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Detailed Assessment of Air Quality on Reigate Hill and in Redhill Town Centre.

August 2010

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Document Control

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Contents

Reigate and Banstead Borough Council confirms that it accepts the recommendations made in this report.

1 Introduction

1.1 Air Quality Consultants Ltd has been commissioned by Reigate and Banstead Borough Council (RBBC) to undertake a Detailed Assessment of air quality at two locations: Reigate Hill and Redhill Town Centre. These areas are shown in Figure 1. In 2009, the Council completed an Updating and Screening Assessment, which concluded that a Detailed Assessment was required due to measured exceedences of the annual mean nitrogen dioxide objective at both locations (RBBC, 2009). The aim of this Detailed Assessment is to determine whether the air quality objectives are being exceeded at locations with relevant exposure and if so, the extent of the Air Quality Management Area required.

Background

1.2 The Air Quality Strategy for England, Scotland, Wales and Northern Ireland (Defra, 2007) sets out a framework for air quality management, which includes a number of air quality objectives. National and international measures are expected to achieve these objectives in most locations, but where areas of poor air quality remain, air quality management at a local scale has a particularly important role to play. Part IV of the Environment Act 1995 requires local authorities to periodically review and assess air quality in their areas. The role of this process is to identify areas where it is unlikely that the air quality objectives will be achieved. These locations must be designated as Air Quality Management Areas (AQMAs) and a subsequent Air Quality Action Plan developed in order to reduce pollutant emissions in pursuit of the objectives.

1.3 Review and Assessment is a long-term, ongoing process, structured as a series of 'rounds'. Local Authorities in England, Scotland and Wales have now completed the first, second and third rounds of Review and Assessment, with the forth round underway.

1.4 Technical Guidance for Local Air Quality Management (LAQM.TG(09)) (Defra, 2009) sets out a phased approach to the Review and Assessment process. This prescribes an initial Updating and Screening Assessment (USA), which all local 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 (DA).

1.5 The purpose of the Detailed Assessment (DA) 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 DA is that one or more of the air quality objectives are likely to be exceeded, then an AQMA must be declared. Subsequent to the declaration of an AQMA, a Further Assessment should be carried out to confirm that the AQMA declaration is justified; and that the appropriate area has been declared; to ascertain the sources contributing to the exceedence; and 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.

The Air Quality Objectives

1.6 The Government's Air Quality Strategy (Defra, 2007) provides air quality standards and objectives for key air pollutants, which are designed to protect human health and the environment. The 'standards' are set as concentrations below which health 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 a particular 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. It also sets out how the different sectors: industry, transport and local government, can contribute to achieving the air quality objectives. The objectives are prescribed within The Air Quality (England) Regulations 2000 (Stationery Office, 2000) and The Air Quality (England) (Amendment) Regulations 2002 (Stationery Office, 2002). Table 1 summarises the objectives which are relevant to this report. Appendix 1 provides a brief summary of the health effects of nitrogen dioxide.

1.7 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 annual mean objectives, relevant exposure is 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 some bus stations and railway stations that are not fully enclosed.

1.8 Measurements across the UK have shown that the 1-hour nitrogen dioxide objective is unlikely to be exceeded unless the annual mean concentration is greater than 60 µg/m^3 (Defra, 2009). Thus, exceedences of 60 µg/m^3 as an annual mean nitrogen dioxide concentration are used as an indicator of potential exceedences of the 1-hour objective.

Table 1: Air Quality Objectives for Nitrogen Dioxide

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

2 Assessment Methodology

Monitoring

2.1 Monitoring for nitrogen dioxide is carried out using passive diffusion tube in Reigate Hill and Redhill. The monitoring sites are shown in Figures 2 and 3. The diffusion tubes are prepared and analysed by Lambeth Scientific Services using 50% TEA Acetone. It is necessary to adjust diffusion tube data to account for laboratory bias. RBBC has co-located triplicate diffusion tubes with three of its automatic monitoring sites: Michael Crescent (RG1), The Crescent (RG2), and Poles Lane (RG3). Results from these three local surveys have been combined using orthogonal regression[1]. The adjustment factor for 2009 calculated in this way was 1.014.

Modelling

2.2 Annual mean nitrogen dioxide concentrations in both study areas have been assessed using detailed dispersion modelling (using ADMS-Roads v2.3 and ADMS-4.2). The model outputs have been verified against the diffusion tube measurements described in paragraph 2.1. Owing to differences in traffic data availability, as well as the level of model complexity required for the two separate areas, the approaches taken are slightly different and are explained in full in Appendices 2 and 3. For both study areas, concentrations have been predicted across grids of receptors to allow concentration isopleths to be plotted. In addition, concentrations have been predicted at a number of worst-case receptor locations. The receptors are shown in Figure 4 for Reigate Hill and Figure 5 for Redhill. The Reigate Hill modelling has been carried out for 2009 and 2015. The Redhill modelling has been carried out for 2009 only.

Uncertainty

2.3 There is an element of uncertainty 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-predictions or under-predictions. All of the measurements presented have an intrinsic margin of error. Defra (2009) suggests that this is of the order of plus or minus 20% for diffusion tube data, provided that appropriate QA/QC procedures are applied. The model results rely on measured and modelled traffic data which has its own inherent uncertainty. 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 the emissions per vehicle conform to the factors published in Defra's Emission Factor Toolkit (EFT V4.1); it has been assumed that wind conditions measured at Gatwick Airport during 2009 will occur throughout both study areas, and it has been assumed that the subsequent dispersion of emitted pollutants will conform to a Gaussian distribution over flat

[1] Using the same method as is used in Defra's national co-location database.

terrain. An important step in the assessment is verifying the dispersion model against the measured data. By comparing the model results with measurements, data have been corrected for any under- or over-prediction (see Appendices 2 and 3 for details of the model verification).

2.4 The UK Government's Air Quality Expert Group (AQEG) has published a report on trends in primary nitrogen dioxide in the UK (AQEG, 2007). This examines evidence that shows that while NOx emissions have fallen in line with predictions made a decade previously, the composition of NOx has, in some urban environments, changed. This may have caused nitrogen dioxide levels at some locations to fall less rapidly than was expected. The latest guidance from Defra has been followed regarding NOx to NO_2 relationships (Defra, 2010).

2.5 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 locations.

3 Results

Reigate Hill

Monitoring

3.1 There is one diffusion tube monitoring site within the Reigate Hill study area (Figure 2). Recent measurements are summarised in Table 2. The period mean concentration measured in 2007 indicated that the objective was being exceeded by a considerable margin. The annual mean concentration in 2008 also showed an exceedence of the objective. The 2009 data showed concentrations marginally below the objective level. Table 2 thus indicates some substantial improvements over the three-year period, but it is difficult to base a judgement regarding long-term concentration trends on just three years of data, particularly given the poor data capture in 2007.

Table 2: Annual Mean Nitrogen Dioxide Concentrations Measured at the Diffusion Tube Site on Reigate Hill (µg/m^3)

Site	Site Description	2007[a]	2008[b]	2009[c]
RB125	Lamp post 29, Opposite Reigate Hill Close, Reigate Hill	**54.9**	**43.9**	39.4
Objective		**40**		

[a] Data available for June to December, annual adjustment factor of 1.02 applied as described in Appendix B of RBBC, 2009. Bias adjusted using a local factor of 1.145.
[b] All > 90% data capture. Bias adjusted using a local factor of 1.02.
[c] All > 90% data capture. Bias adjusted using a local factor of 1.014.

Modelling

3.2 Predicted annual mean nitrogen dioxide concentrations in 2009 and 2015 at each of the receptor locations shown in Figure 4 are set out in Table 3. In 2009, the objective is expected to be exceeded at Receptors 1, 7 and 8. Receptor 1 is at the southern end of the Reigate Hill study area, near to the railway line, while Receptors 7 and 8 are in the north of the area, closer to the M25. At the other receptors, concentrations are predicted to be lower, with the lowest concentration of 31.7 μg/m^3 predicted at Receptor 3 (Reigate Manor Hotel).

3.3 By 2015, Defra expects a range of measures introduced at national and international levels to have reduced road traffic emissions and background air pollution levels. Thus, the predictions for 2015 show no objective exceedences.

3.4 Figures 6 to 11 show concentration isopleths along Reigate Hill in 2009 and 2015. In 2009, the level of the objective is predicted to be exceeded immediately adjacent to the A217. Across most of the study area, the exceedence is confined to an area so close to the roadway that there is no relevant exposure, but some locations with relevant exposure will be affected and these locations occur along the full length of the study area (see Figures 6 and 7).

3.5 The 40 μg/m^3 exceedence contour in Figure 10 extends beyond the edges of the study area. However, the area to the south of the railway line (i.e. immediately south of the Reigate Hill study area in Figure 7) is already an AQMA and thus does not need to be included within this Detailed Assessment. Furthermore, there is no relevant exposure near to the A217 between the northern edge of the study area and the M25.

3.6 By 2015, the isopleths show that the level of the objective will not be exceeded except immediately adjacent to the A217 between Howard Place and the railway line.

Table 3: Modelled Annual Mean Nitrogen Dioxide Concentrations at Selected Worst-Case Receptors on Reigate Hill (μg/m^3)

Receptor	2009	2015
1	**46.4**	35.1
2	38.1	27.7
3	31.7	22.6
4	36.6	26.4
5	38.7	28.0
6	33.8	24.2
7	**42.3**	31.1
8	**43.6**	32.2
Objective	**40**	

Redhill

Monitoring

3.7 Monitoring data for the diffusion tube sites within the Redhill study area (Figure 2) are summarised in Table 4. In 2007, the objective was exceeded at every operational site except RB122, next to Marketfield Way. In 2008, the objective was exceeded at all four operational sites. In 2009, two additional sites were added. The objective was only exceeded at one site in 2009 (Site RB121, next to Princess Way). Concentrations at the two new sites (RB140 and RB141) were less than 30 $\mu g/m^3$ and thus well below the objective level. As with Reigate Hill, Table 4 shows some substantial improvements over the three-year period, but it is difficult to base a judgement about long-term concentration trends on just three years of data.

