Gloucestershire Council

Air Quality CONSULTANTS

Further Assessment of Air Quality in the Cribbs Causeway, Staple Hill, and Kingswood AQMAs – South Gloucestershire Council

September 2011

Experts in air quality management & assessment

Document Control

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Contents

1 Introduction

1.1 This report is the Further Assessment of nitrogen dioxide concentrations within the Cribbs Causeway, Staple Hill and Kingswood Air Quality Management Areas (AQMA), South Gloucestershire. The report is one of a series produced by, and on behalf of, South Gloucestershire Council, which periodically review and assess air quality within the District. South Gloucestershire Council accepts the conclusions of this report and intends to implement all the recommendations.

The Air Pollutant of Concern

1.2 Nitrogen dioxide is associated with adverse effects on human health. At high levels nitrogen dioxide causes inflammation of the airways. Long-term exposure may affect lung function and respiratory symptoms. Nitrogen dioxide also enhances the response to allergens in sensitive individuals (Defra, 2007).

The Air Quality Objectives

1.3 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 economic efficiency, practicability, technical feasibility and timescale. 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 1.

Table 1: Relevant Air Quality Objectives

Pollutant	Time Period	Objective
Nitrogen Dioxide	1-hour mean	200 μg/m^3 not to be exceeded more than 18 times a year
	Annual mean	40 μg/m^3

1.4 The objectives for nitrogen dioxide were to be achieved by 2005, and continue to apply in all future years thereafter. The air quality objectives only apply where members of the public are likely to be regularly present for the averaging time of the objective (i.e. where people will be exposed to pollutants). For the annual mean objective, relevant exposure is mainly limited to residential properties, schools and hospitals. The 1-hour objective applies at these locations as well as at any outdoor location where a member of the public might reasonably be expected to stay for 1 hour or

more, such as shopping streets, parks and sports grounds, as well as bus stations and railway stations that are not fully enclosed.

1.5 Measurements across the UK have shown that the 1-hour nitrogen dioxide objective is unlikely to be exceeded where the annual mean concentration is below 60 μg/m^3 (Defra, 2009). Therefore, 1-hour nitrogen dioxide concentrations will only be considered if the annual mean concentration is above this level.

1.6 The European Union has also set limit values for nitrogen dioxide. 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 (Stationery Office, 2007).The objectives are the same as, or more stringent than, the limit values, thus it is appropriate to focus on the objectives.

Introduction to Review and Assessment

1.7 The Air Quality Strategy (Defra, 2007) provides the policy framework for air quality management and assessment in the UK. As well as providing the air quality objectives listed above, it also sets out how the different sectors: industry, transport and local government can contribute to achieving the air quality objectives. Local authorities are seen to play a particularly important role. The strategy describes the Local Air Quality Management (LAQM) regime that has been established, whereby every authority has to carry out regular Reviews and Assessments of air quality in its area to identify whether the objectives have been, or will be, achieved at relevant locations, by the applicable date.

1.8 Review and Assessment is carried out as a series of rounds. Local Air Quality Management Technical Guidance (LAQM.TG(09)) (Defra, 2009) sets out a phased approach to the current round of Review and Assessment. This prescribes an initial Updating and Screening Assessment (USA), which all authorities must undertake. It is based on a checklist to identify any matters that have changed since the previous round. If the USA identifies any areas where there is a risk that the objectives may be exceeded, which were not identified in the previous round, then the Local Authority should progress to a Detailed Assessment.

1.9 The purpose of the Detailed Assessment is to determine whether an exceedence of an air quality objective is likely and the geographical extent of that exceedence. If the outcome of the Detailed Assessment is that one or more of the air quality objectives are likely to be exceeded, then an Air Quality Management Area (AQMA) must be declared. Subsequent to the declaration of an AQMA, a Further Assessment should be carried out; 1) to confirm that the AQMA declaration is justified and that the appropriate area has been declared; 2) to ascertain the sources contributing to the exceedence; and 3) to calculate the magnitude of reduction in emissions required to achieve the objective. This information can be used to inform an Air Quality Action Plan, which will identify measures to improve local air quality.

Key Findings of Previous Review and Assessment Reports

1.10 In September 2008, a Detailed Assessment (South Gloucestershire Council, 2008) was undertaken for the following areas in South Gloucestershire, due to monitored exceedences of the annual mean objective for nitrogen dioxide:

- Cribbs Causeway – at the M5 Roundabout (Junction 17);
- Staple Hill – at the Broad Street (A4175), High Street (B4465), Victoria Street and Soundwell Road (A4017) crossroads; and
- Kingswood – along Regent Street (A420).

1.11 It was concluded that Air Quality Management Areas (AQMAs) should be declared for each of the locations identified. The AQMAs were declared in April 2010.

1.12 The latest Updating and Screening Assessment was published in April 2010 (South Gloucestershire Council, 2010). The report concluded that there were no exceedences of any pollutants of concern outside of the Air Quality Management Areas.

1.13 The 2011 Progress report presenting 2009 and 2010 monitoring data is currently being undertaken by Air Quality Consultants (South Gloucestershire Council, 2011).

Scope

1.14 Guidance within LAQM.TG(09) (Defra, 2009) explains that a Further Assessment report allows authorities to:

- confirm their original assessment, and thus ensure they were correct to designate an AQMA in the first place;
- calculate more accurately what improvement in air quality, and corresponding reduction in emissions, would be required to attain the air quality objectives within the AQMA;
- refine their knowledge of sources of pollution, so that the air quality Action Plan may be appropriately targeted;
- take account of any new guidance issued by Defra and the Devolved Administrations, or any new policy developments that may have come to light since declaration of the AQMA;
- take account of any new local developments that were not fully considered within the earlier Review and Assessment work. This might, for example, include the implications of new transport schemes, commercial or major housing developments etc, that were not committed or known of at the time of preparing the Detailed Assessment;
- carry out additional monitoring to support the conclusion to declare the AQMA;
- corroborate the assumptions on which the AQMA has been based, and to check that the original designation is still valid, and does not need amending in any way; and

- respond to any comments made by statutory consultees in respect of the Detailed Assessment.

2 Study Area and AQMA Location

Cribbs Causeway

2.1 The Cribbs Causeway AQMA encompasses an area adjacent to Junction 17 of the M5, and includes a single residential property (Figure 1). There are no other locations of relevant exposure within the AQMA. There are no locations additional to those relevant for the annual objective that are relevant for the 1-hour objective.

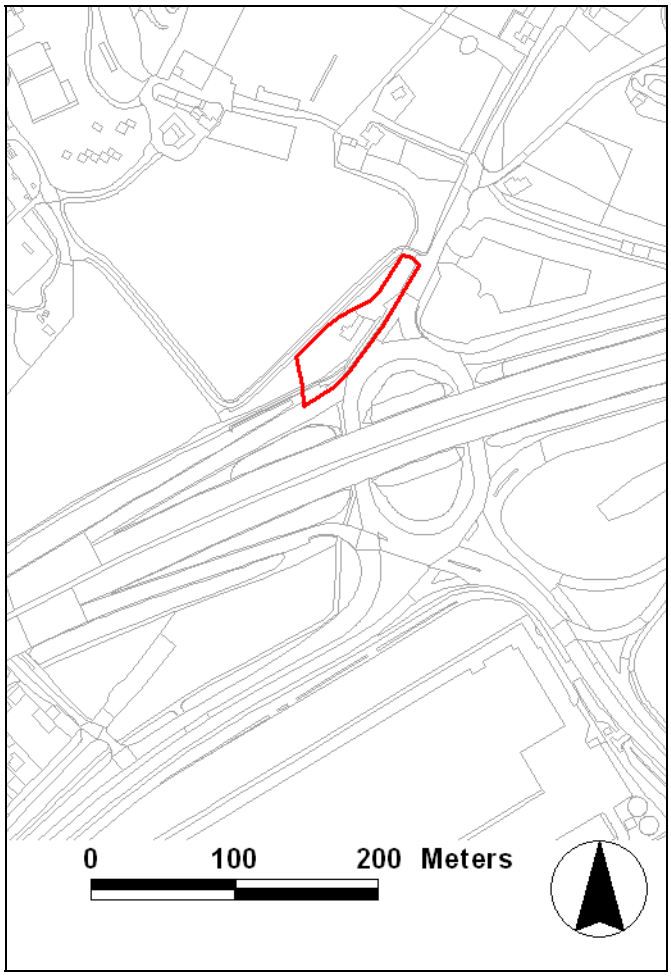

Figure 1: Cribbs Causeway AQMA. AQMA boundary shown in red. (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

Staple Hill

2.2 The Staple Hill AQMA encompasses properties along Broad Street, Victoria Street, High Street and Soundwell Road, close to the junction between all four roads (Figure 2). The majority of properties within the AQMA along High Street and Broad Street are commercial, but with residential properties on the first floor of some premises. Properties along Victoria Street and Soundwell Road are residential on both the ground and first floor. There are no locations additional to those relevant for the annual objective that are relevant for the 1-hour objective.

2.3 The study area includes the area extending beyond the AQMA boundary on Broad Street, Victoria Street, High Street and Soundwell Road.

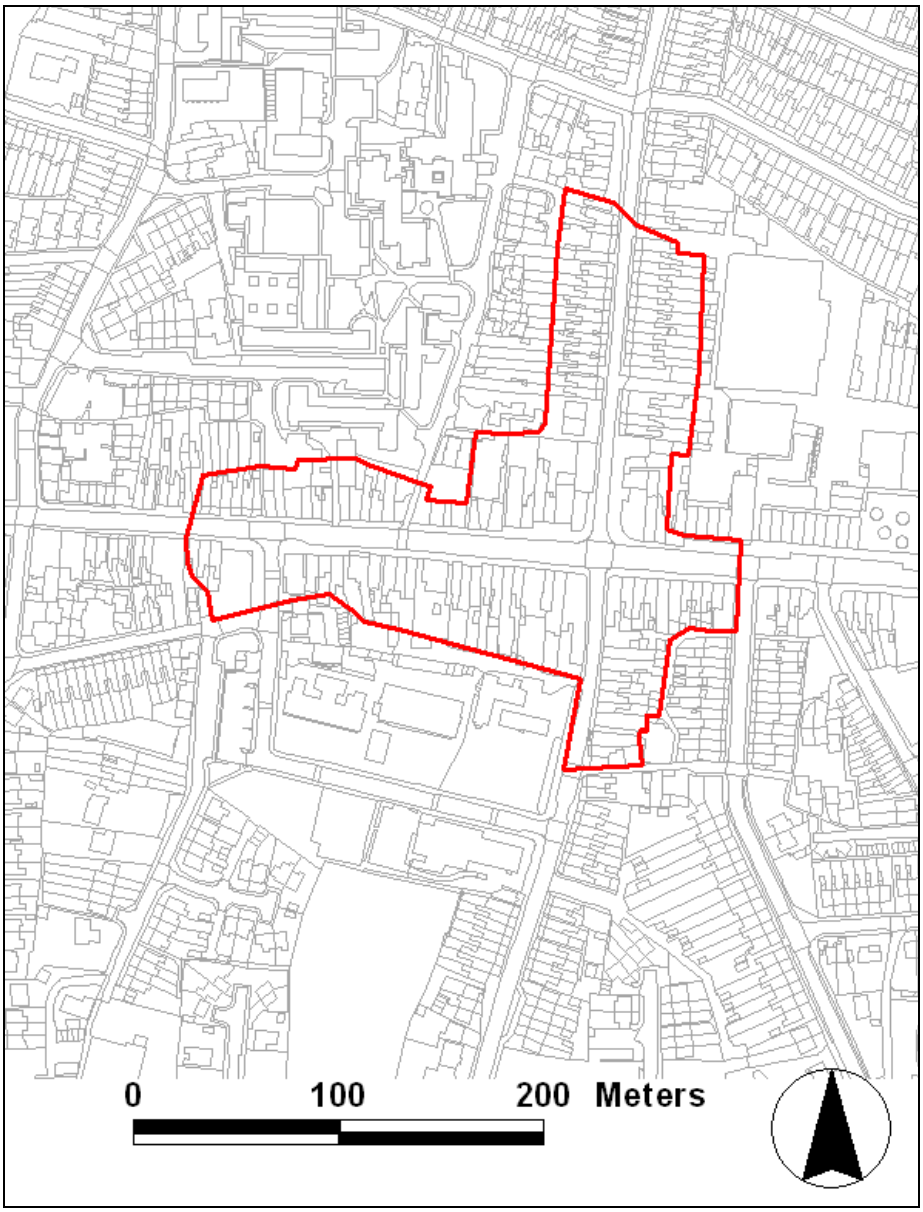

Figure 2: Staple Hill AQMA. AQMA boundary shown in red. (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

Kingswood

2.4 The Kingswood AQMA encompasses properties along Regent Street (Figure 3). The majority of properties within the AQMA are commercial, but with relevant exposure for the annual mean objective in the residential units at first floor level. There is an outdoor area, with benches on the northern area of Regent Street, where the 1-hour objective applies.

2.5 The study area includes an area extending beyond the AQMA boundary to the east on High Street, to the west on Two Mile Hill Road, and to the south on Hanham Road.