Table 4: Annual Mean Nitrogen Dioxide Concentrations Measured at Diffusion Tube Sites in Redhill ($\mu g/m^3$)

Site	Site Description	2007[a]	2008[b]	2009[c]
RB120	Lamp post Outside 21, Redstone Hill Redhill	**51.1**	**41.9**	36.5
RB121	Lamp Post 271, Opposite Ladbrook Grove, Redhill	**47.6**	**47.0**	**42.9**
RB122	Roundabout Sign 5158 near Carpark, Marketfield Way, Redhill	38.7	**46.5**	39.8
RB123	Lamp post 3, outside Age Concern Cromwell Road, Redhill	**48.6**	**43.4**	39.9
RB140	Flat 2, 45 Ladbrook Grove, Redhill, RH1 1JQ	-	-	29.4
RB141	Near Roundabout outside 105 Station Road, Redhill, opposite Donyngs	-	-	29.6
Objective		**40**		

[a] Data available for June to December, annual adjustment factor of 1.02 applied as described in Appendix B of RBBC, 2009. Bias adjusted using a local factor of 1.145.
[b] All > 90% data capture. Bias adjusted using a local factor of 1.02.
[c] All > 90% data capture. Bias adjusted using a local factor of 1.014.

Modelling

3.8 Predicted annual mean nitrogen dioxide concentrations in 2009 at each of the receptor locations shown in Figure 5 are set out in Table 5. The objective is predicted to be exceeded at three out of the 43 receptors. These are Receptors 16 (corner of Queensway and High St), Receptor 21 (on The Stations Roundabout), and Receptor 29 (Princess Way).

3.9 Concentrations are also shown as isopleths in Figures 12 to 17. These show that annual mean concentrations exceed 40 $\mu g/m^3$ around Princess Way, the Princess Way / London Road roundabout, the bus station, the entrance to the Harlequin Theatre and Sainsbury car parks, Marketfield Way, and the junction of Brighton Road and High Street. Predicted concentrations exceed 60 $\mu g/m^3$ within the bus station, but the bus station is only served by local buses, so exposure in terms of the 1-hour objective is unlikely. The contour plots do not extend as far south as Receptor 43 but it is clear from the receptor results and the contour plot in Figure 14 that exceedences this far south along Brighton Road are highly unlikely.

Table 5: Modelled Annual Mean Nitrogen Dioxide Concentrations at Selected Worst-Case Receptors in Redhill in 2009 (µg/m^3)

Receptor	Concentration	Receptor	Concentration	Receptor	Concentration
1	24.5	**16**	**40.3**	**31**	28.1
2	23.4	**17**	24.3	**32**	29.1
3	24.8	**18**	24.0	**33**	29.1
4	24.8	**19**	34.3	**34**	28.2
5	24.6	**20**	29.3	**35**	25.9
6	24.8	**21**	**43.6**	**36**	25.2
7	29.6	**22**	24.4	**37**	27.6
8	32.8	**23**	24.6	**38**	29.0
9	26.1	**24**	23.4	**39**	36.0
10	26.9	**25**	28.7	**40**	37.2
11	25.8	**26**	28.8	**41**	37.8
12	27.1	**27**	29.8	**42**	38.5
13	33.6	**28**	31.9	**43**	29.2
14	29.0	**29**	**44.0**		
15	29.6	**30**	38.3		
Objective	**40**				

Redhill 2016 Modelling

3.10 A series of new developments are planned for Redhill between 2010 and 2015, and as part of the redevelopment plans for the town centre, air quality was modelled for 2016 assuming all of the development work had been completed - Figures 18 to 24. Full details of the assessment methodology for 2016 can be found in 'Assessment of Air Quality in Redhill' (AQC, 2009).

3.11 The 2016 modelling was carried out before Defra issued its latest vehicle emission factors (EFT V4.2) and thus relied on Defra's previous dataset (EFT V3). Furthermore, the model was verified against a different set of measurements. Because of these issues, the 2016 results cannot be compared directly with the 2009 data. However were the 2016 model to be rerun with the latest (EFT V4.2) emissions factors and using the verification reported in Appendix 3, then the resultant concentrations would be lower than those reported in Table 6.

3.12 Using the older emissions factors (EFT V3) the annual mean concentration of nitrogen dioxide is predicted to meet the relevant air quality standard in 2016 (Table 6), although concentrations at two sites (Receptors 21 and 29) will be close to the objective.

3.13 Nitrogen dioxide concentrations along Brighton Road to the south of Redhill were not modelled for 2016 at Receptor 42, nor were concentrations west of Redhill at the junction of Station Road and Hatchlands Road. However as the relevant standards were met in 2009 at these sites, and as concentrations are predicted to fall further by 2016, it is unlikely that nitrogen dioxide concentrations will breach the air quality standards at these sites in 2016.

Table 6: Modelled Annual Mean Nitrogen Dioxide Concentrations at Specific Receptors in Redhill in 2016 with Proposed Developments (µg/m^3)

Receptor	2016 With Development	Receptor	2016 With Development
Receptor 1	23.0	**Receptor 17**	21.7
Receptor 2	22.0	**Receptor 18**	21.5
Receptor 3	22.6	**Receptor 19**	30.6
Receptor 4	22.9	**Receptor 20**	24.7
Receptor 5	23.2	**Receptor 21**	38.7
Receptor 6	23.8	**Receptor 22**	22.2
Receptor 7	29.2	**Receptor 23**	22.9
Receptor 8	31.9	**Receptor 24**	21.9
Receptor 9	24.6	**Receptor 25**	25.2
Receptor 10	23.9	**Receptor 26**	25.3
Receptor 11	22.8	**Receptor 27**	26.7
Receptor 12	24.7	**Receptor 28**	29.7
Receptor 13	33.0	**Receptor 29**	39.9
Receptor 14	26.6	**Receptor 30**	34.1
Receptor 15	29.2	**Receptor 31**	24.4
Receptor 16	37.1		
Objective	**40**		

4 Conclusions and Recommendations

4.1 A Detailed Assessment of annual mean nitrogen dioxide concentrations along Reigate Hill and in Redhill has been carried out. These areas were identified as being at risk of exceeding the annual mean objective for nitrogen dioxide in the Council's 2009 Updating and Screening Assessment.

The Detailed Assessment has been carried out using a combination of measurements and detailed dispersion modelling, with the model results verified against the measurements.

4.2 The assessment has identified locations where the annual mean nitrogen dioxide objective is being exceeded at locations of relevant exposure within Reigate Hill and Redhill. It is therefore recommended that the Council declares AQMAs for both Reigate Hill and Redhill. These should cover, as a minimum, the areas shown in Figure 10 and 17 wherever the highlighted areas coincide with locations with relevant exposure as identified in paragraph 1.7. A more precautionary approach would be to ensure that the entire area shown as exceeding 36 $\mu g/m^3$ in Figures 10 and 17 is declared in order to account for potential model uncertainty.

4.3 Finally, it is recommended that Reigate and Banstead Borough Council considers these recommendations and advises Defra on the actions it will take.

5 References

AQC (2009) Assessment of Air Quality in Redhill - Volume 1: Report. October 2009.

AQEG (2007) Trends in Primary Nitrogen Dioxide in the UK.

Defra (2007) The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, July 2007.

Defra (2009) Review & Assessment: Technical Guidance LAQM.TG(09).

Defra (2010) Air Quality Archive at http://www.airquality.co.uk

DfT (2007) English Regional Traffic Growth and Speed Forecasts. Available at www.dft.gov.uk/pgr/economics/ntm/AF07_Annex_Baseline_summary.xls

DfT (2008) Regional Transport Statistics. Available at: http://www.dft.gov.uk/pgr/statistics/datatablespublications/regionaldata/rts/regtranstats2008

DfT (2009) TEMPRO (Version 6.2) System. Available at www.tempro.org.uk

Reigate and Banstead Borough Council (2009) Updating and Screening Assessment for Reigate and Banstead Borough Council. Available from www.reigate-banstead.gov.uk/Images/2009_03999_RPR_005_RBBC_final_050809incl%20consult1a_tcm9-37188.pdf

Stationery Office (2000) Air Quality Regulations, 2000, Statutory Instrument 928.

Stationery Office (2002) Air Quality (England) (Amendment) Regulations, 2002, Statutory Instrument 3043.

6 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.
AQMA	Air Quality Management Area
ADMS Roads	Atmospheric Dispersion Modelling System for Roads.
NOx	Nitrogen oxides (taken as NO + NO_2)
NO	Nitric Oxide
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).
HDV	Heavy Duty Vehicle
LDV	Light Duty Vehicle

7 Figures

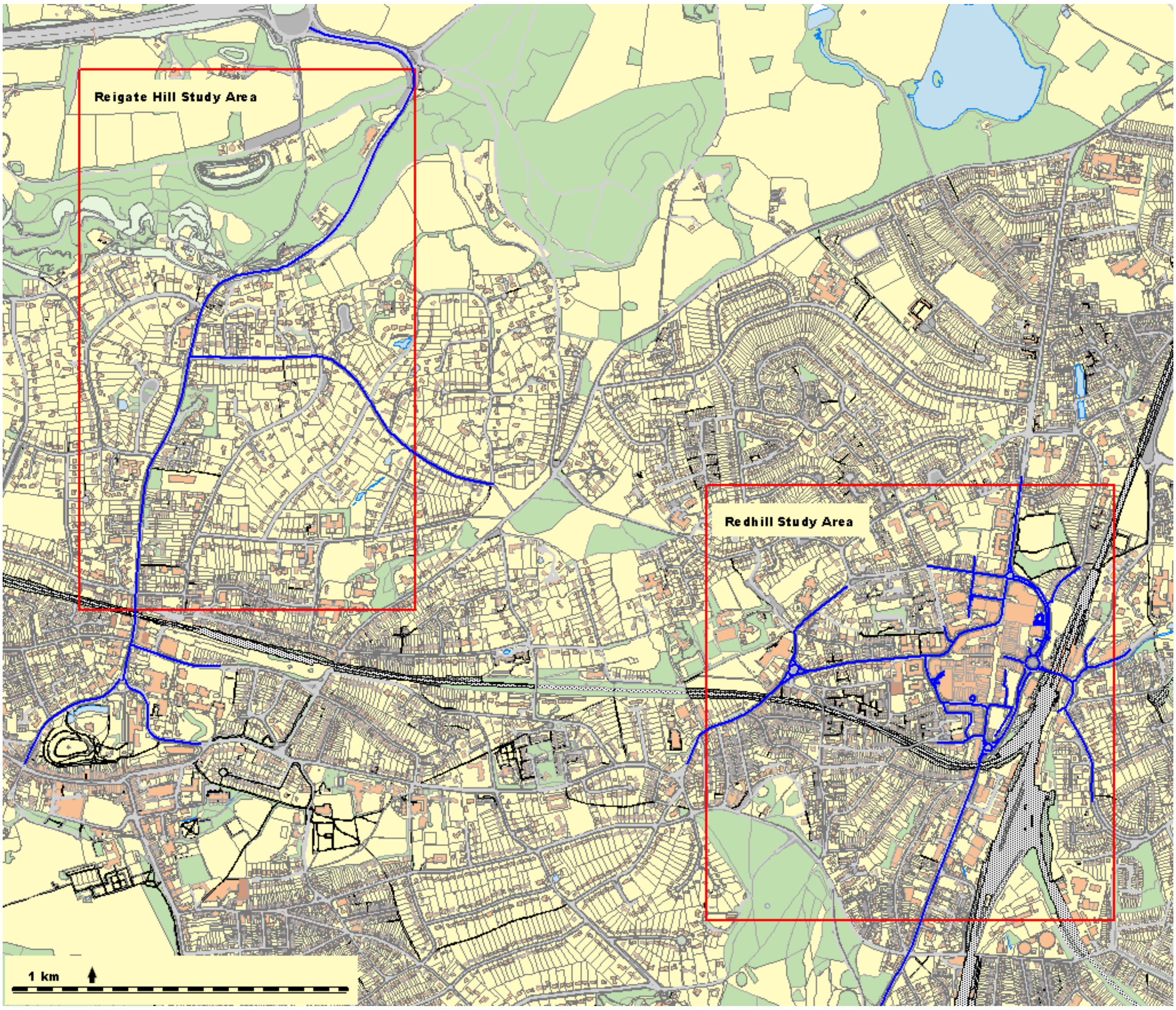


Figure 1: Reigate Hill and Redhill Study Areas (red lines) (blue lines show roads included in dispersion modelling