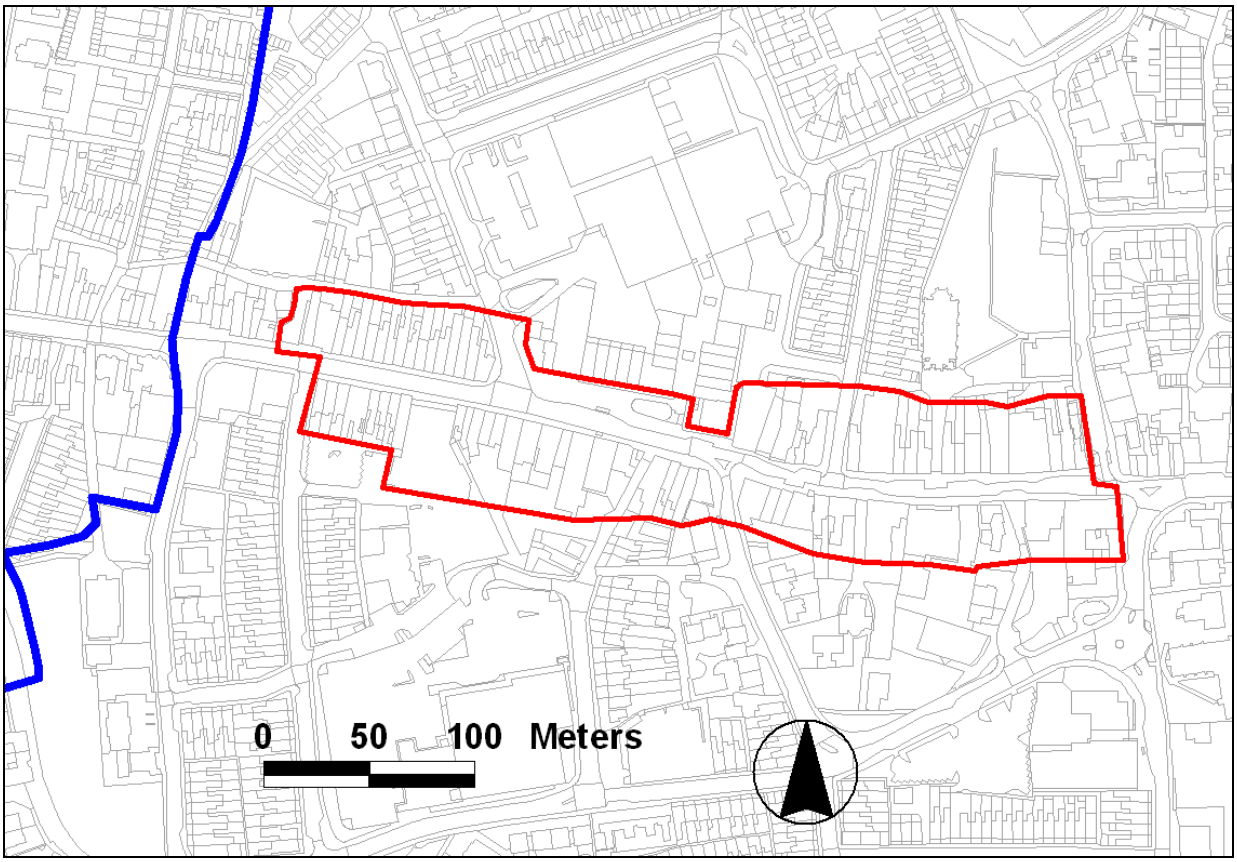

Figure 3: Kingswood AQMA. AQMA boundary shown in red. Blue line denotes South Gloucestershire boundary. (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

3 Local Developments since Declaration of the AQMA

New and Proposed Local Developments

3.1 There have been no major developments in the Kingswood or Staple Hill Areas since the Detailed Assessment was carried out. With regards to the Cribbs Causeway AQMA, there are a number of developments which cumulatively could increase traffic through J17 of the M5. The Core Strategy indicates 1,750 new dwellings in this area above the existing commitments. For example, the proposed Bristol Zoo development (National Conservation Wildlife Park) is expected to attract 600,000 visitors per year, though the timescale for completion of this development is likely to be 15 – 20 years. Construction of the Northfield development, which includes a new link road (Hayes Way) from the A38 to Highwood Road, has begun since the Detailed Assessment. The new link road is not expected to have a significant impact on the Cribbs Causeway AQMA, as it is sufficient distance from it. Although it is likely that the Cribbs Causeway AQMA will be revoked in the next year or so, it is judged, based on current monitoring, that concentrations are sufficiently below the objectives to go ahead with this revocation, even in light of development in this area. South Gloucestershire Council is committed to working within the planning system to minimise emissions from new developments, and will continue to monitor the M5, J17 and surrounding area, or other locations which may be impacted on by new developments.

National Developments

3.2 The latest guidance from Defra in LAQM.TG(09) (Defra, 2009) has been followed regarding NOx to NO_2 relationships. All the latest tools associated with the release of LAQM.TG(09) (Defra, 2009) have been used for this assessment.

4 New Monitoring and Modelling Data

New Monitoring

4.1 During 2010, South Gloucestershire Council operated three continuous monitoring sites which measured nitrogen dioxide. Two of these sites are located well away from the study areas. The Kingswood automatic monitoring site is located to the east of the Kingswood AQMA boundary, however, this site ceased operation in September 2010, as the property on which the site was situated had been sold.

4.2 South Gloucestershire Council also operates an extensive network of diffusion tubes in and around all three AQMAs. In all cases, 2010 annual means have been used in this assessment, but Tables 2, 3 and 4 also present 2008 and 2009 annual means for comparison and context.

4.3 It should be noted that in previous review and assessment reports, concentrations at some diffusion tube monitoring sites had been distance adjusted using the fall-off with distance calculator

published by Defra (Defra, 2011b). Although the adjustment calculator can be used as an indicator of pollutant concentrations on a residential façade, it is a screening tool based on average nitrogen dioxide fall-off curves. Modelled concentrations are a more accurate representation of pollutant concentrations at a residential façade, as they are based on detailed dispersion modelling, which takes account of site specific conditions, including meteorological data, road geometry, and specific local emission rates; as well as measured data and background concentrations. Diffusion tube concentrations presented in this report have not been adjusted for distance.

Bias Adjustment of Diffusion Tubes

4.4 Diffusion tube measurements may exhibit substantial bias compared to the reference method (chemiluminescent analyser) for measuring nitrogen dioxide. As a result, LAQM.TG(09) recommends that Local Authorities should apply a 'bias adjustment factor', which is calculated by undertaking a co-location study with a real time analyser. If this cannot be undertaken within the local authority area, then a default factor made available within a spreadsheet on the Review and Assessment helpdesk website should be used (Defra, 2011a). The Council uses Bristol Scientific Services for analysis of diffusion tubes (20% TEA in Water). For this study, the 2010 data have been adjusted using the national factor provided on the Review and Assessment Helpdesk website (0.85; spreadsheet version 04/11).

Diffusion Tube Data at Cribbs Causeway

4.5 The diffusion tube monitoring locations in close proximity to the Cribbs Causeway AQMA are shown in Figure 4 and results are presented in Table 2. Concentrations exceeding the objective are presented in bold.

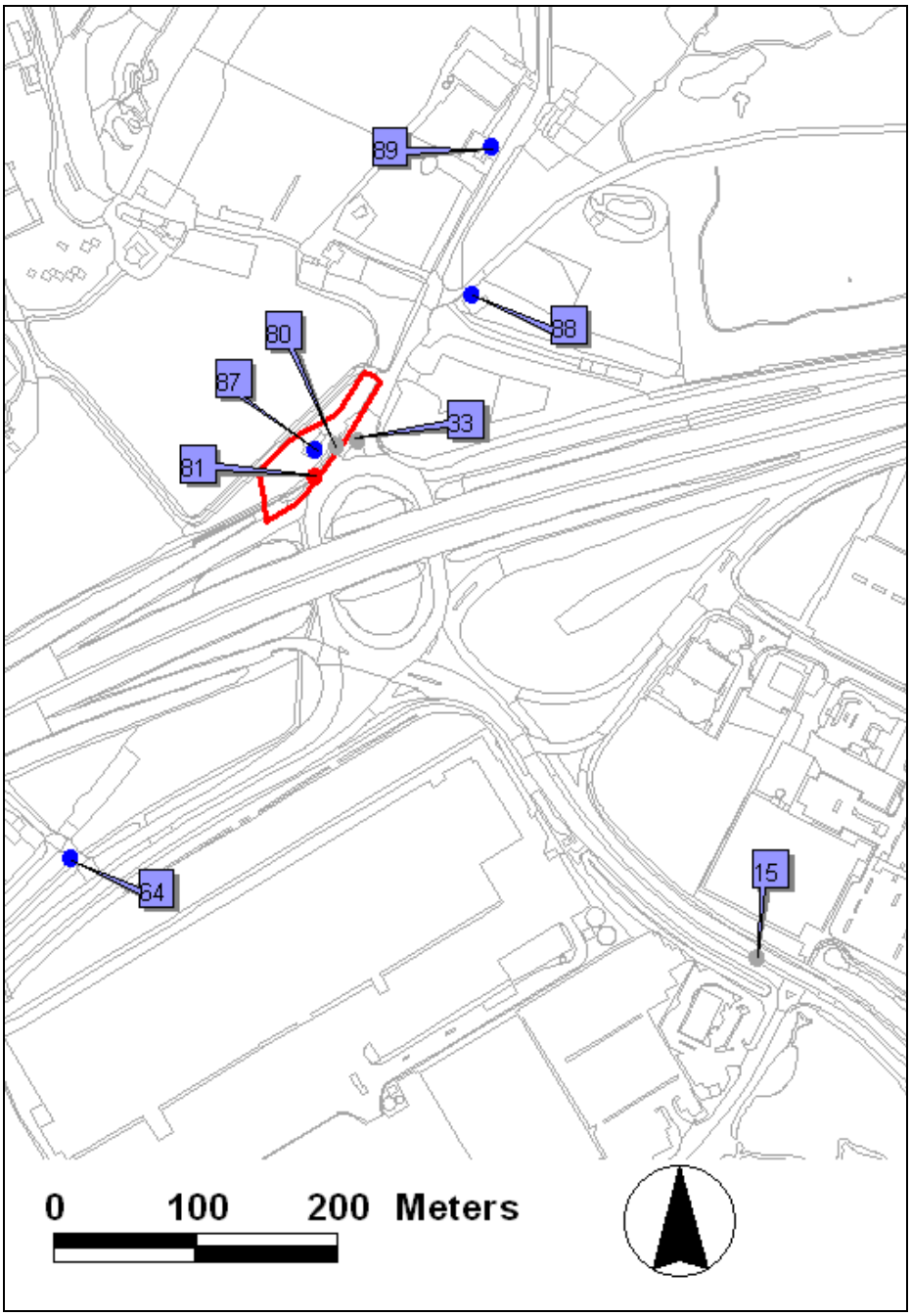

Figure 4: Monitoring Locations in Close Proximity to the Cribbs Causeway AQMA. (Monitoring Sites exceeding the Objective Shown in Red, Below the Objective Shown in Blue and no Longer Operational Shown in Grey). (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

Table 2: Diffusion Tube Data within the Cribbs Causeway Study Area

Site Name	Location	In AQMA ?	Data Capture for 2009 Calendar Year (%)	Data Capture for 2010 Calendar Year (%)	Annual Mean Concentrations (µg/m^3)		
					2008[a]	2009[b]	2010[c]
15	Cribbs Causeway - Merlin Road	N	58%	n/a	39.9	34.8[d]	n/a
33	Cribbs Causeway - M5 Roundabout	N	83%	n/a	**51.7**	**48.5**	n/a
64	Cribbs Causeway - Holly Cottage	N	100%	100%	**41.7**	36.9	39.7
80	Cribbs Causeway - Hollywood Cottage Blackhorse Hill (nr "no access to M4 & SSC" sign)	Y	67%	n/a	**61.5**	**61.5[d]**	n/a
81	Cribbs Causeway - Hollywood Cottage Blackhorse Hill (nearest M5 Roundabout)	Y	75%	100%	**62.6**	**56.0[d]**	**70.1**
87	Cribbs Causeway - Hollywood Cottage facade	Y	25%	100%	n/a	33.0[d]	33.0
88	Cribbs Causeway - Blackhorse Hill St. Swithin's Lodge facade	N	17%	100%	n/a	25.0[d]	25.9
89	Cribbs Causeway - Blackhorse Hill The Ferns facade	N	25%	100%	n/a	20.0[d]	24.2

[a] bias adjusted using a national factor of 0.87 as reported in the USA (2009)

[b] bias adjusted using a national factor of 0.79 (as reported in Progress Report, 2011)

[c] bias adjusted using a national factor of 0.85 (as reported in Progress Report, 2011)

[d] Annualised, (as reported in Progress Report, 2011)

4.6 There are two operational tubes located within the AQMA boundary. Monitoring at diffusion tube monitoring site 87 commenced in October2009, and is located on the façade of the residential property. Diffusion tube monitoring site 81 is located close to the roadside. Concentrations at diffusion tube monitoring site 81 have been well above the objective for the past three years, however there is no relevant exposure at this location. Measured concentrations at diffusion tube monitoring site 87, located at the residential façade in a worst-case location, were well below the objective in 2009 and 2010.

4.7 There are no other diffusion tube monitoring sites at locations with relevant exposure which exceed the objective.

4.8 Based on the above monitoring results, it is unlikely that concentrations at locations of relevant exposure within the AQMA boundary are being exceeded and the AQMA may no longer be required. However, there has only been one full year of monitoring data available at site 87 (only three months data was available for 2009), and further monitoring is required to reach a definitive conclusion. Should monitoring results in 2011 remain below the objective, then it would be appropriate to revoke the AQMA. It is recommended that monitoring be continued at this location,

to confirm that the concentration remains below the objective. Triplicate tubes at this location would provide a more robust annual average concentration.

Diffusion Tube Data in Staple Hill

4.9 The diffusion tube monitoring locations in close proximity to the Staple Hill AQMA are shown in Figure 5 and Table 3. Concentrations exceeding the objective are presented in bold.