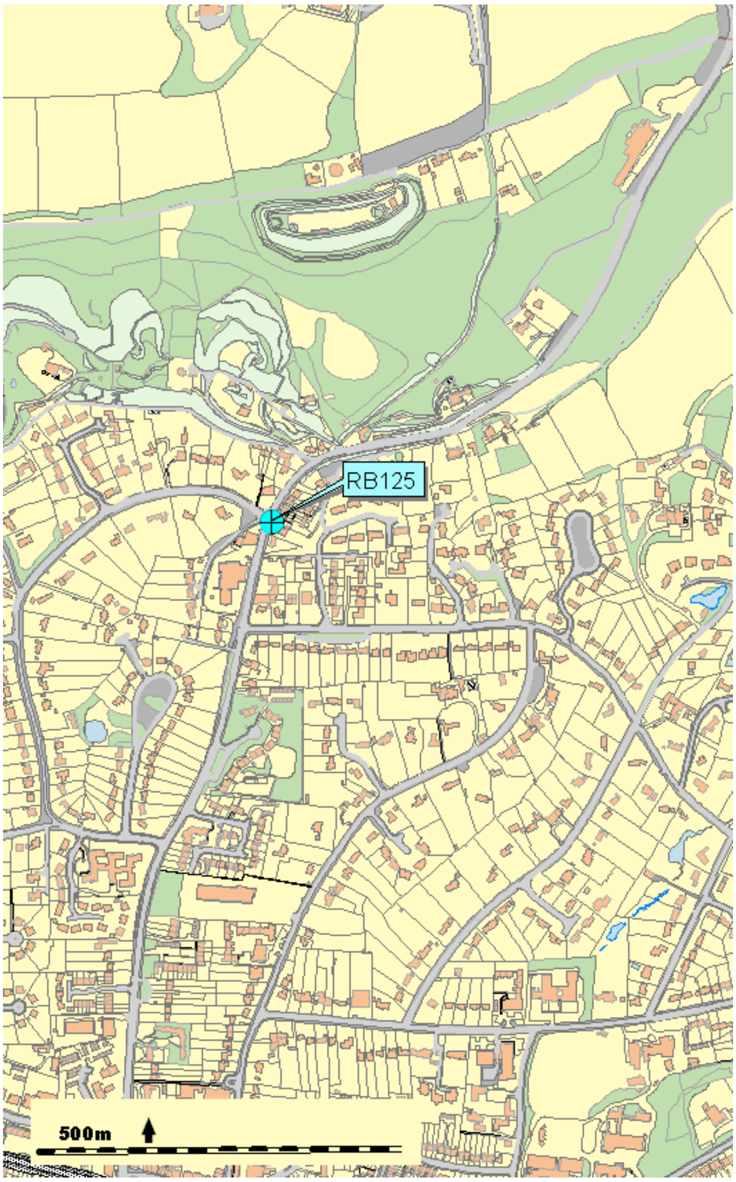


Figure 2: Reigate Hill Diffusion Tube Monitoring Site

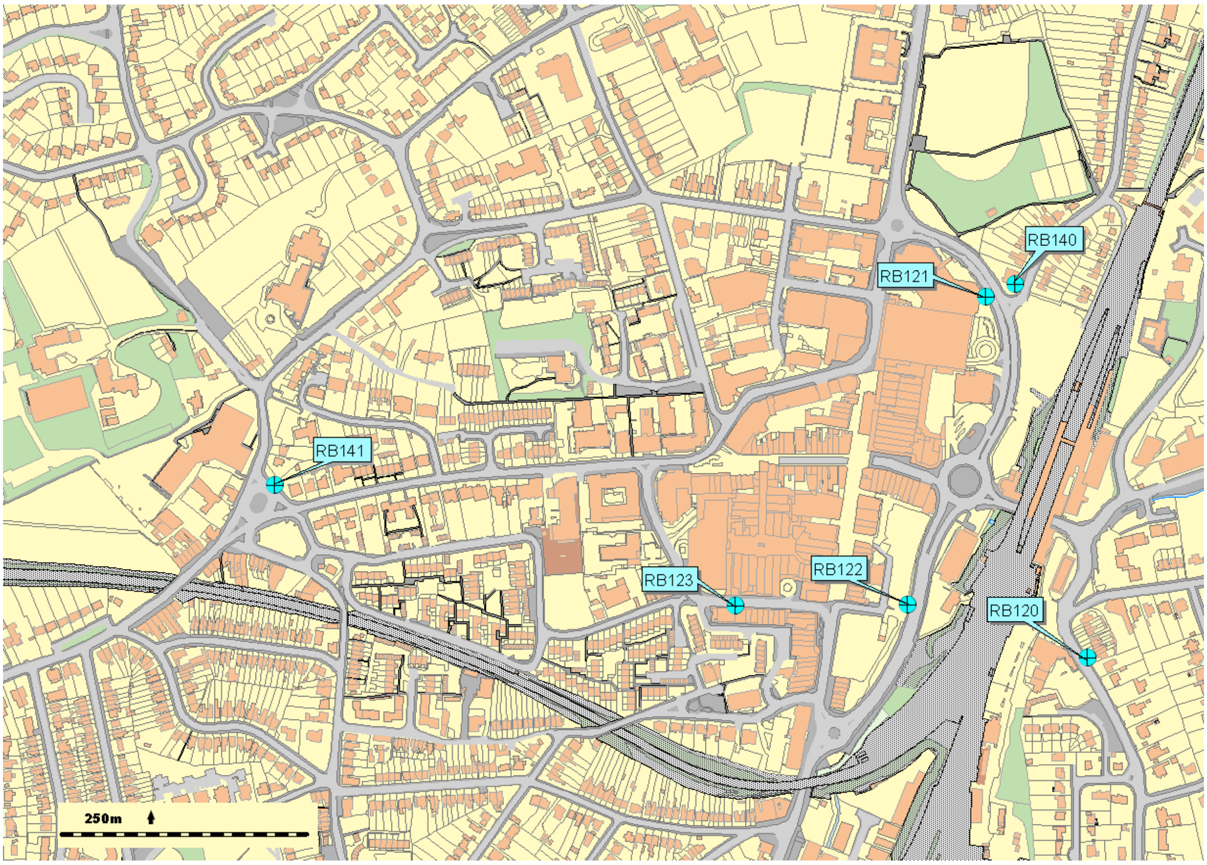


Figure 3: Redhill Diffusion Tube Monitoring Sites

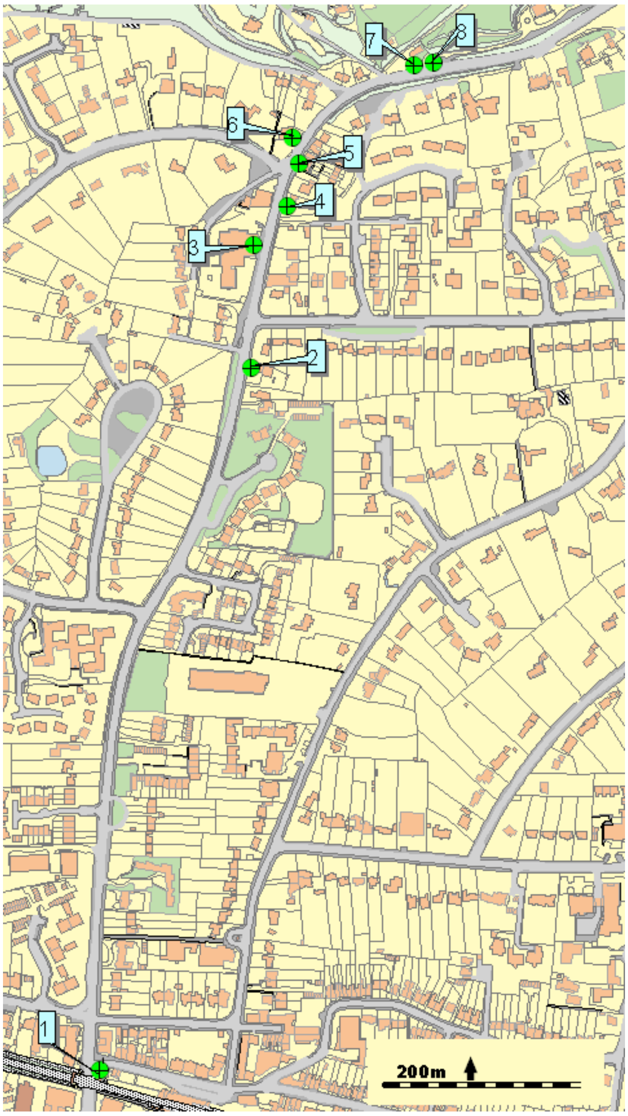


Figure 4: Reigate Hill Receptor Locations

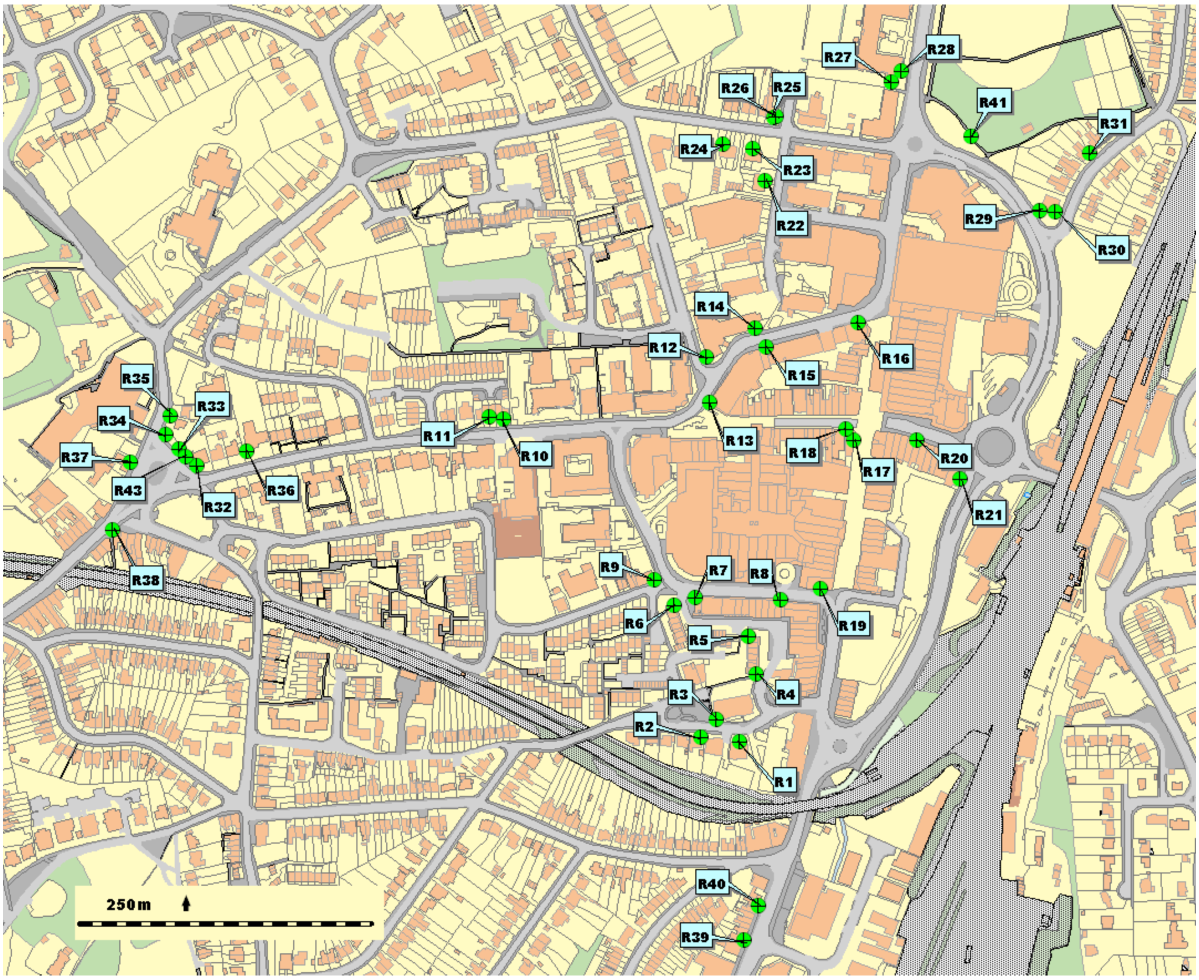


Figure 5: Redhill Receptor Locations

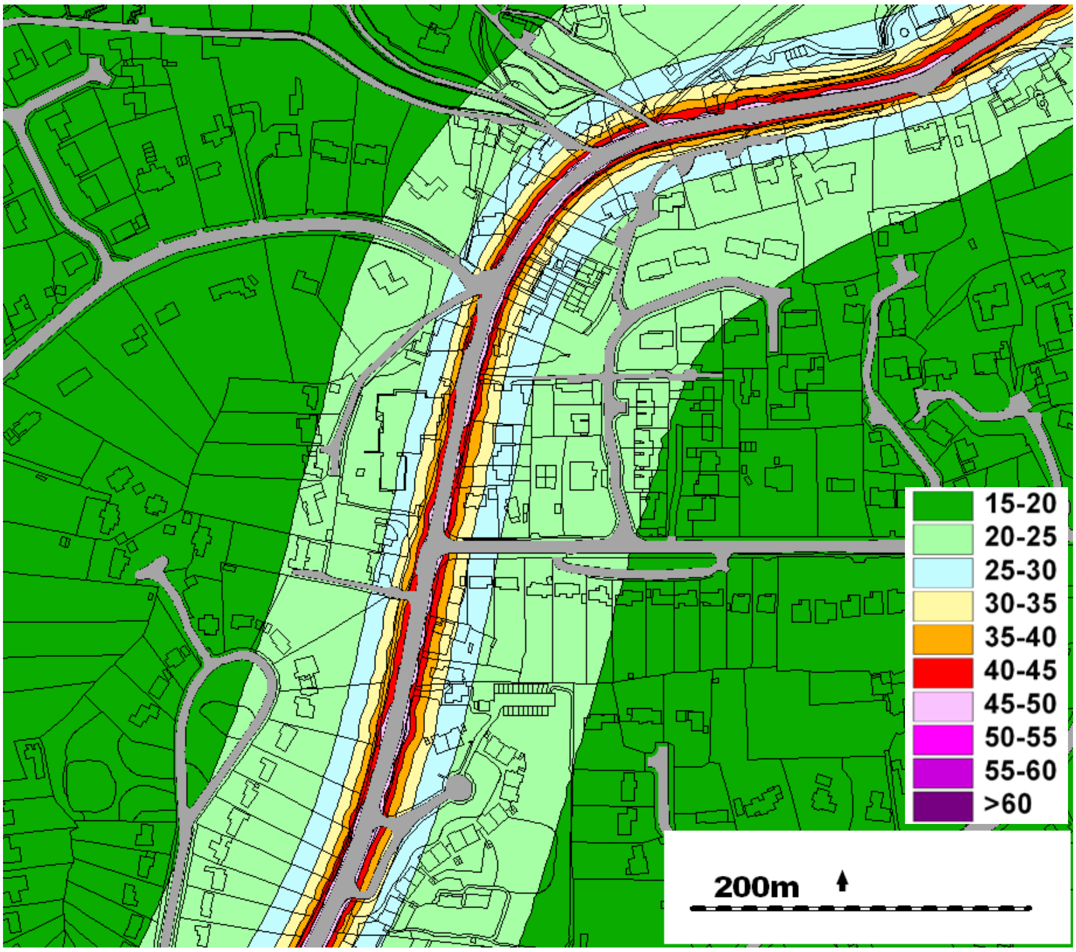


Figure 6: Predicted Annual Mean Nitrogen Dioxide Concentrations in 2009 in the Northern Half of Reigate Hill (μg/m^3)

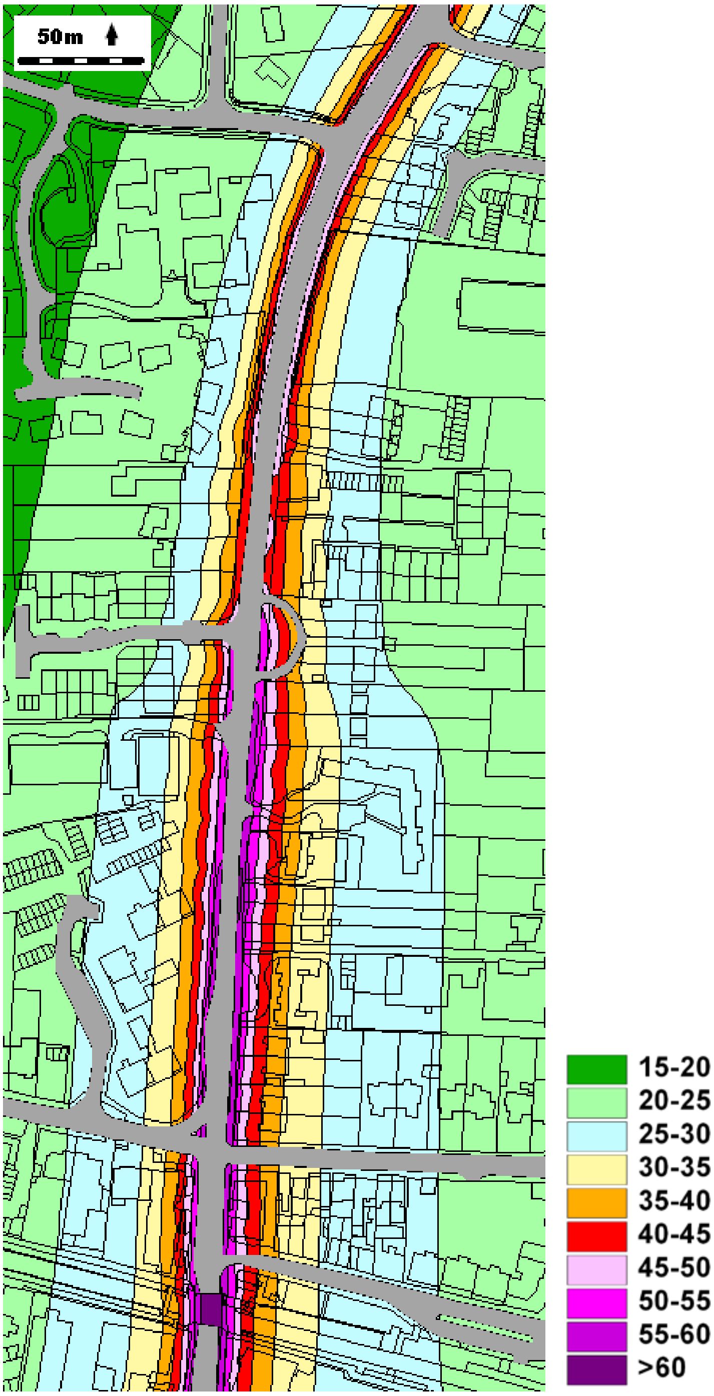


Figure 7: Predicted Annual Mean Nitrogen Dioxide Concentrations in 2009 in the Southern Half of Reigate Hill (μg/m^3)

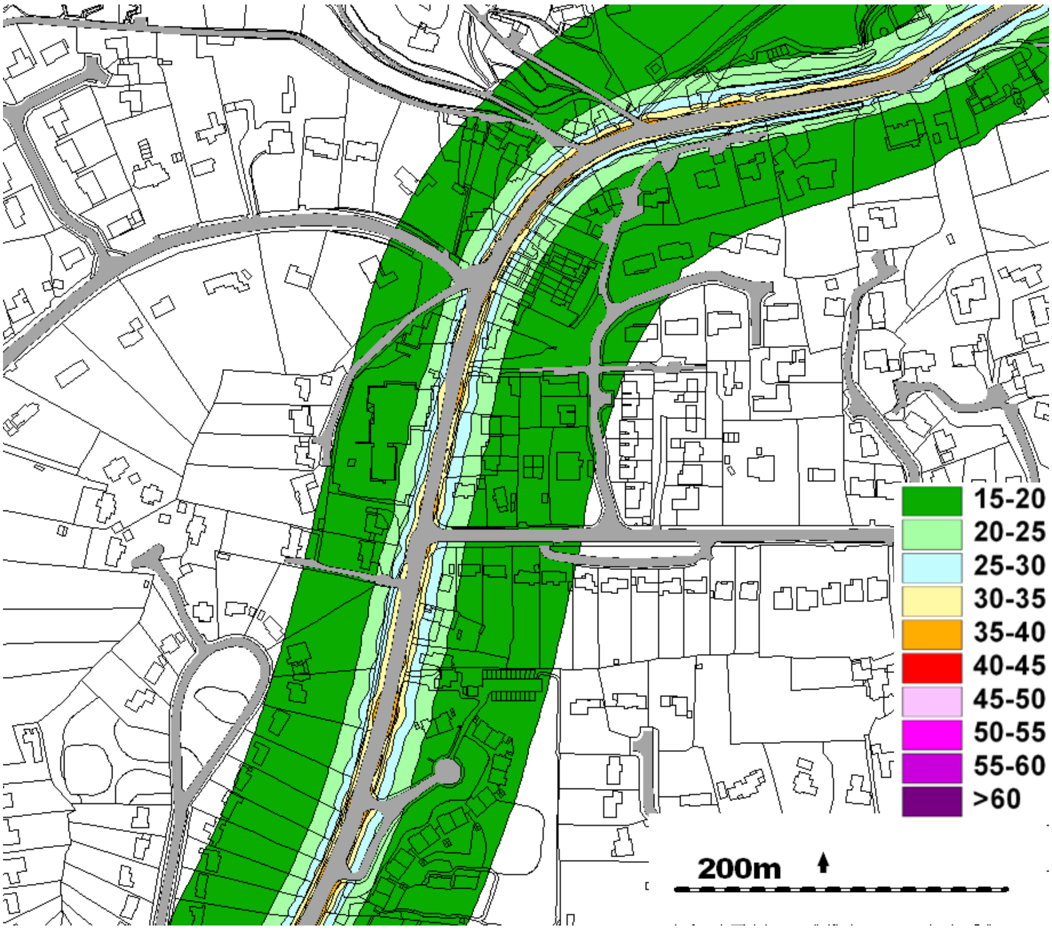


Figure 8: Predicted Annual Mean Nitrogen Dioxide Concentrations in 2015 in the Northern Half of Reigate Hill (μg/m^3)

Figure 9: Predicted Annual Mean Nitrogen Dioxide Concentrations in 2015 in the Southern Half of Reigate Hill (μg/m^3)

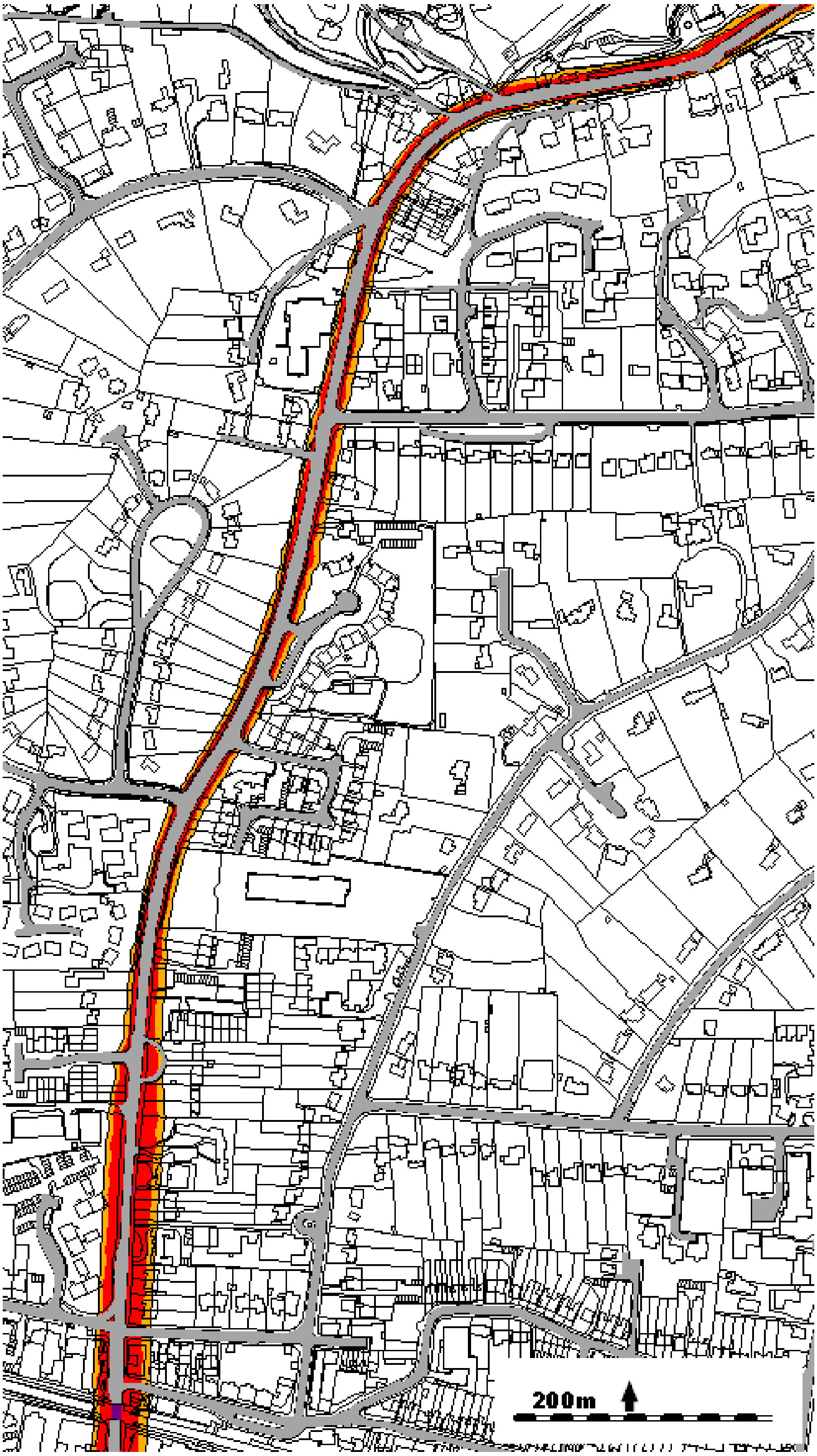


Figure 10: Predicted Exceedences of 36 μg/m^3 (orange) and 40 μg/m^3 (red) as Annual Mean Nitrogen Dioxide Concentrations in 2009 on Reigate Hill (μg/m^3)