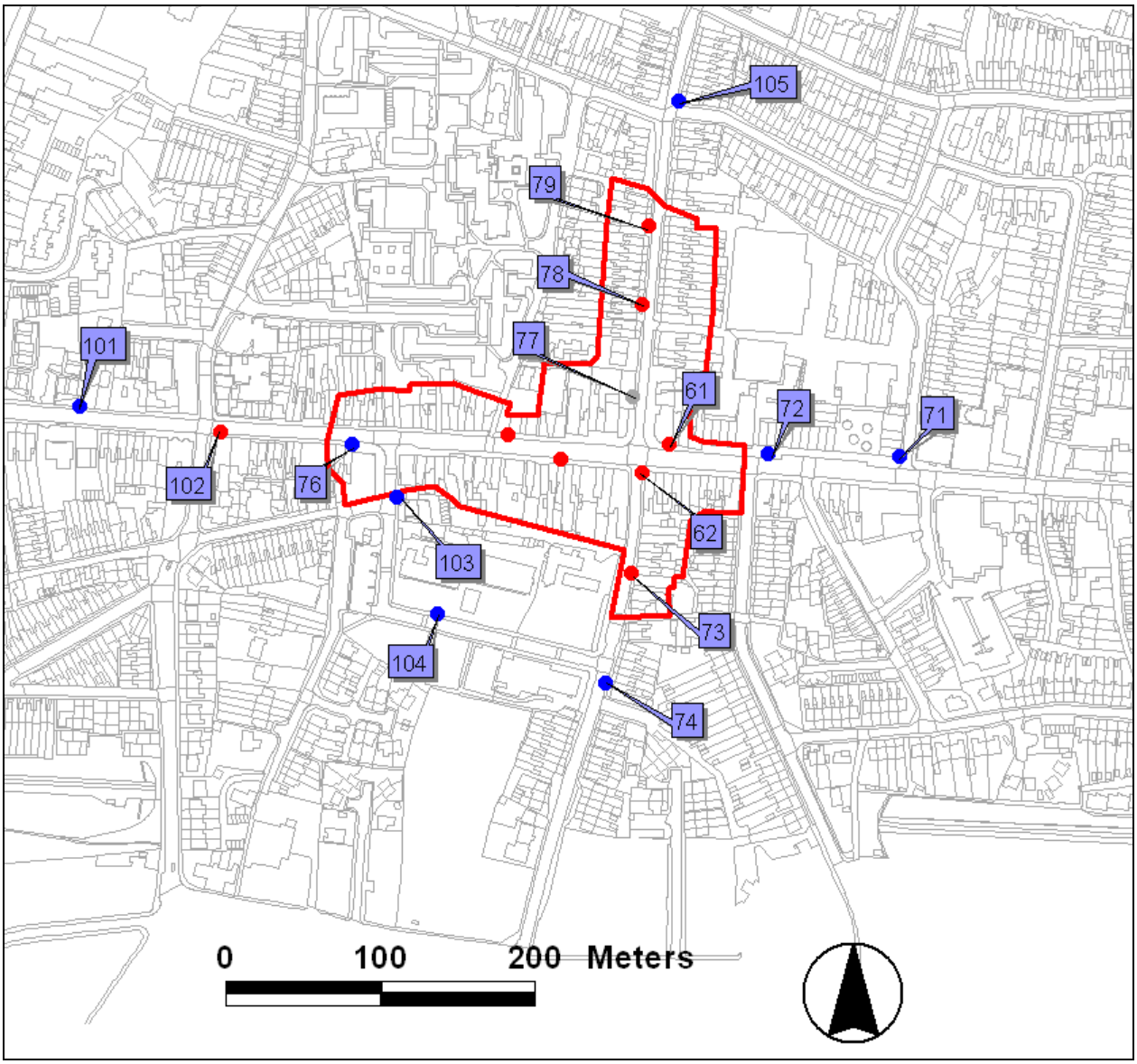

Figure 5: Monitoring Locations in Close Proximity to the Staple Hill AQMA. (Monitoring Sites exceeding the Objective Shown in Red, Below the Objective Shown in Blue and no Longer Operational Shown in Grey). (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

Table 3: Diffusion Tube Data within the Staple Hill Study Area

Site Name	Location	In AQMA ?	Data Capture for 2009 Calendar Year (%)	Data Capture for 2010 Calendar Year (%)	Annual Mean Concentrations (µg/m^3)		
					2008[a]	2009[b]	2010[c]
29	Staple Hill - 123 High Street Backhouse Bet	Y	92%	100%	**42.2**	39.7	**45.4**
61	Staple Hill Crossroads - 1 Broad Street HSBC	Y	92%	100%	**44.5**	**41.7**	**47.3**
62	Staple Hill Crossroads - 2 Broad Street Port Petite façade	Y	92%	100%	**43.5**	39.9	**47.4**
71	Staple Hill - 11 The Square Lamplight	N	67%	92%	29.1	25.9[d]	30.0
72	Staple Hill - 25 Broad Street Westbury Inks	N	92%	100%	35.2	32.6	35.4
73	Staple Hill - 11 Soundwell Road Liberty	Y	92%	100%	**43.7**	38.9	**47.9**
74	Staple Hill - 29-31 Soundwell Road opp Page Comm Assoc	N	92%	92%	36.6	30.8	34.3
75	Staple Hill - 118 High Street Santander	Y	92%	100%	**43.7**	**43.0**	**42.8**
76	Staple Hill - 84-86 High Street Staple Oak Pub façade	Y	83%	100%	**41.9**	34.8	37.8
77	Staple Hill - Victoria Street in front of AB Autos car yard	Y	67%	n/a	**42.9**	39.9[d]	n/a
78	Staple Hill - 9-11 Victoria Street	Y	83%	83%	**44.9**	**41.5**	**45.5**
79	Staple Hill - 27-29 Victoria Street	Y	92%	100%	**45.7**	37.5	**41.2**
101	Staple Hill - High Street lp outside Beech House	N	17%	100%	n/a	25.3[d]	31.2
102	Staple Hill - 58 High Street Aladdin's Cave	N	8%	100%	n/a	**43.5[d]**	**44.8**
103	Staple Hill - Page Road Brookridge Court	N	25%	100%	n/a	26.7[d]	28.1
104	Staple Hill – Page Road Staple Hill Primary School	N	25%	92%	n/a	22.2[d]	28.1
105	Staple Hill – North Street lp outside no. 2	N	17%	100%	n/a	27.6[d]	33.4

[a] bias adjusted using a national factor of 0.87 as reported in the USA (2009)

[b] bias adjusted using a national factor of 0.79 (as reported in Progress Report, 2011)

[c] bias adjusted using a national factor of 0.85 (as reported in Progress Report, 2011)

[d] Annualised, (as reported in Progress Report, 2011)

4.10 There are eight monitoring sites which measured an exceedence of the annual mean objective within the study area in 2010, seven of which are located within the AQMA boundary. Measured concentrations at diffusion tube monitoring site 102, located outside the AQMA boundary, exceeded the objective in 2010 and in 2009, however data were only available for one month in 2009. Measured concentrations at all other locations were below the objective.

Monitoring Data in Kingswood

4.11 The diffusion tube monitoring locations in close proximity to the Kingswood AQMA are shown in Figure 6 and Table 4. Concentrations exceeding the objective are presented in bold.

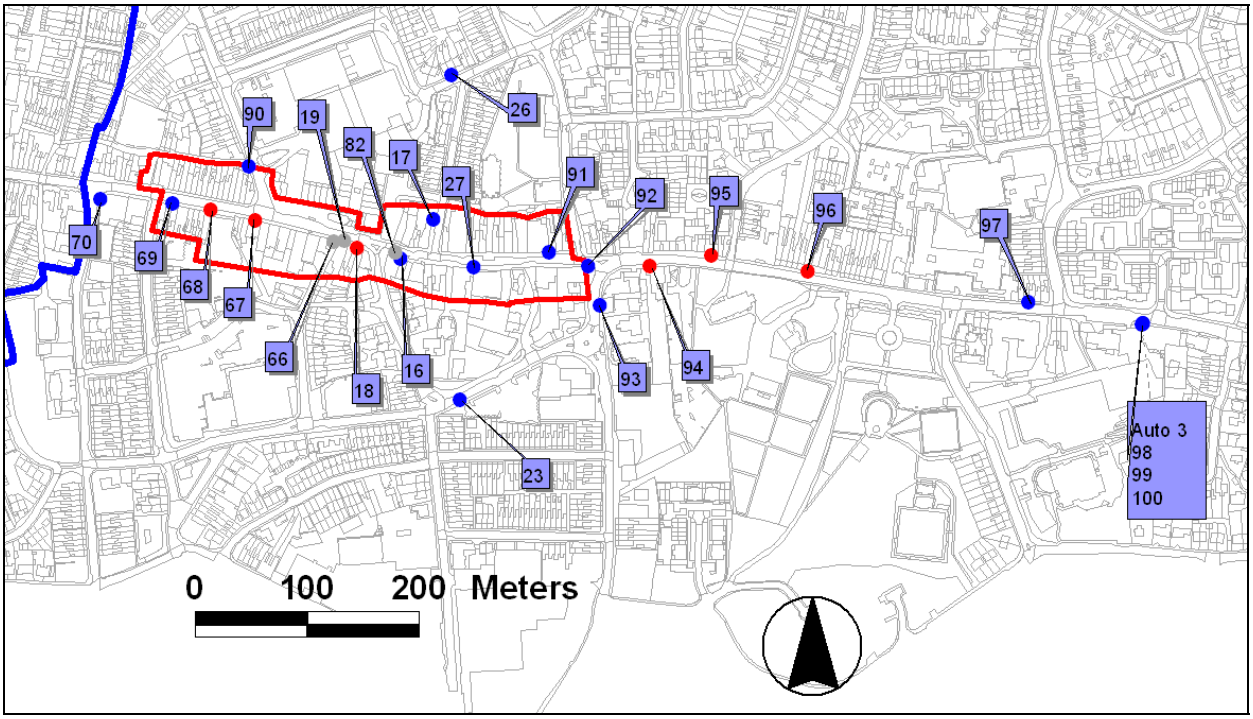

Figure 6: Monitoring Locations in Close Proximity to the Kingswood AQMA. (Monitoring Sites exceeding the Objective Shown in Red, Below the Objective Shown in Blue and no Longer Operational Shown in Grey). Blue Line denotes South Gloucestershire boundary. (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

Table 4: Diffusion Tube Data within the Kingswood Study Area

Site Name	Location	In AQMA ?	Data Capture for 2009 Calendar Year (%)	Data Capture for 2010 Calendar Year (%)	Annual Mean Concentrations (µg/m^3)		
					2008[a]	2009[b]	2010[c]
16	Kingswood - 78 Regent Street Barclays façade	Y	83%	100%	**40.8**	29.5	34.7
17	Kingswood - 79 Regent Street HSBC	Y	92%	92%	28.9	25.3	27.0
18	Kingswood - 70 Regent Street CM Lea facade	Y	83%	100%	**45.6**	38.3	**40.8**
19	Kingswood - 66 Regent Street Pedestrian Lights	Y	67%	n/a	**50.0**	**42.6**	n/a
23	Kingswood - Cecil Road	N	100%	92%	39.3	33.1	36.4
26	Kingswood - Gilbert Road	N	100%	100%	29.0	23.4	24.7
27	Kingswood - 90 Regent Street Nat West façade	Y	100%	100%	**41.9**	39.3	38.6
66	Kingswood Regent Street - Somerfield Arch façade	Y	67%	n/a	29.9	28.8[d]	n/a
67	Kingswood - 40 Regent Street Thomas Cook façade	Y	92%	100%	**45.8**	**41.9**	**42.2**
68	Kingswood - 26-32 Regent Street QS Store façade	Y	83%	100%	**48.3**	**41.9**	**45.0**
69	Kingswood - 12 Regent Street Cameras Plus façade	Y	83%	100%	**40.2**	37.3	39.6
70	Kingswood - Two Mile Hill Road Job Centre Plus façade	N	83%	100%	36.3	34.1	37.8
82	Kingswood - 78 Regent Street One way signpost	Y	67%	n/a	36.5	33.4[d]	n/a
90	Kingswood - Downend Road Junction with Boultons Road	Y	17%	92%	n/a	30.1[d]	35.0
91	Kingswood - 119 Regent Street Razzle Dazzle	Y	25%	100%	n/a	29.6[d]	36.7
92	Kingswood - Regent Street British Legion Club	Y	25%	67%	n/a	31.4[d]	37.3
93	Kingswood - Hanham Road Exchange Flats	N	25%	92%	n/a	29.5[d]	38.4

Site Name	Location	In AQMA ?	Data Capture for 2009 Calendar Year (%)	Data Capture for 2010 Calendar Year (%)	Annual Mean Concentrations (µg/m^3)		
					2008[a]	2009[b]	2010[c]
94	Kingswood - High Street Kings Arms	N	25%	83%	n/a	38.4 [d]	**44.5**
95	Kingswood - 45 High Street Adam Lee	N	25%	100%	n/a	30.2 [d]	**42.8**
96	Kingswood - 71 High Street outside Homeless Project	N	25%	100%	n/a	32.4[d]	**40.8**
97	Kingswood - 129 High Street	N	25%	92%	n/a	31.5[d]	39.0
98, 99, 100	Kingswood – High Street City of Bristol College Co-location	N	25%	92%	n/a	31.0 [d]	37.2
Real time	Kingswood – City of Bristol College, High Street	N	82%	69%	24.6	25.7	25.6[d]

[a] bias adjusted using a national factor of 0.87 (as reported in the USA (2009)

[b] bias adjusted using a national factor of 0.79 (as reported in Progress Report, 2011)

[c] bias adjusted using a national factor of 0.85 (as reported in Progress Report, 2011)

[d] Annualised (as reported in Progress Report, 2011)

4.12 The automatic monitoring site located at the same site as diffusion tube monitoring sites 98, 99 and 100 had a period mean of 23 (annualised to 25.6 µg/m^3).

4.13 There are six monitoring sites where concentrations above the objective were measured in 2010. Three of these sites (18, 67 and 68) are within the AQMA boundary, however; the other three (94, 95 and 96) are located on High Street (close to the junction with Hanham Road), outside of the AQMA boundary. A number of diffusion tube monitoring sites, both inside and outside of the AQMA boundary, approach the objective level, including diffusion tube monitoring site 97, located approximately 400 m from the AQMA boundary.

New Modelling

4.14 Annual mean concentrations of nitrogen dioxide from road sources in 2011 have been modelled within the Staple Hill and Kingswood area using ADMS Roads (version 3). Modelling of the Cribbs Causeway AQMA was not considered necessary, as, should measured concentrations remain below the objective in 2011, it is likely that the AQMA will be revoked. Further details of the dispersion modelling methodology and details of the input parameters are set out below and in Appendix 1 and Appendix 2.

Road Traffic Impacts

4.15 The contribution of emissions from road traffic to the annual mean concentrations of nitrogen dioxide within each study area has been modelled using ADMS Roads (version 3). The following input data were used:

- South Gloucestershire Council provided 12-hour flows, split into a number of vehicle classes. These were annualised appropriately using conversion factors calculated from published DfT statistics (DfT, 2011). There will be uncertainty associated with these traffic data, however, the conclusions of the assessment are unlikely to be particularly sensitive to this uncertainty.
- Specific diurnal flow profiles have been calculated from local traffic data provided by the Council;
- Detailed fleet composition data were provided, and therefore the emissions from each vehicle class were calculated using ADMS Roads (version 3) for each vehicle class individually. This enabled detailed source apportionment;
- Speeds are based on the speed limit, but also take into account the proximity to a junction and traffic speeds observed during the site visit. Queue lengths in the Staple Hill area where there are specific congestion issues have been provided by the Council;
- The locations of roads and buildings (including road width) were obtained using Ordnance Survey mapping information;
- Meteorological data from Filton have been used. Complete wind and temperature data were available, however, cloud cover was missing and was provided by data from Lulsgate and then Lyneham.

4.16 The model has been verified by comparing the predicted results with local measurements (within each study area), and the model output adjusted accordingly. Details of model verification are presented in Appendix 1.