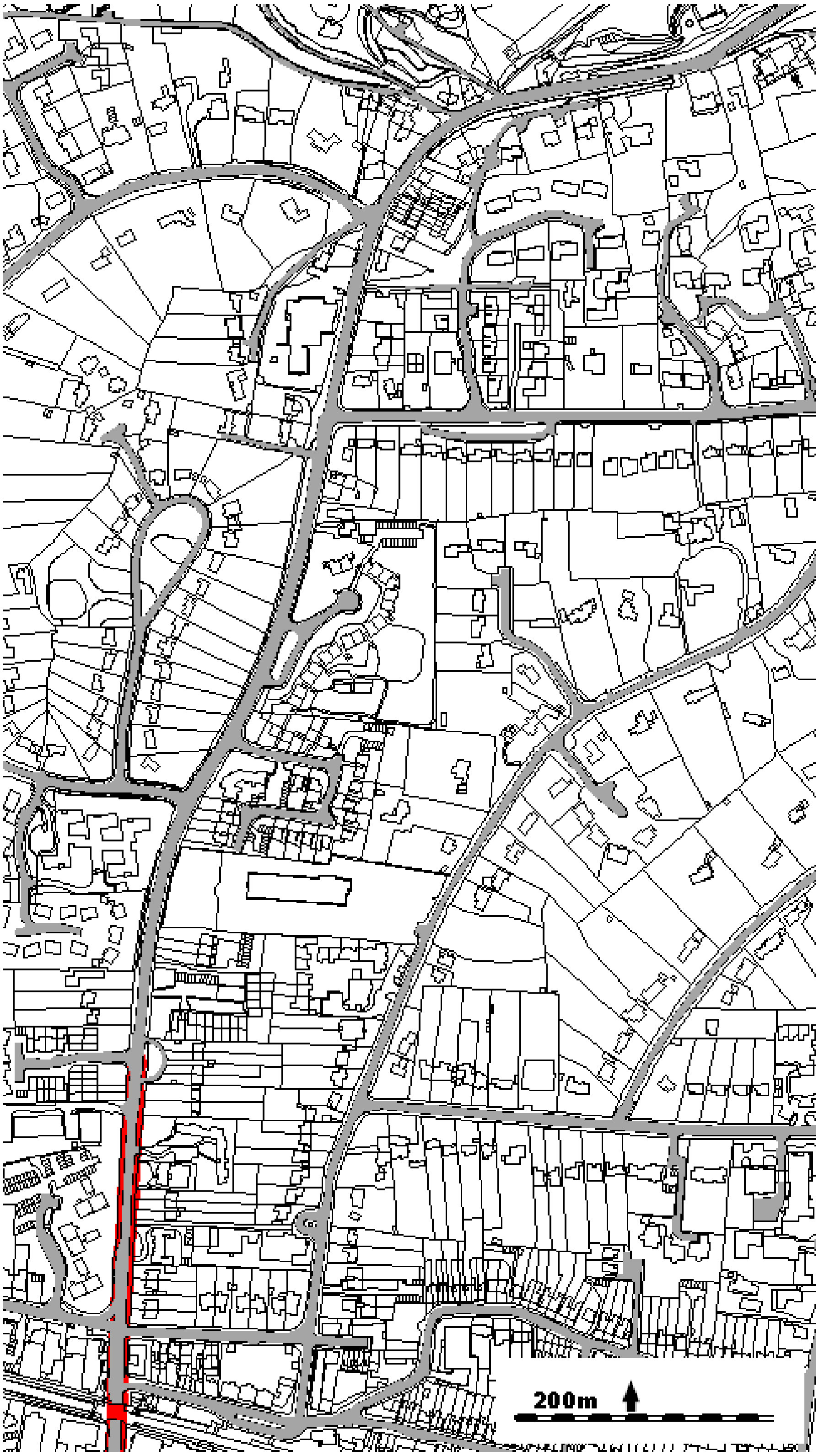


Figure 11: Predicted Exceedences of 40 μg/m^3 as an Annual Mean Nitrogen Dioxide Concentrations in 2015 on Reigate Hill (μg/m^3)

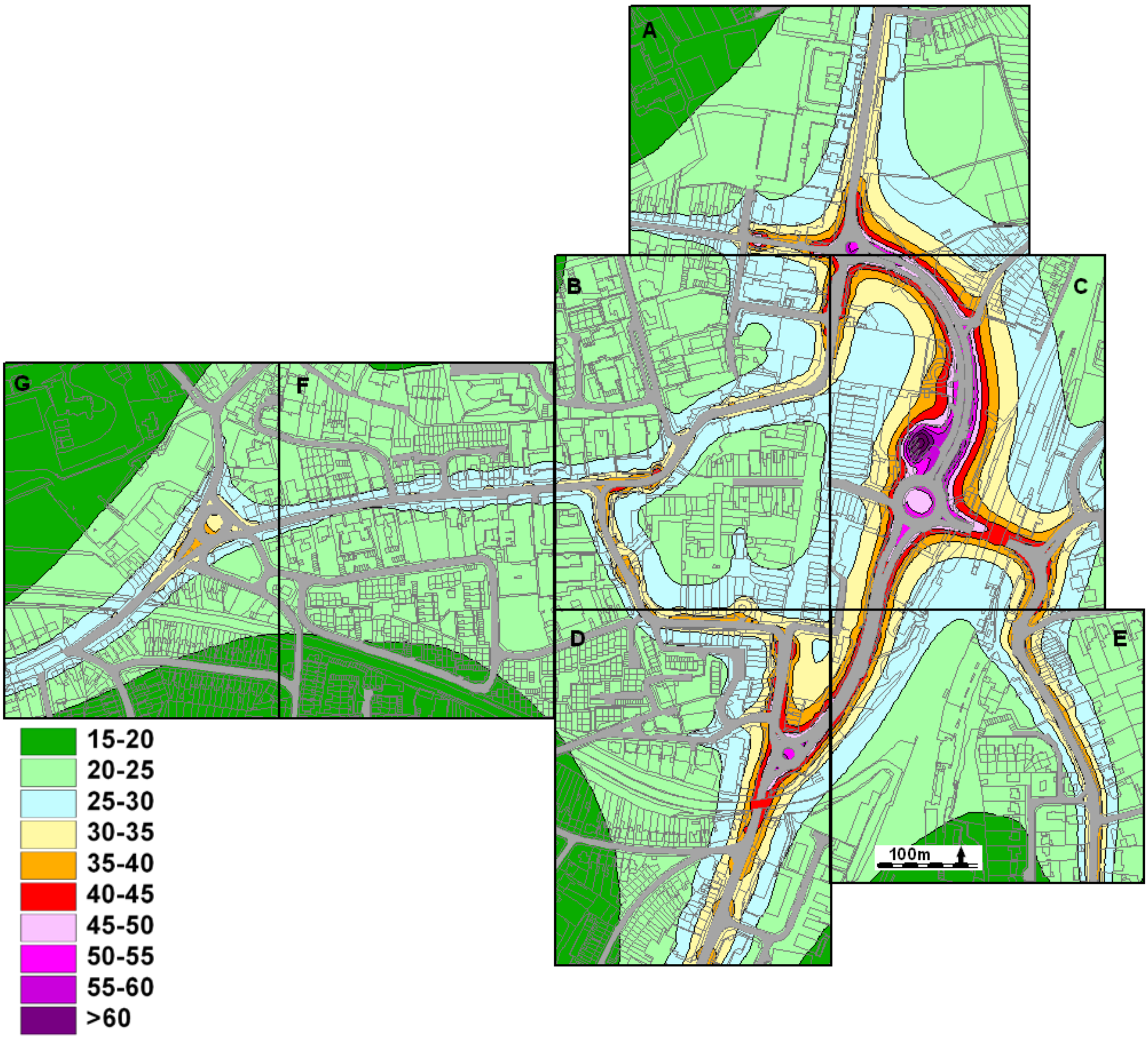


Figure 12: Predicted Annual Mean Nitrogen Dioxide Concentrations in 2009 across Redhill ($\mu g/m^3$) – Also showing Inset Areas for Subsequent Figures

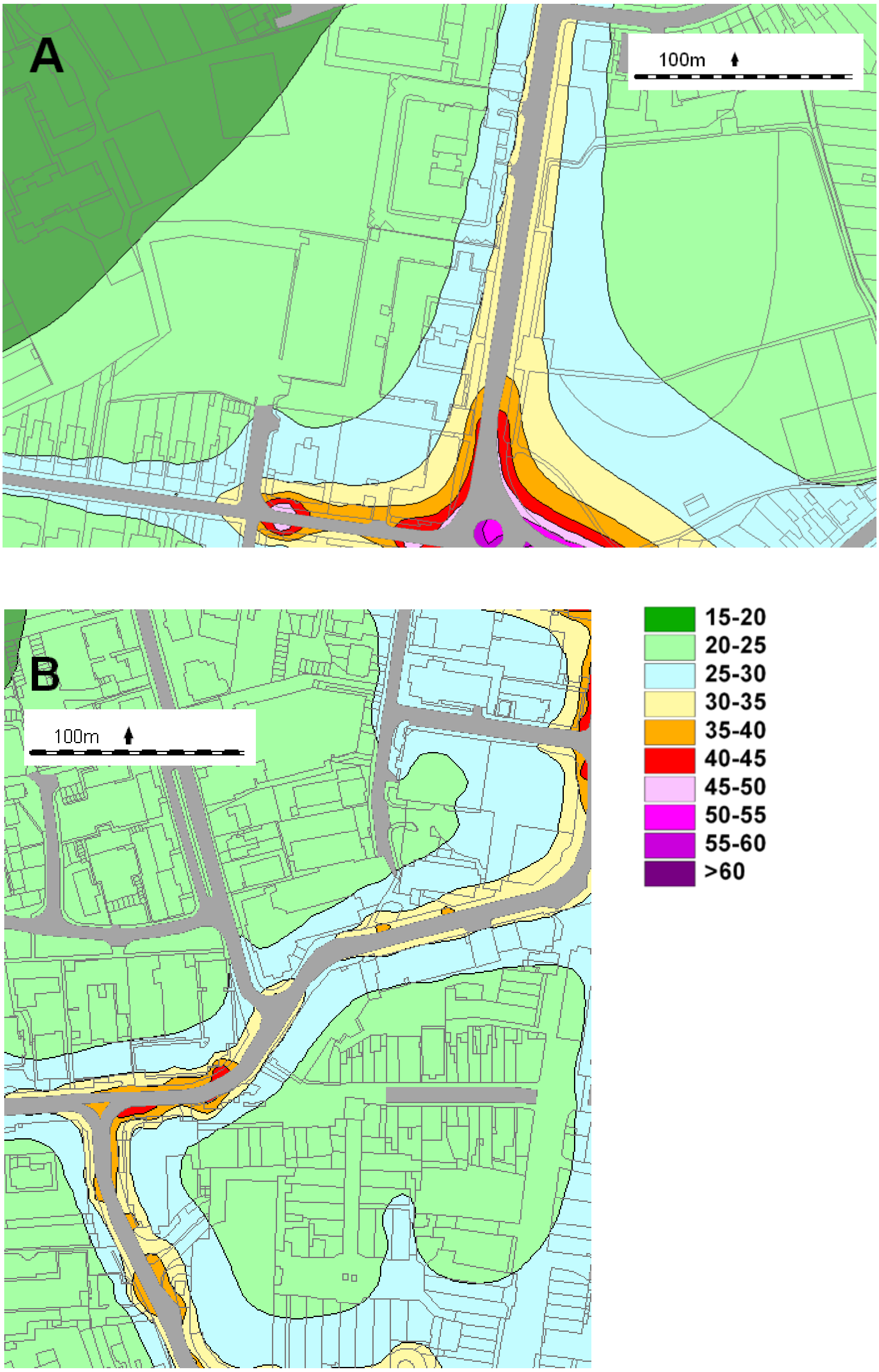
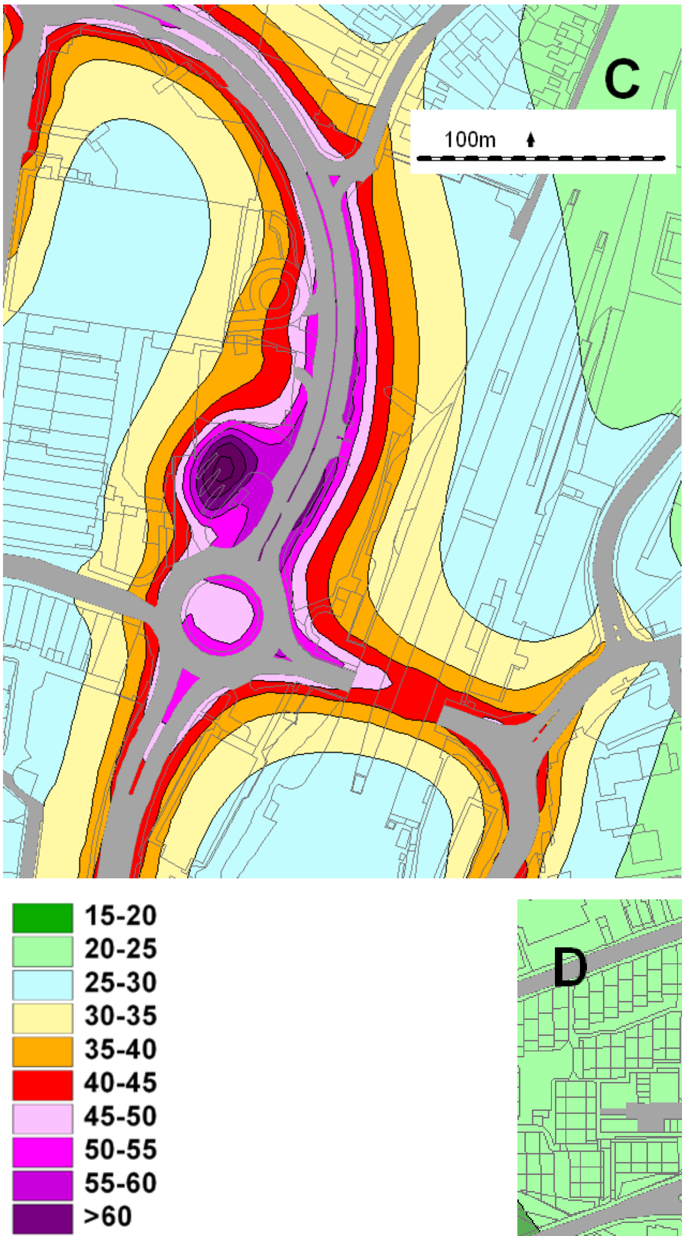