Modelling Uncertainty

4.17 Uncertainty is inherent in all measured and modelled data. All values presented in this report are the best possible estimates, but uncertainties in the results might cause over- or under-predictions. All of the measured concentrations presented have an intrinsic margin of error. The Local Air Quality Management Support (Defra 2011a) suggests that this is of the order of plus or minus 20% for diffusion tube data and plus or minus 10% for automatic measurements. The model results rely on traffic data provided by South Gloucestershire Council and any uncertainties inherent in these data will carry into this assessment. There will be additional uncertainties introduced because the modelling has simplified real-world processes into a series of algorithms. For example, it has been assumed that wind conditions measured at Filton during 2010 will have occurred throughout the study areas during 2010; and it has been assumed that the dispersion of emitted pollutants will

conform to a Gaussian distribution over flat terrain. An important step in the assessment is verifying the dispersion model against the measured data. By comparing the model results with measurements, and correcting for the under-prediction of the model, the uncertainties can be reduced.

4.18 Even when applying a verification factor, it is not feasible to accurately predict concentrations. In both the Staple Hill and the Kingswood study area, a number of monitoring sites are used to verify the modelled results. When looking at the relationship between modelled and measured results (see figures of graphs in Appendix 1 and Appendix 2), the relationship between the data points is not precisely linear, and a best fit line is used to determine the verification factor. Applying this verification factor will broadly improve the accuracy of the modelled results, however, it does not account for the variance between the verification factors calculated at individual sites. Adjusted modelled concentrations at each diffusion tube site will be slightly over predicted or under predicted, and similarly, predicted concentrations at all receptor locations will be slightly over predicted or under predicted. Modelled results should be looked at in context together with nearby measured concentrations.

4.19 The limitations to the assessment should be borne in mind when considering the results set out in the following sections. While the model should give an overall accurate picture, i.e. one without bias, there will be uncertainties for individual receptors. The results are 'best estimates' and have been treated as such in the discussion.

Concentrations at Specific Receptors

4.20 Locations representing worst-case residential exposure along the roads within each study area were selected for modelling. Receptors on the building facades of each property along each of the AQMAs were selected for each of the study areas. Although not all properties have relevant exposure on the ground floor, concentrations are predicted at ground floor and at first floor heights, 1.5 m and 4.5 m respectively.

Staple Hill

4.21 Receptor locations are shown in Figure 7. Annual mean nitrogen dioxide concentrations predicted for each of these receptors are presented in Table 5. The highest predicted concentration in 2010 is 67.6 µg/m^3, at Receptor 3 on Soundwell Road. This exceeds 60 µg/m^3 and thus the 1-hour nitrogen dioxide objective may be exceeded at this location.

4.22 The northern part of Soundwell Road has been modelled as a canyon. Predicted concentrations at the diffusion tube monitoring site 62 are over predicted when the verification factor is applied (see discussion on verification factor, paragraph 4.18), and thus concentrations at Receptor 3, which is in close proximity, may also be slightly over predicted.

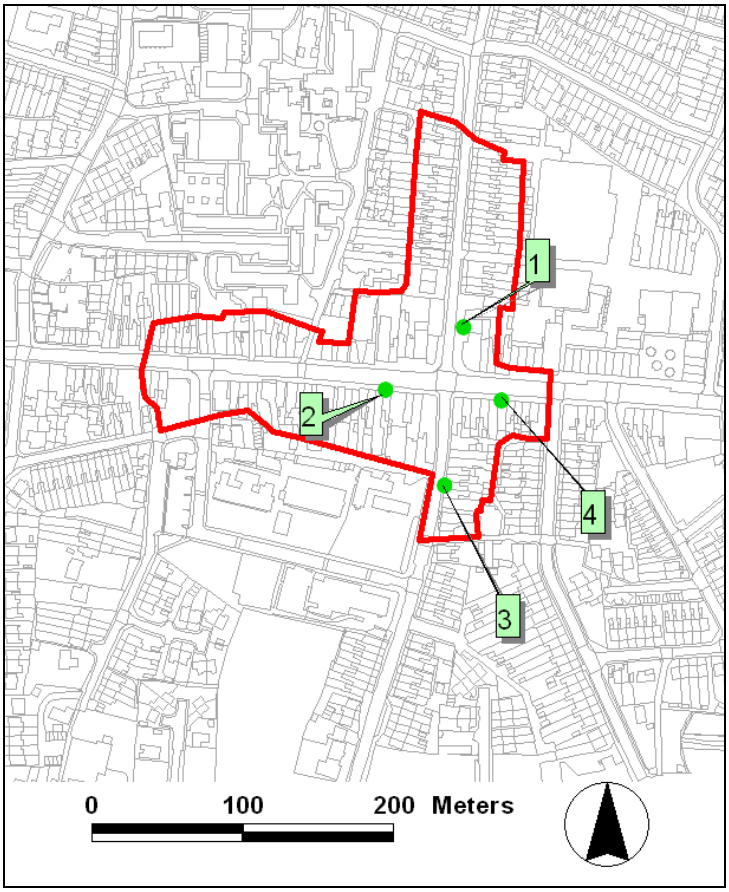

Figure 7: Specific Receptor Locations in the Staple Hill Study Area. AQMA Boundary shown in red. (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

Table 5: Predicted Annual Mean Concentrations of Nitrogen Dioxide (µg/m^3) in 2011 within the Staple Hill Study Area

Receptor	Annual Mean Concentration (µg/m^3)	
	Ground Floor	First Floor
1	**50.8**	39.2
2	**51.3**	38.6
3	**67.6**	**41.8**
4	**56.4**	**42.3**

[a] Values in bold are predicted exceedences of the objective.

4.23 Concentrations have also been predicted at each property façade to enable the extent of the exceedence area to be to be determined. Concentrations have been predicted on both the ground floor and the first floor level (Figure 8a and Figure 8b).

4.24 These confirm that there are relevant locations outside of the current AQMA at which concentrations are likely to have exceeded the annual mean nitrogen dioxide objective in 2011.

4.25 The AQMA boundary should therefore be amended to include, as a minimum, those relevant locations where exceedences have been predicted alongside Broad Street, High Street, Soundwell Road, Victoria Street and into North Street. Attention should to paid to whether a property has relevant exposure on the ground floor or first floor. Due to uncertainties associated with the modelling, it may be appropriate to include all locations where concentrations exceed 36 μg/m^3. Outside the study area, there are unlikely to be any exceedences as the properties are located further away from the road and traffic is more free-flowing.

4.26 Concentrations were predicted to exceed 60 μg/m^3 at a number of ground-floor locations within the canyon area on Soundwell Road. This is likely to be due to over predictions of the model, as discussed in paragraph 4.21. There is no relevant exposure on the ground floor in this area. As measured concentrations do not exceed 60 μg/m^3 at any relevant location, and in particular at the nearby diffusion tube monitoring site 62, (where a concentration of 47.4 μg/m^{3}was measured in 2010), it is concluded that exceedences of the 1-hour objective are unlikely.

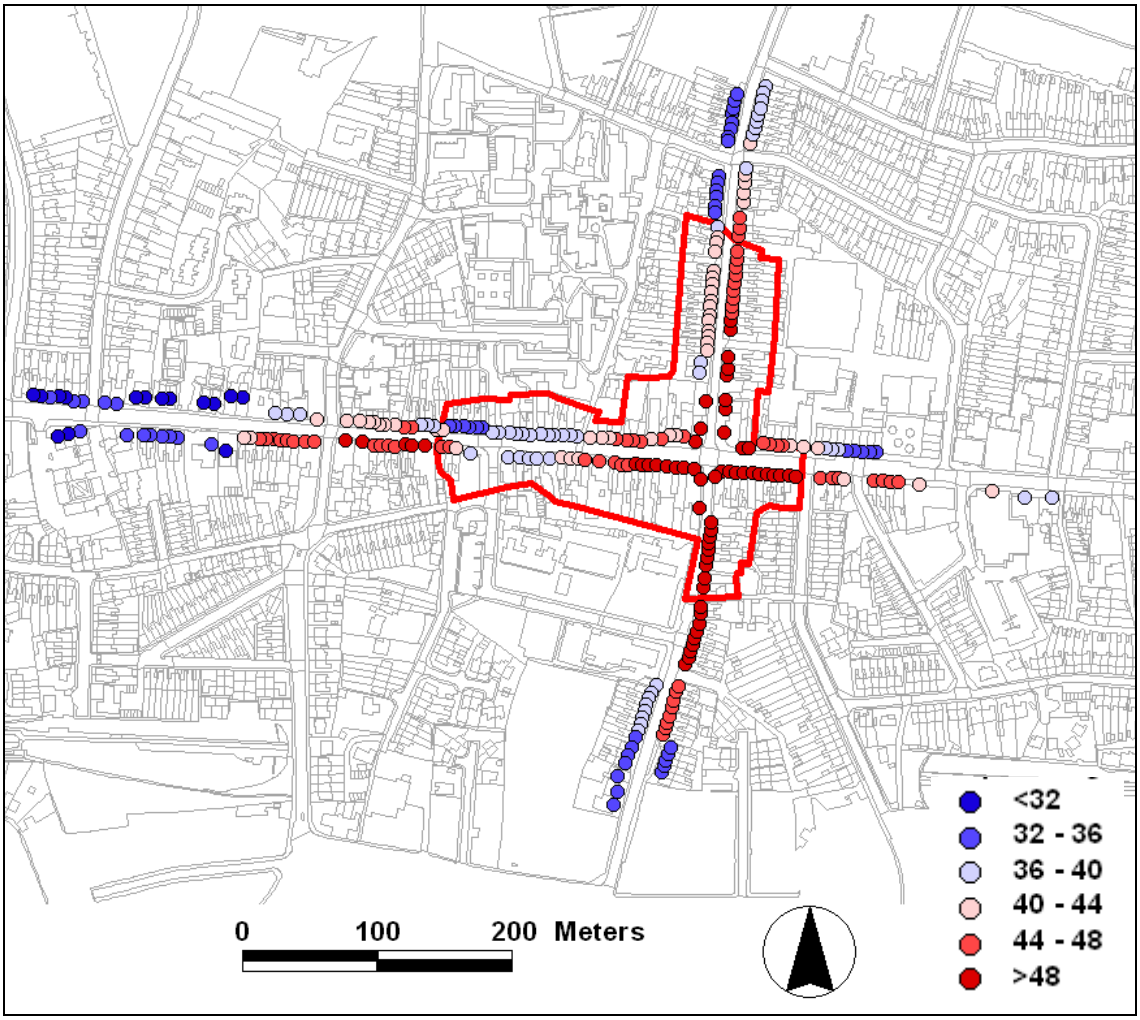

Figure 8a: Predicted Concentrations of Nitrogen Dioxide (μg/m^3) at Ground-Floor Level in the Staple Hill Study Area (2011). AQMA boundary shown in red. (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

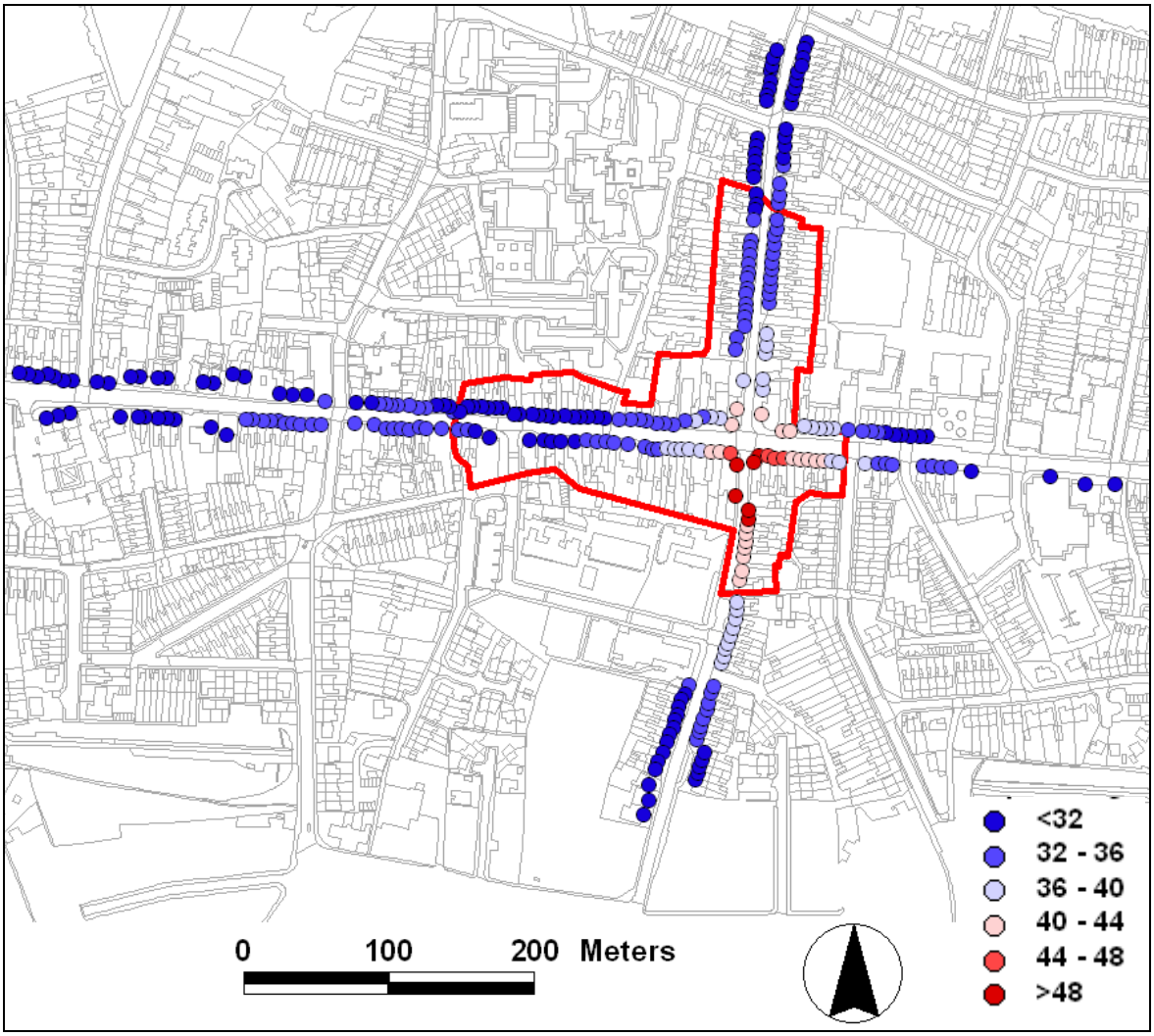

Figure 8b: Predicted Concentrations of Nitrogen Dioxide (µg/m^3) at First-Floor Level in the Staple Hill Study Area (2011). AQMA boundary shown in red. (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

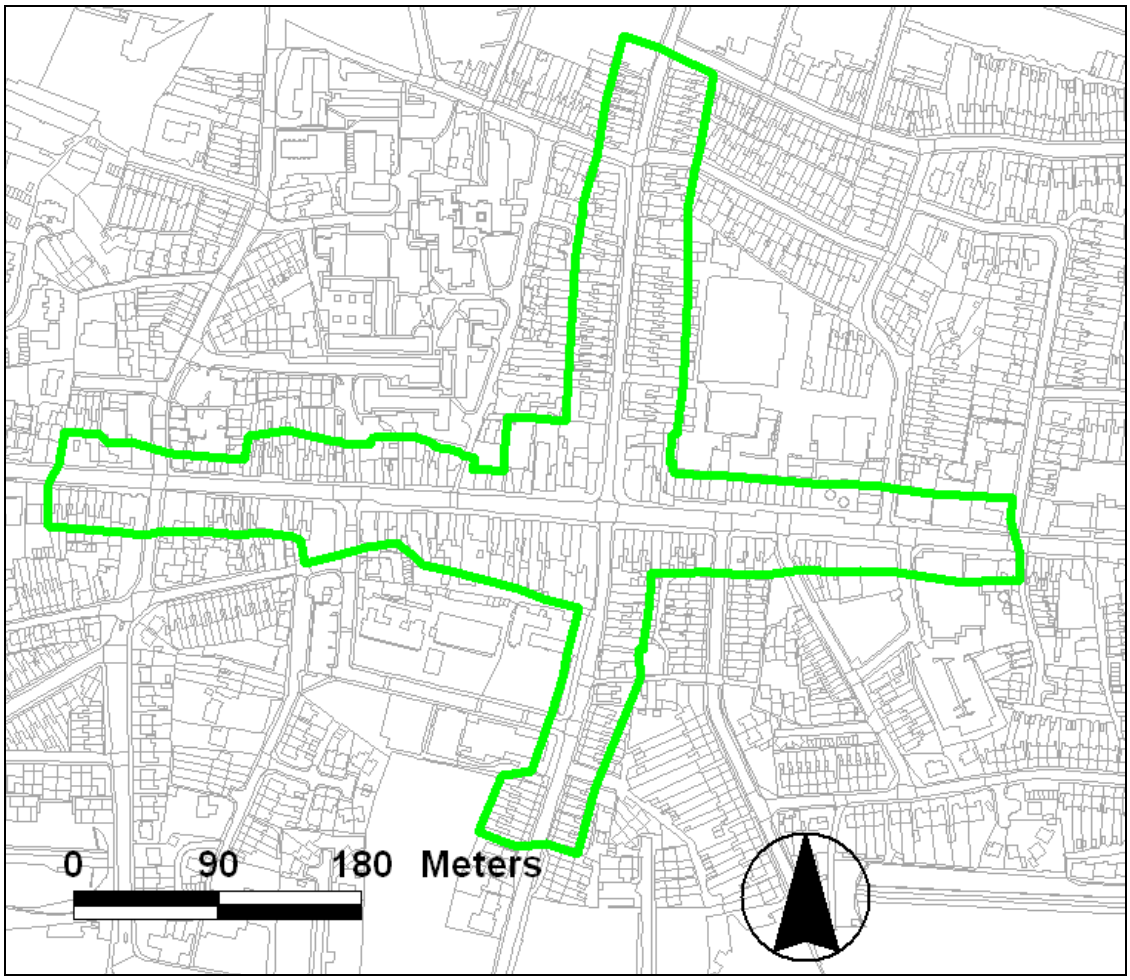

Figure 8c: Proposed AQMA Boundary for Staple Hill (Proposed Boundary shown in Green) (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

Kingswood

4.27 Receptor locations are shown in Figure 9. Annual mean nitrogen dioxide concentrations predicted for each of these receptors are presented in Table 6. The highest predicted concentration in 2011 is 70.3 µg/m^3 at Receptor 7. However, there is no relevant exposure at ground-floor level and concentrations decline rapidly by first-floor level. Concentrations are also predicted to exceed the annual mean objective at Receptors 2, 3, 4, 6 and Receptor 8. There are no relevant locations where annual mean concentrations are predicted to be greater than 60 µg/m^3 and thus it is unlikely that the 1-hour objective will be exceeded.

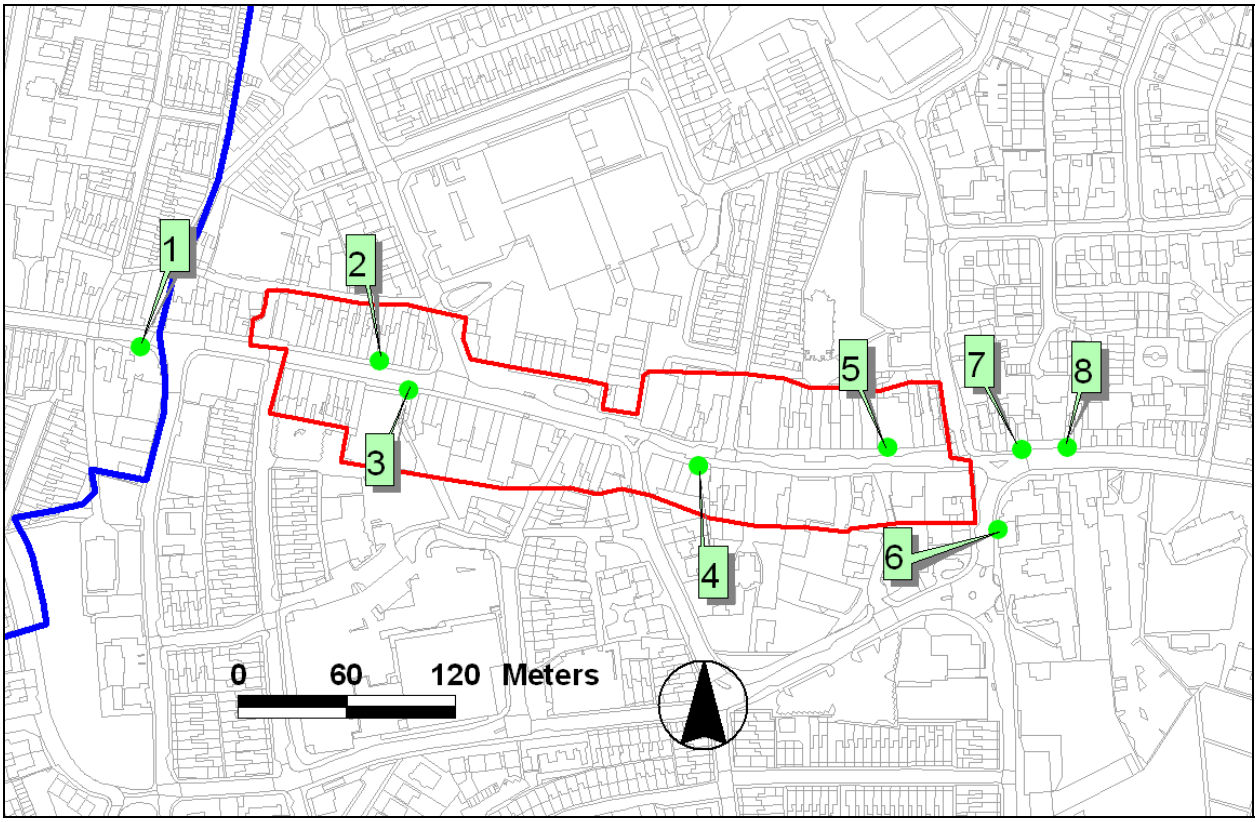

Figure 9: Specific Receptor Locations in the Kingswood Study Area. AQMA boundary shown in red. Blue Line denotes South Gloucestershire boundary. (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

Table 6: Predicted Annual Mean Concentrations of Nitrogen Dioxide (µg/m^3) in 2011 within the Kingswood Study Area

Receptor	Annual Mean Concentration (µg/m^3)	
	Ground Floor	First Floor
1	33.5	27.6
2	**49.0**	31.2
3	**52.2**	32.4
4	**40.8**	35.1
5	37.5	31.6
6	**67.0**	**42.8**
7	**70.3**	**40.1**
8	**56.6**	**50.5**

[a] Values in bold are predicted exceedences of the objective.

4.28 Concentrations have also been predicted at each property façade to enable the extent of the exceedence area to be to be determined. Concentrations have been predicted on both the ground-floor and the first-floor level (Figure 10a and Figure 10b).

4.29 It should be noted that many receptor locations only have relevant exposure at first floor level. Nonetheless, there are relevant locations outside of the current AQMA, at which concentrations are likely to have exceeded the annual mean nitrogen dioxide objective in 2011.

4.30 The AQMA boundary should therefore be amended to include, as a minimum, those relevant locations where exceedences have been predicted, in particular to the east of the AQMA boundary along High street, and to the west beyond Regent Street along Two Mile Hill Road. The Kingswood AQMA lies close to South Gloucestershire Council's boundary with Bristol City Council. For completeness, receptors have been included in the area extending beyond the unitary boundary further along Two Mile Hill Road, however any receptors located beyond the South Gloucestershire boundary are not relevant. This is also reflected in 2010 monitored data for this area, where monitoring sites 94, 95 and 96 measured concentrations of 44.5 µg/m^3, 42.8 µg/m^3 and 40.8 µg/m^3 respectively, and monitoring site 70 measured a concentration of 37.8 µg/m^3, approaching the objective. Due to uncertainties associated with the modelling, it may be appropriate to include all locations where concentrations exceed 36 µg/m^3. Outside the study area there are unlikely to be any exceedences as the properties are located further away from the road and traffic is more free-flowing.

4.31 No exceedences of 60 µg/m^3 as an annual mean nitrogen dioxide concentration have been identified at locations of relevant exposure, and thus exceedences of the 1-hour objective are unlikely.

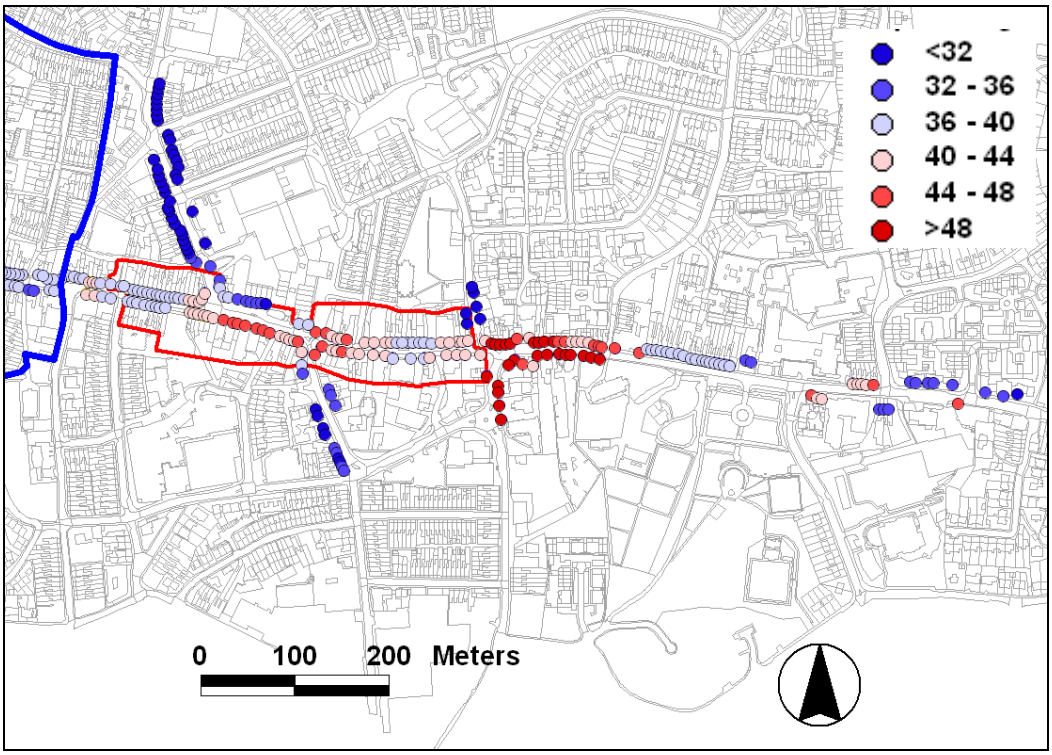

Figure 10a: Predicted Concentrations of Nitrogen Dioxide (µg/m^3) at Ground-Floor Level in the Kingswood Study Area (2011). AQMA boundary shown in red. South Gloucestershire Council Boundary Shown in Blue. (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

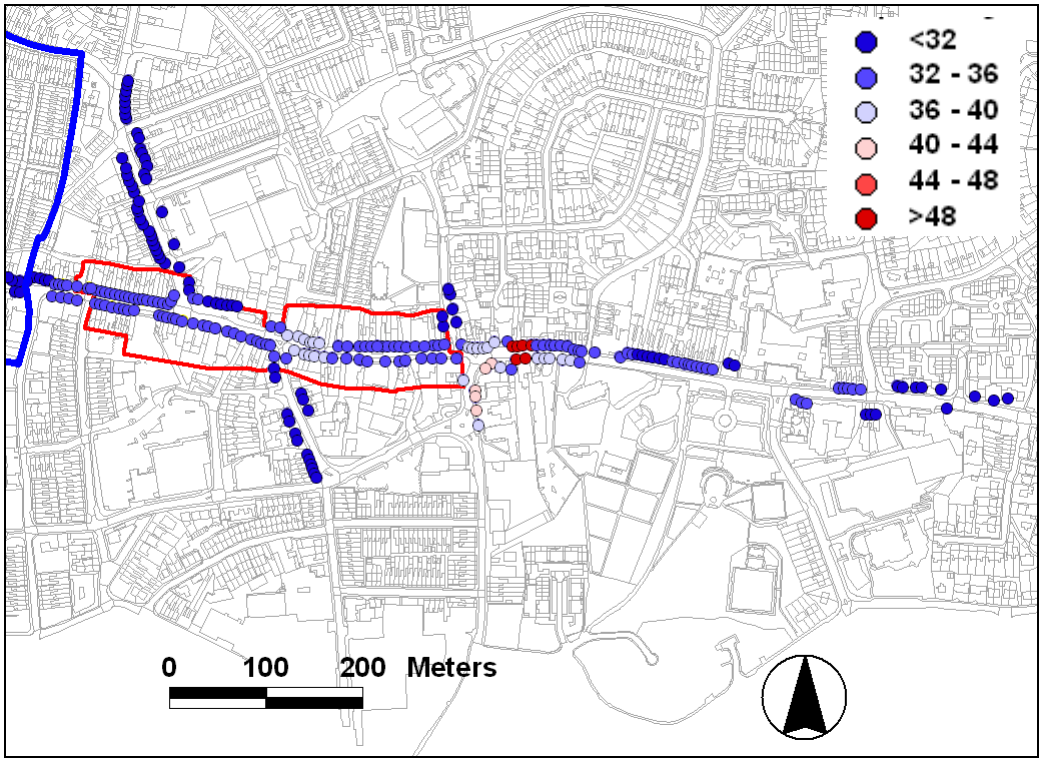

Figure 10b: Predicted Concentrations of Nitrogen Dioxide (µg/m^3) at First-Floor Level in the Kingswood Study Area (2011). AQMA boundary shown in red. South Gloucestershire Council Boundary Shown in Blue. (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