Figure 13: Predicted Annual Mean Nitrogen Dioxide Concentrations in 2009 in Redhill Insets A and B (μg/m³)



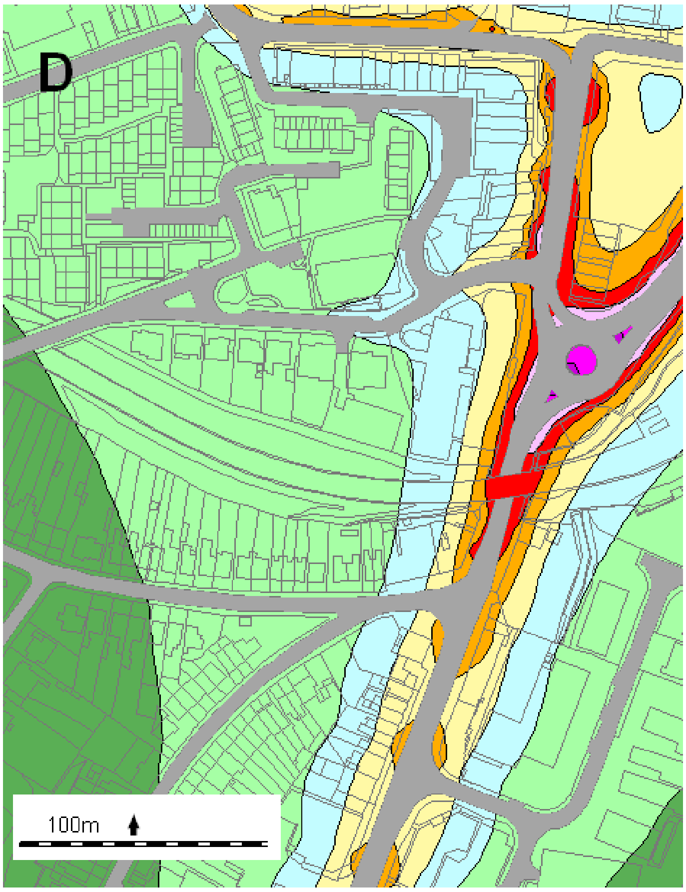


Figure 14: Predicted Annual Mean Nitrogen Dioxide Concentrations in 2009 in Redhill Insets C and D (μg/m^3)

Figure 15: Predicted Annual Mean Nitrogen Dioxide Concentrations in 2009 in Redhill Insets E and F (μg/m³)

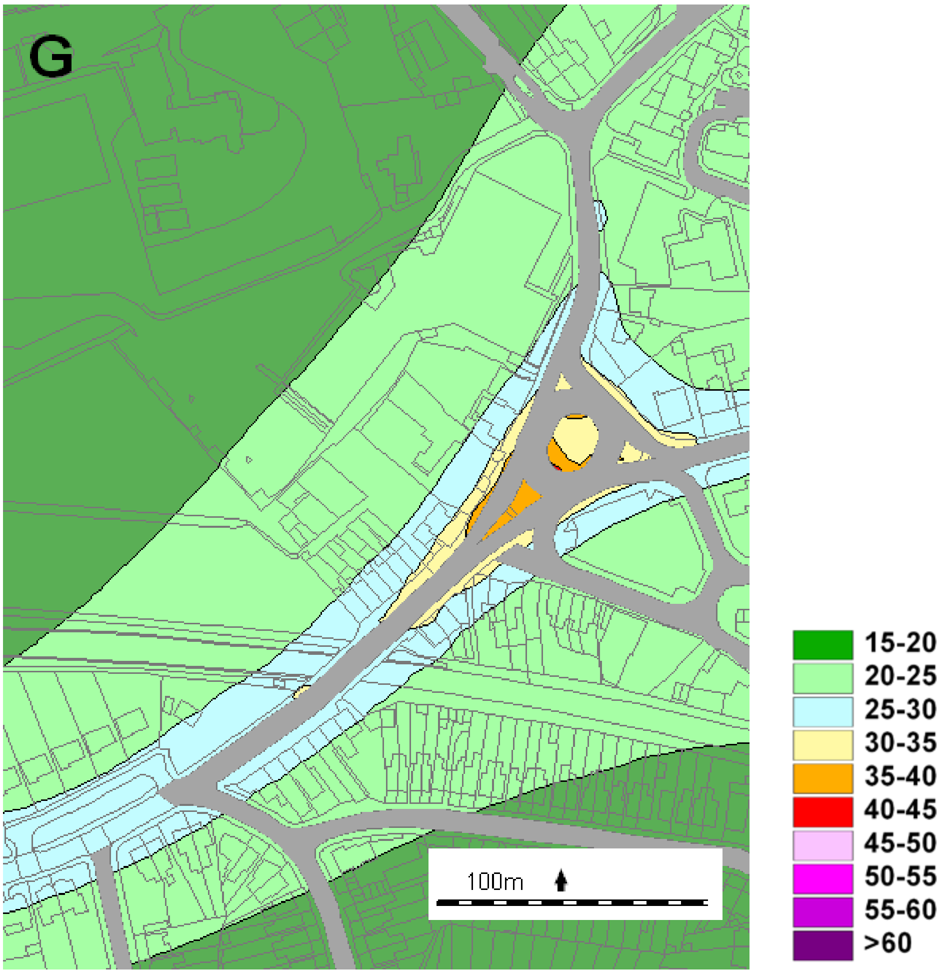


Figure 16: Predicted Annual Mean Nitrogen Dioxide Concentrations in 2009 in Redhill Inset G (μg/m³)