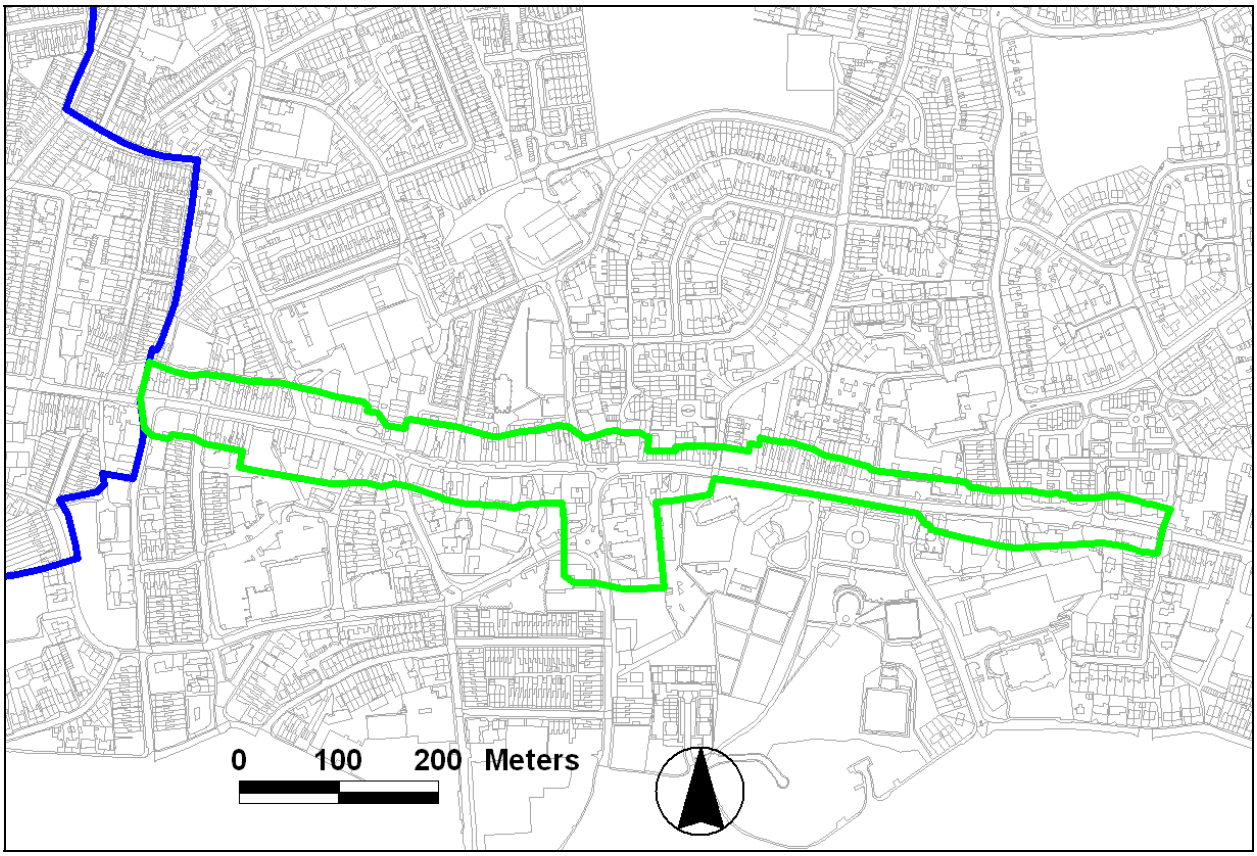

Figure 10c: Proposed AQMA Boundary for Kingswood (Proposed Boundary shown in Green). South Gloucestershire Council Boundary Shown in Blue. (© Crown copyright and database rights [2011] Ordnance Survey [100023410])

5 Source Apportionment

5.1 In order to develop an appropriate action plan it is necessary to identify the sources contributing to the objective exceedences within the Staple Hill and Kingswood AQMAs. The data presented here can be used to inform future traffic management decisions, and have been calculated in line with guidance provided in LAQM.TG(09) (Defra, 2009).

5.2 Results predicted at the ground floor have been presented, however, it should be noted that not all receptors have relevant exposure at the ground floor. Results will nonetheless provide a reasonable representation of the relative contribution of each source.

Staple Hill

5.3 Table 7 and Figure 11 set out the relative contributions of traffic emissions. The following categories have been included in the source apportionment:

- Ambient Background (Bkgd);
- Motorcycle (MCL);
- Cars;
- Light Goods Vehicles (LGV);
- Bus;
- Heavy Goods Vehicles (HGV);

5.4 Four receptor locations identified previously as exceeding the objective have been used to provide an overview of source contributions. Table 7 and Figure 12 show, the most significant component at all receptors is the ambient background concentration. The next most significant portion at receptors 1, 2 and 3 is from cars, followed by buses. At receptor 4, cars and buses contribute an equal portion. In most cases, emissions from cars and buses together are the main local contributors to the overall concentration.

Table 7: Predicted Annual Mean (2011) Nitrogen Dioxide Concentrations and the Contribution of Each Source Type to the Total

Receptor	Annual Mean Concentration (µg/m^3)						
	Bkgd	Car	MCL	LGV	Bus	HGV	Total
1	18.8	12.2	0.1	6.0	7.3	6.4	50.8
2	18.8	12.2	0.1	5.4	9.7	5.1	51.3
3	18.8	16.6	0.2	8.1	15.0	8.8	67.6
4	18.8	12.8	0.1	5.6	13.2	5.8	56.4
	% Contribution to Total						
	Bkgd	Car	MCL	LGV	Bus	HGV	Total
1	37.1	24.1	0.2	11.7	14.4	12.5	100
2	36.7	23.7	0.2	10.5	19.0	10.0	100
3	27.9	24.6	0.2	12.0	22.2	13.1	100
4	33.4	22.8	0.2	9.9	23.5	10.3	100

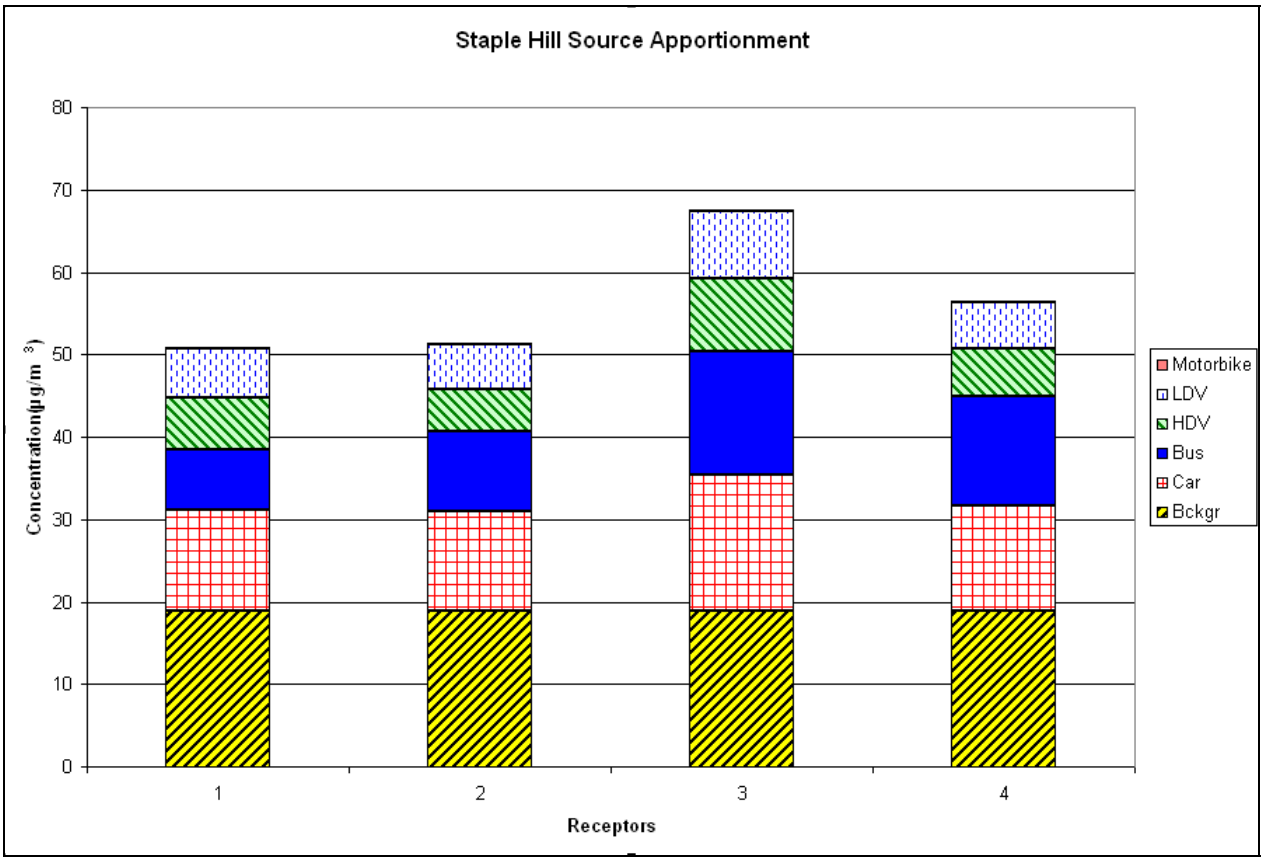

Figure 11: Relative Contribution of Each Source Type to the Total Predicted Annual Mean Nitrogen Dioxide Concentration (µg/m^3) at Receptor Locations

Kingswood

5.5 Table 8 and Figure 12 set out the relative contributions of traffic emissions. The following categories have been included in the source apportionment:

- Ambient Background (Bkgd);
- Motorcycle (MCL);
- Cars;
- Light Goods Vehicles (LGV);
- Bus;
- Heavy Goods Vehicles (HGV);

5.6 Six receptor locations identified previously as exceeding the objective have been used to provide an overview of source contributions. Table 8 and Figure 13 show, the most significant component at all receptors is the ambient background concentration. Buses contribute the next most significant component. Emissions from all road sources except buses are significantly lower at receptors 2, 3 and 4 than those predicted at receptors 6, 7 and 8. This is predominantly due to one way traffic flows, on Regent Street. Receptors 6, 7 and 8 are affected by two-way traffic, whereas receptors 2, 3 and 4 only experiences general traffic eastbound, with buses, taxis, motorcycles and bicycles in the westbound direction.

Table 8: Predicted Annual Mean (2011) Nitrogen Dioxide Concentrations and the Contribution of Each Source Type to the Total

Receptor	Annual Mean Concentration (µg/m^3)						
	Bkgd	**Car**	**MCL**	**LGV**	**Bus**	**HGV**	**Total**
2	17.7	7.7	0.1	3.4	14.5	5.6	**49.0**
3	17.7	8.5	0.1	3.8	15.8	6.3	**52.2**
4	18.2	5.5	0.1	2.4	10.6	4.0	**40.8**
6	17.7	15.5	0.2	7.7	16.1	9.9	**67.0**
7	17.7	16.2	0.2	8.2	17.4	10.6	**70.3**
8	16.3	12.6	0.1	6.4	12.8	8.3	**56.6**
	% Contribution to Total						
	Bkgd	**Car**	**MCL**	**LGV**	**Bus**	**HGV**	**Total**
2	36.1	15.7	0.2	7.0	29.5	11.5	100
3	33.9	16.3	0.2	7.3	30.2	12.1	100
4	44.6	13.5	0.2	5.9	25.9	9.9	100
6	26.4	23.1	0.2	11.6	24.0	14.8	100
7	25.2	23.1	0.2	11.6	24.8	15.1	100
8	28.9	22.3	0.2	11.2	22.7	14.7	100

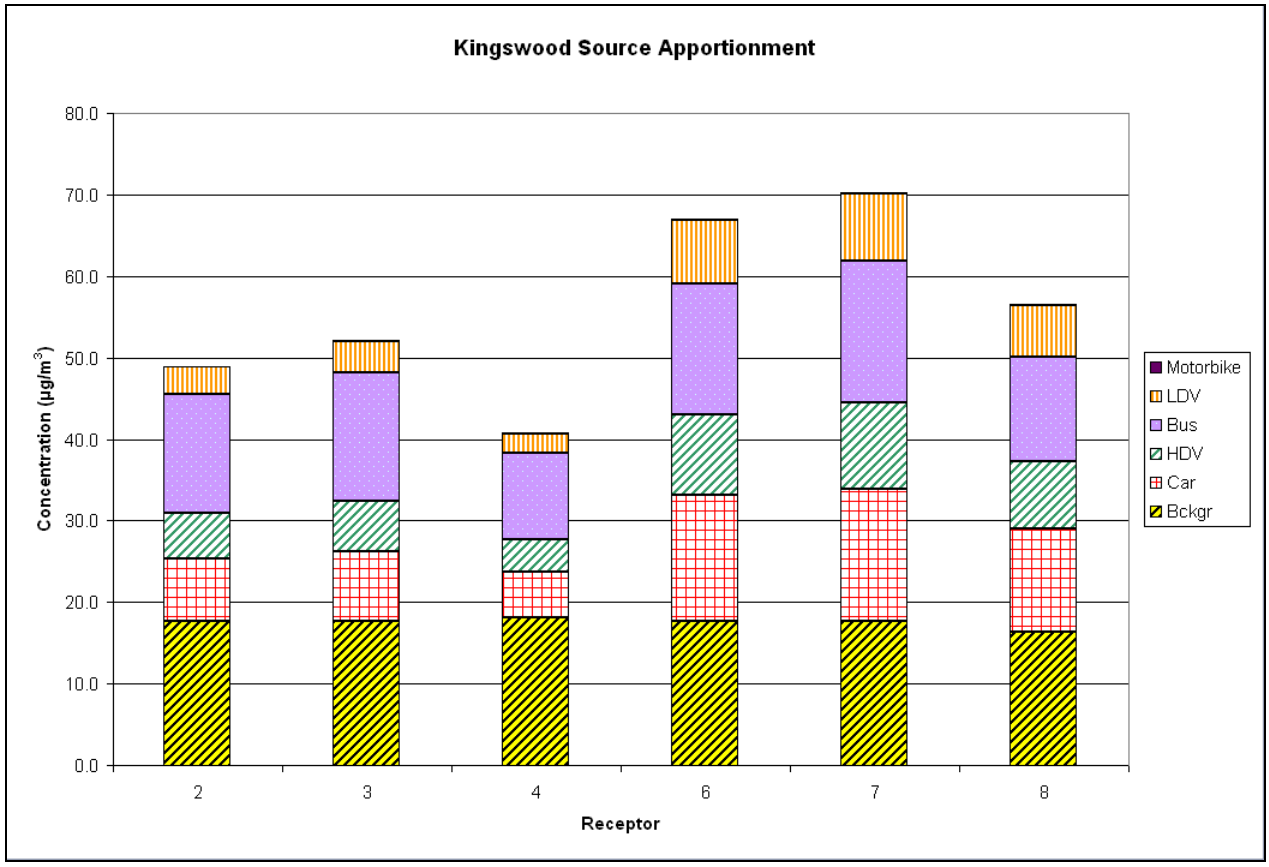

Figure 12: Relative Contribution of Each Source Type to the Total Predicted Annual Mean Nitrogen Dioxide Concentration (µg/m^3) at Receptor Locations

6 Air Quality Improvements Required

6.1 The degree of improvement needed in order for the annual mean objective for nitrogen dioxide to be achieved is defined by the difference between the highest measured or predicted concentration and the objective level (40 μg/m^3).

Staple Hill

6.2 The highest nitrogen dioxide concentration was modelled at Receptor 3 (67.6μg/m^3), requiring a reduction of 27.6μg/m^3 in order for the objective to be achieved. It should, however, be noted that at this location the model appears to be over-predicting concentrations when compared with local monitored results. Reductions are based on concentrations at ground floor level, however this might not be the case at all receptors; in particular, there is no ground floor exposure at receptor 3. This reduction is therefore considered to be very much worst case.

6.3 In terms of describing the reduction in emissions required, it is more useful to consider nitrogen oxides (NOx). The required reduction in local nitrogen oxides emissions has been calculated in line with guidance presented in LAQM.TG(09) (Defra, 2009). Table 9 sets out the required reduction in local emissions of NOx that would be required at each of the Receptors where an exceedence was predicted in 2011, in order for the annual mean objective to have been achieved. At Receptor 3, local emissions would need to have been 66.3% lower in order to meet the objective. It should be noted that concentrations are considered to be over predicted at this location, as discussed earlier in the report. In particular, the reductions are based on ground floor concentrations.

Table 9: Improvement in Annual Mean Nitrogen Dioxide Concentrations and in Emissions of Oxides of Nitrogen at Receptors within Staple Hill in 2011.

Receptor	Required reduction in annual mean nitrogen dioxide concentration (μg/m^3)	Required reduction in emissions of oxides of nitrogen from local roads (%)
1	10.8	40.1
2	11.3	41.2
3	27.6	66.3
4	16.4	51.6

Kingswood

6.4 The highest nitrogen dioxide concentration was modelled at Receptor 7 (70.3μg/m^3), requiring a reduction of 30.3μg/m^3 in order for the objective to be achieved. As for Staple Hill, this modelled concentration represents a worst case assumption, at ground floor level, right on the junction with slow moving traffic for most of the day. This assumes there is relevant exposure at the ground

floor level at this location, which might not be the case. As can be seen in Table 6, by first floor level, concentrations are only marginally exceeding the objective.

6.5 In terms of describing the reduction in emissions required, it is more useful to consider nitrogen oxides (NOx). The required reduction in local nitrogen oxides emissions has been calculated in line with guidance presented in LAQM.TG(09) (Defra, 2009). Table 10 sets out the required reduction in local emissions of NOx that would be required at each of the Receptors where an exceedence was predicted in 2011, in order for the annual mean objective to have been achieved. At Receptor 7, local emissions would need to have been 67.9% lower in order to meet the objective. It should be noted that there is no relevant exposure on the ground floor at this location.

Table 10: Improvement in Annual Mean Nitrogen Dioxide Concentrations and in Emissions of Oxides of Nitrogen at Receptors within the Kingswood Study Area in 2011.

Receptor	Required reduction in annual mean nitrogen dioxide concentration (µg/m^3)	Required reduction in emissions of oxides of nitrogen from local roads (%)
2	9.0	34.4
3	12.2	42.2
4	0.8	3.9
6	27.0	64.8
7	30.3	67.9
8	16.6	49.4

7 Summary and Conclusions

7.1 Nitrogen dioxide concentrations within and around the Cribbs Causeway, Staple Hill and Kingswood AQMA have been assessed through a combination of diffusion tube monitoring and detailed dispersion modelling. Monitoring results indicate that the annual mean nitrogen dioxide objective was exceeded in 2010 within the Staple Hill and Kingswood AQMAs, and also at locations of relevant exposure outside of the AQMAs. Concentrations were below the objectives in the Cribbs Causeway AQMA.

7.2 It is therefore recommended that:

- Monitoring is continued at the Cribbs Causeway AQMA, with a view to revoking the AQMA in 2012. The Action Plan for Cribbs Causeway will therefore be put on hold and resources focussed on Kingswood and Staple Hill;
- The Staple Hill AQMA should be extended to include locations where exceedences have been predicted alongside Broad Street, High Street, Soundwell Road, Victoria Street and into North Street, and monitoring should continue; and
- The Kingswood AQMA should be extended to include, as a minimum, the area to the west into Two Mile Hill Road and to the East along High Street, and monitoring should continue.

7.3 Source apportionment of the local traffic emissions has been undertaken. This shows ambient background concentrations contribute the largest proportion to the overall concentration, followed by, in the majority of cases, emissions from cars and buses on the local roads. In a number of cases, emissions from HDVs also contribute a significant proportion to the overall concentration. This highlights the importance of keeping all sources under consideration when contemplating measures to include within the action plan.

8 References

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9 Glossary

Standards	A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal. Seven are included in Regulations with respect to Local Air Quality Management.
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.
AQMA	Air Quality Management Area
ADMS Roads	Atmospheric Dispersion Modelling System for Roads.
NOx	Nitrogen oxides
NO_2	Nitrogen dioxide
$\mu g/m^3$	Microgrammes per cubic metre.
Roadside	A site sampling between 1 m of the kerbside of a busy road and the back of the pavement. Typically this will be within 5 m of the road, but could be up to 15 m (Defra, 2009).
HGV	Heavy Goods Vehicle
LGV	Light Goods Vehicle
MCL	Motorcycles

A1 Appendix 1: Dispersion Modelling Methodology Staple Hill

A1.1 Annual mean concentrations of nitrogen dioxide during 2011 have been modelled using the Atmospheric Dispersion Modelling System for roads (ADMS Roads). ADMS Roads is one of the dispersion models accepted for modelling within LAQM.TG(09) (Defra, 2009). Road sources were modelled using ADMS Roads (version 3).

Traffic Data:

A1.2 Traffic data were provided by South Gloucestershire Council and annualised as described in the main report. A summary of the Annual Average Daily Traffic (AADT) flows entered into the model is provided in Table A1.1.

Table A1.1: Summary of AADT Flows in Staple Hill (2011)

Location	Cars	MCL	LGV	BUS	HGV	Total
Victoria Street	7383	118	1388	101	175	9164
Broad St	8121	109	1259	260	138	9886
Soundwell Road	7653	122	1403	184	179	9541
High St	7449	74	1189	162	125	8999

Background Concentrations:

A1.3 Background concentrations of nitrogen dioxide have been taken from the national maps of background concentrations published by Defra (Defra, 2011b). The background concentrations used in the modelling are presented in Table A1.2.

Table A1.2: Background Concentrations in the Staple Hill Study Area (µg/m^3)[a]

	NO_2
2010	17.6 – 19.4
2011	16.9 – 18.7

[a] The area lies within three grid squares, therefore a range is presented

Model Verification:

A1.4 Most nitrogen dioxide (NO_2) is produced in the atmosphere by reaction of nitric oxide (NO) with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emissions of nitrogen oxides (NOx = NO + NO_2).The model has been run to predict the annual mean NOx concentrations during 2010 at the diffusion tube monitoring sites within the area. Concentrations have been modelled at the appropriate height of the monitors.

A1.5 The model output of road-NOx (i.e. the component of total NOx coming from road traffic) has been compared with the 'measured' road-NOx. Measured road-NOx was calculated from the measured NO_2 concentrations and the predicted background NO_2 concentration using the NOx from NO_2 calculator available on the Defra LAQM Support website (Defra, 2011a).

A1.6 A primary adjustment factor was determined as the slope of the best-fit line between the 'measured' road contribution and the model derived road contribution, forced through zero (Figure A1.1).This factor was then applied to the modelled road-NOx concentration for each receptor to provide adjusted modelled road-NOx concentrations. The total nitrogen dioxide concentrations were then determined by combining the adjusted modelled road-NOx concentrations with the predicted background NO_2 concentration within the NOx from NO_2 calculator available on the Defra LAQM Support website (Defra, 2011a).A secondary adjustment factor was finally calculated as the slope of the best-fit line applied to the adjusted data and forced through zero (Figure A1.2).

A1.7 The following primary and secondary adjustment factors have been applied to all modelled nitrogen dioxide data:

- Primary adjustment factor : 9.986
- Secondary adjustment factor: 1.009

A1.8 The results imply that the model is under-predicting the road-NOx contribution. This is a common experience with this and most other models. The final NO_2 adjustment is minor.

A1.9 Figure A1.3 compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NO_2, and shows a 1:1 relationship.

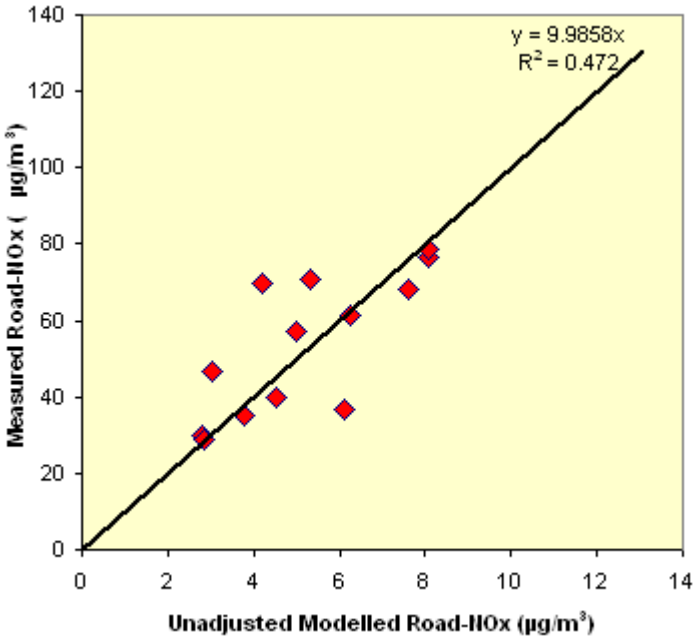

Figure A1.1: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations

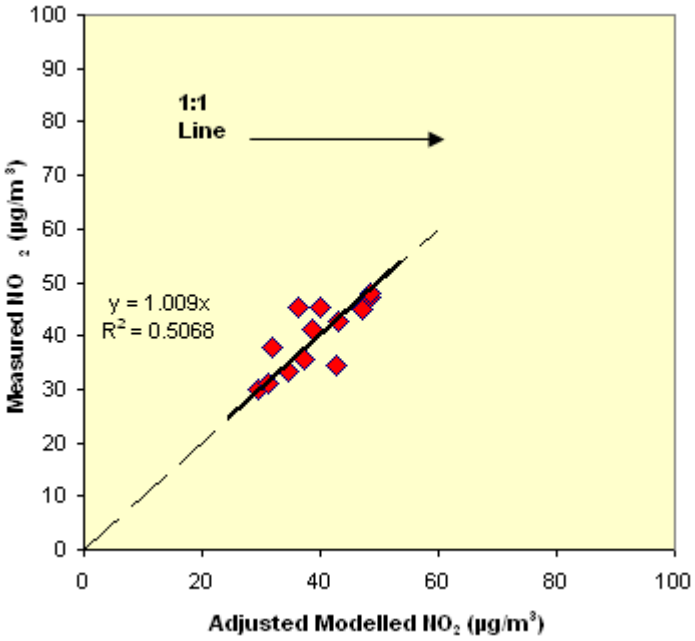

Figure A1.2: Comparison of Measured Total NO_2 to Primary Adjusted Modelled Total NO_2 Concentrations

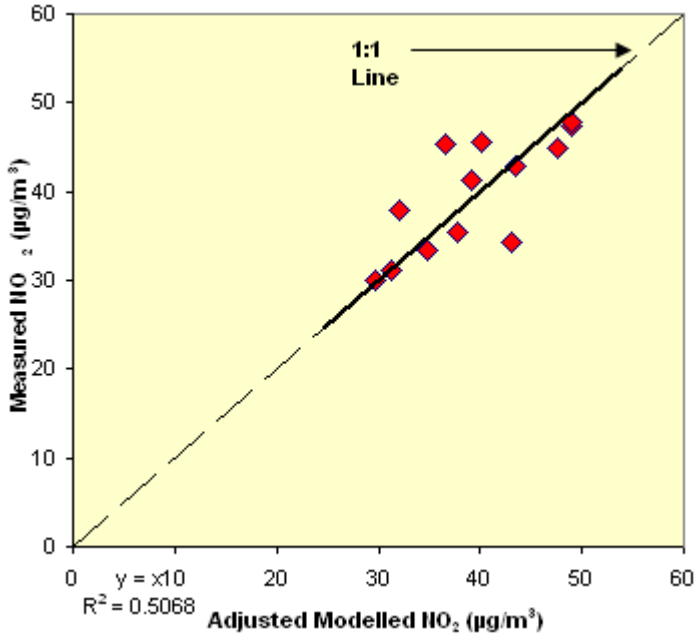

Figure A1.3: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations

A2 Appendix 2: Dispersion Modelling Methodology Kingswood

A2.1 Annual mean concentrations of nitrogen dioxide during 2011 have been modelled using the Atmospheric Dispersion Modelling System for roads (ADMS Roads). ADMS Roads is one of the dispersion models accepted for modelling within LAQM.TG(09) (Defra, 2009). Road sources were modelled using ADMS Roads (version 3).