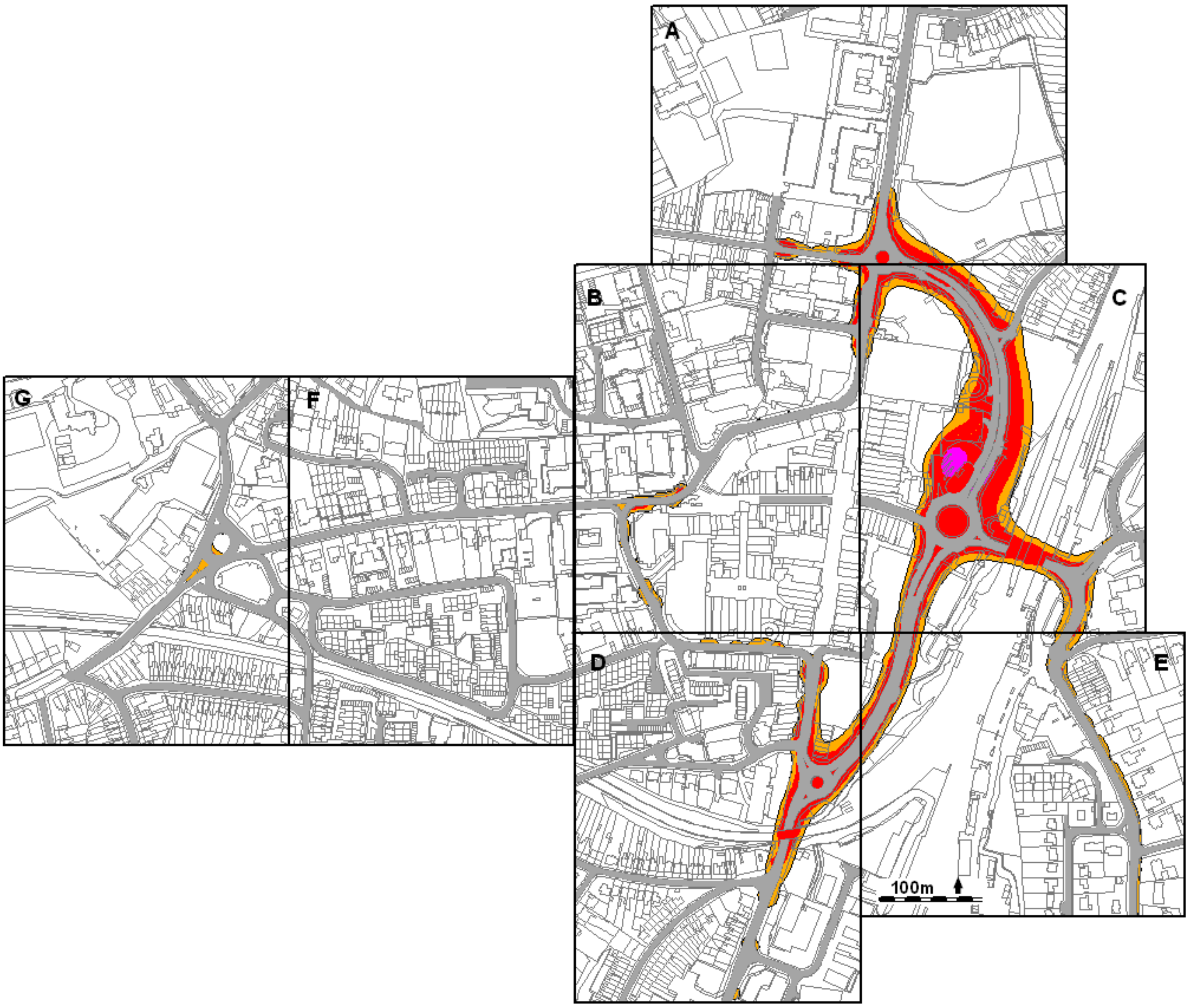


Figure 17: Area with Predicted Exceedences of 36 $\mu g/m^3$ (orange), 40 $\mu g/m^3$ (red) and 60 $\mu g/m^3$ (pink) as annual mean Nitrogen Dioxide Concentrations in 2009

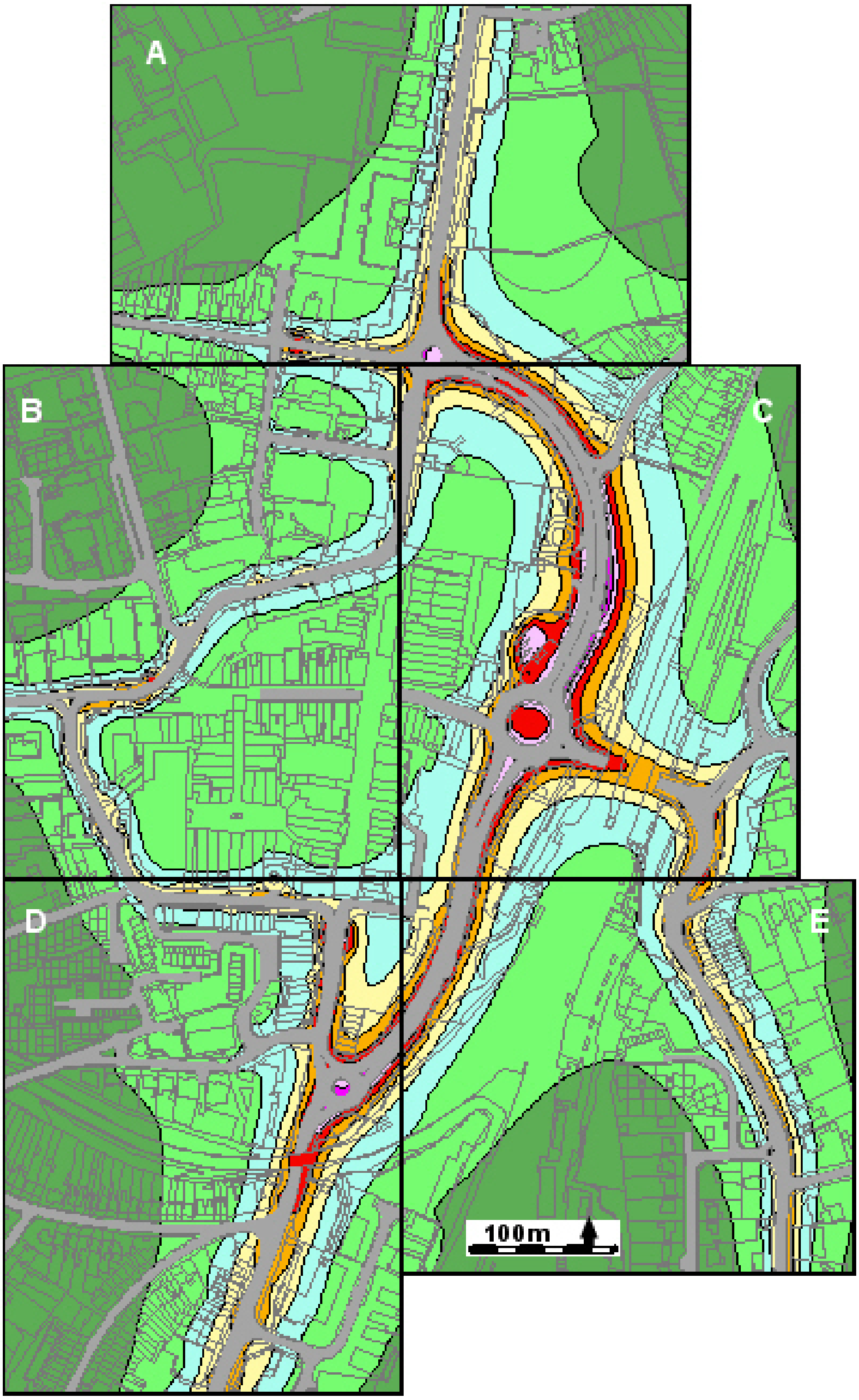


Figure 18: Predicted Annual Mean Nitrogen Dioxide Concentrations Across Redhill Town Centre in 2016 – With Development (µg/m^3)

Figure 19: Predicted Annual Mean Nitrogen Dioxide Concentrations Across Area A in 2016 – With Development (µg/m^3)

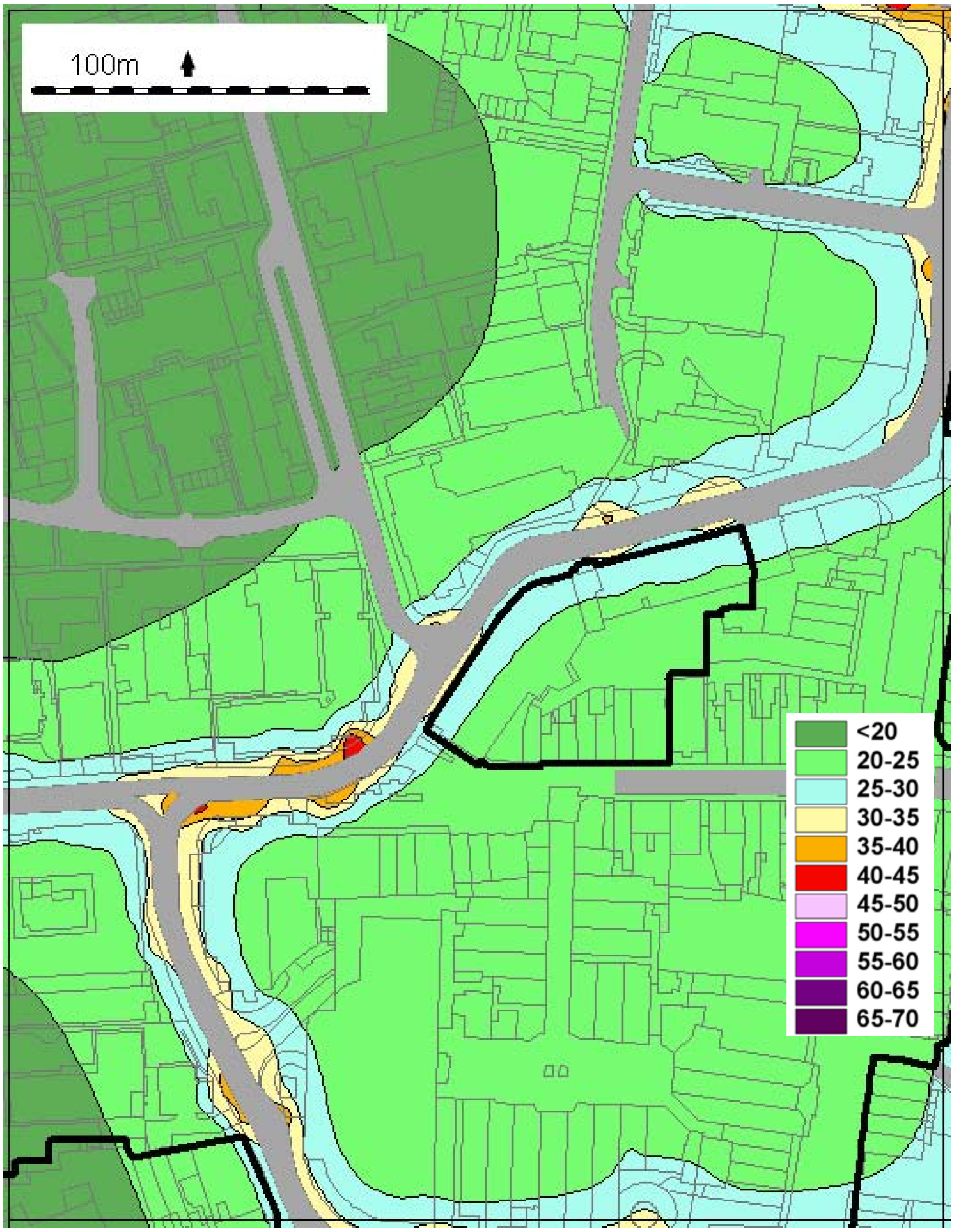


Figure 20: Predicted Annual Mean Nitrogen Dioxide Concentrations Across Area B in 2016 – With Development (μg/m^3)