Traffic Data:

A2.2 Traffic data were provided by South Gloucestershire Council. A summary of the Annual Average Daily Traffic (AADT) flows entered into the model is provided in Table A1.1. Sections of Regent Street, High Street and Hanham Road have been included in the model as a 'canyon'.

Table A1.1: Summary of AADT Flows (2011)

Location	Cars	LGV	MCL	BUS	HGV	Total
A420 Regent St West of junction with Downend Road	6,074	1,039	199	417	137	7,865
A4017 Downend Rd	4,813	806	141	79	83	5,921
A420 Regent St East of Junction with Downend Road	6,122	1,156	213	479	131	8,101
A420 Regent St East of junction with Moravian Road	6,074	1,039	199	417	137	7,865
Moravian Road	4,813	806	141	79	83	5,921
A420 Regent St West of junction with Moravian Road	6,122	1,156	213	479	131	8,101
Park Road	622	80	7	5	11	725
A420 High Street	11,272	2,133	317	320	199	14,241
B4046 Hanham Road	11,008	2,030	300	321	181	13,840
A420 Regent Street West of junction with Hanham Road	6,245	1,175	177	271	153	8,022
High Street	10,209	1,961	319	152	113	12,753

Background Concentrations:

A2.3 Background concentrations of nitrogen dioxide have been taken from the national maps of background concentrations published by Defra (Defra, 2011b). The background concentrations used in the modelling are presented in Table A2.2.

Table A2.2: Background Concentrations Kingswood (µg/m^3)[a]

	NO_2
2010	16.5 – 18.3
2011	15.9 – 17.6

[a] The area lies within three grid squares

Model Verification:

A2.4 Most nitrogen dioxide (NO_2) is produced in the atmosphere by reaction of nitric oxide (NO) with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emissions of nitrogen oxides (NOx = NO + NO_2). The model has been run to predict the annual mean NOx concentrations during 2010 at the diffusion tube monitoring sites within the area. Concentrations have been modelled at the appropriate height of the monitors.

A2.5 The model output of road-NOx (i.e. the component of total NOx coming from road traffic) has been compared with the 'measured' road-NOx. Measured road-NOx was calculated from the measured NO_2 concentrations and the predicted background NO_2 concentration using the NOx from NO_2 calculator available on the Defra LAQM Support website (Defra, 2011a).

A2.6 The study area includes roads modelled as street canyons and roads not modelled as street canyons. Due to differences in the way the model operates in each of these scenarios, it is considered appropriate to calculate separate verification factors for each. Two separate verification factors were calculated based on the monitoring sites located inside and outside the canyons. Results are presented below.

A2.7 Due to low data capture at the Kingswood automatic monitoring site during 2010, (68.9%), the triplicate diffusion tube data have been used for model verification, which also represent worst case.

Within Canyon

A2.8 Seven diffusion tube monitoring sites were modelled within a street canyon, 16, 27, 91, 94, 67, 68 and 69. A primary adjustment factor was determined as the slope of the best fit line between the 'measured' road contribution and the model derived road contribution, forced through zero (Figure A2.1). This factor was then applied to the modelled road-NOx concentration for each receptor to provide adjusted modelled road-NOx concentrations. The total nitrogen dioxide concentrations

were then determined by combining the adjusted modelled road-NOx concentrations with the predicted background NO_2 concentration within the NOx from NO_2 calculator available on the Defra LAQM Support website (Defra, 2011a). A secondary adjustment factor was finally calculated as the slope of the best fit line applied to the adjusted data and forced through zero (Figure A2.2).

A2.9 The following primary and secondary adjustment factors have been applied to all modelled nitrogen dioxide data:

- Primary adjustment factor : 4.2461
- Secondary adjustment factor: 1.0386

A2.10 The results imply that the model is under-predicting the road-NOx contribution. This is a common experience with this and most other models. The final NO_2 adjustment is minor.

A2.11 Figure A2.3 compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NO_2, and shows a 1:1 relationship.

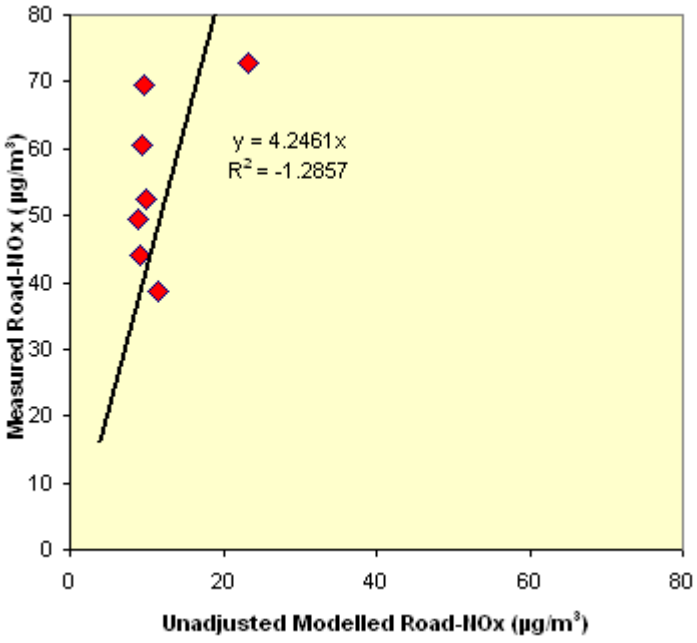

Figure A2.1: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations

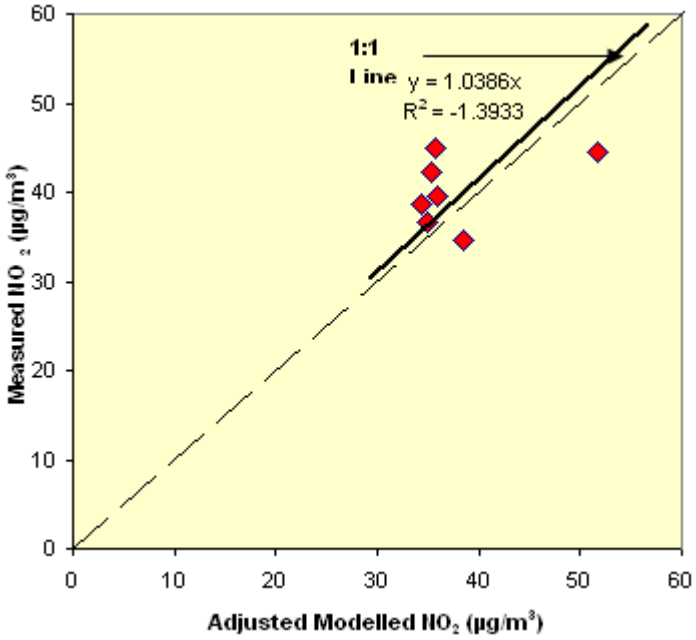

Figure A2.2: Comparison of Measured Total NO2 to Primary Adjusted Modelled Total NO2 Concentrations

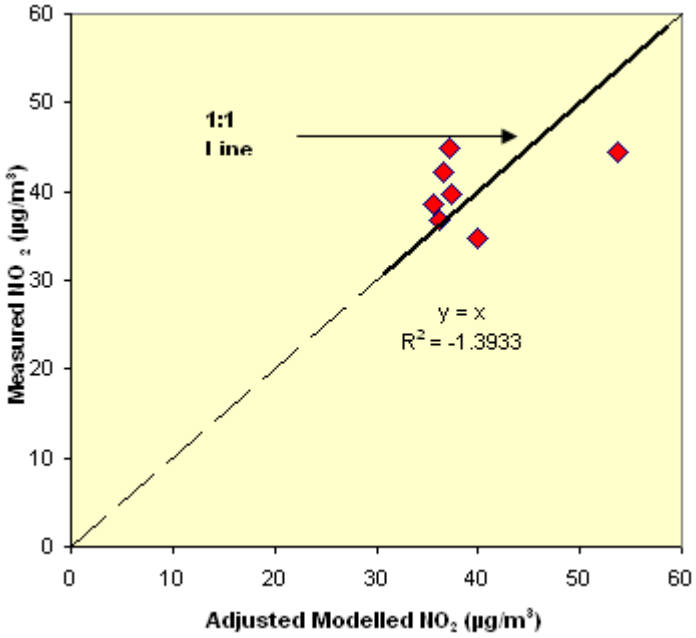

Figure A2.3: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations

Outside Canyon

A2.12 Six diffusion tube monitoring sites were modelled outside of a street canyon, 18, 92, 95, 96, 97 and 98. A primary adjustment factor was determined as the slope of the best fit line between the 'measured' road contribution and the model derived road contribution, forced through zero (Figure A2.4). This factor was then applied to the modelled road-NOx concentration for each receptor to provide adjusted modelled road-NOx concentrations. The total nitrogen dioxide concentrations were then determined by combining the adjusted modelled road-NOx concentrations with the predicted background NO_2 concentration within the NOx from NO_2 calculator available on the Defra LAQM Support website (Defra, 2011a). A secondary adjustment factor was finally calculated as the slope of the best fit line applied to the adjusted data and forced through zero (Figure A2.5).

A2.13 The following primary and secondary adjustment factors have been applied to all modelled nitrogen dioxide data:

- Primary adjustment factor : 7.5862
- Secondary adjustment factor: 1.0034

A2.14 The results imply that the model is under-predicting the road-NOx contribution. This is a common experience with this and most other models. The final NO_2 adjustment is minor.

A2.15 Figure A2.6 compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NO_2, and shows a 1:1 relationship.

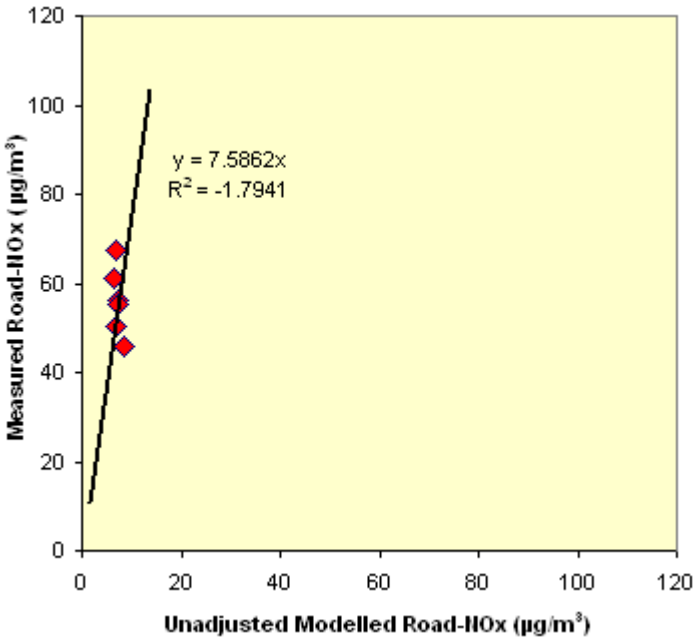

Figure A2.4: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations

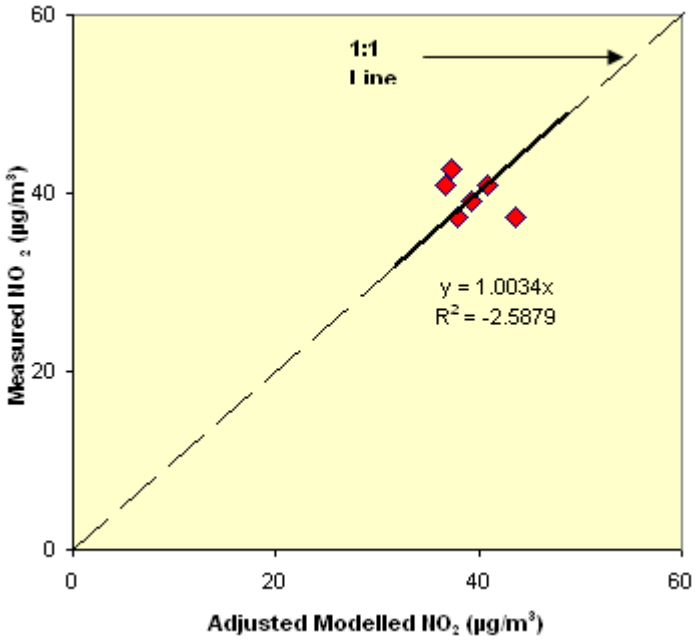

Figure A2.5: Comparison of Measured Total NO_2 to Primary Adjusted Modelled Total NO_2 Concentrations

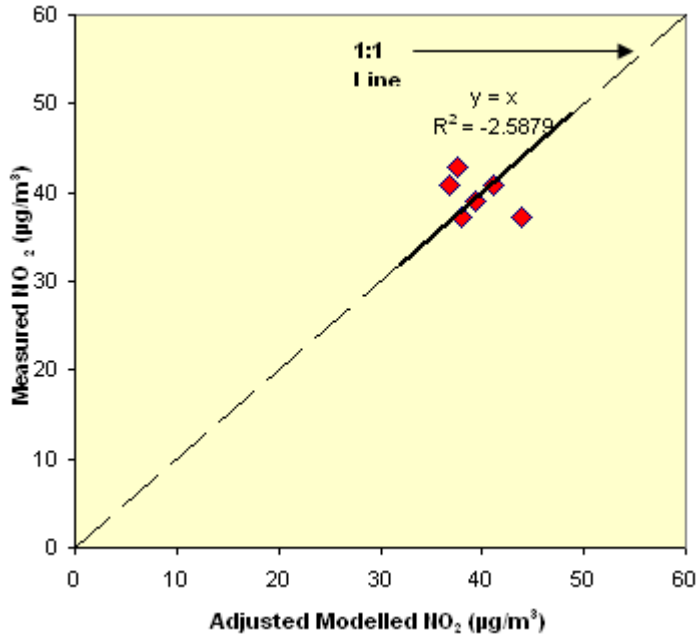

Figure A2.6: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations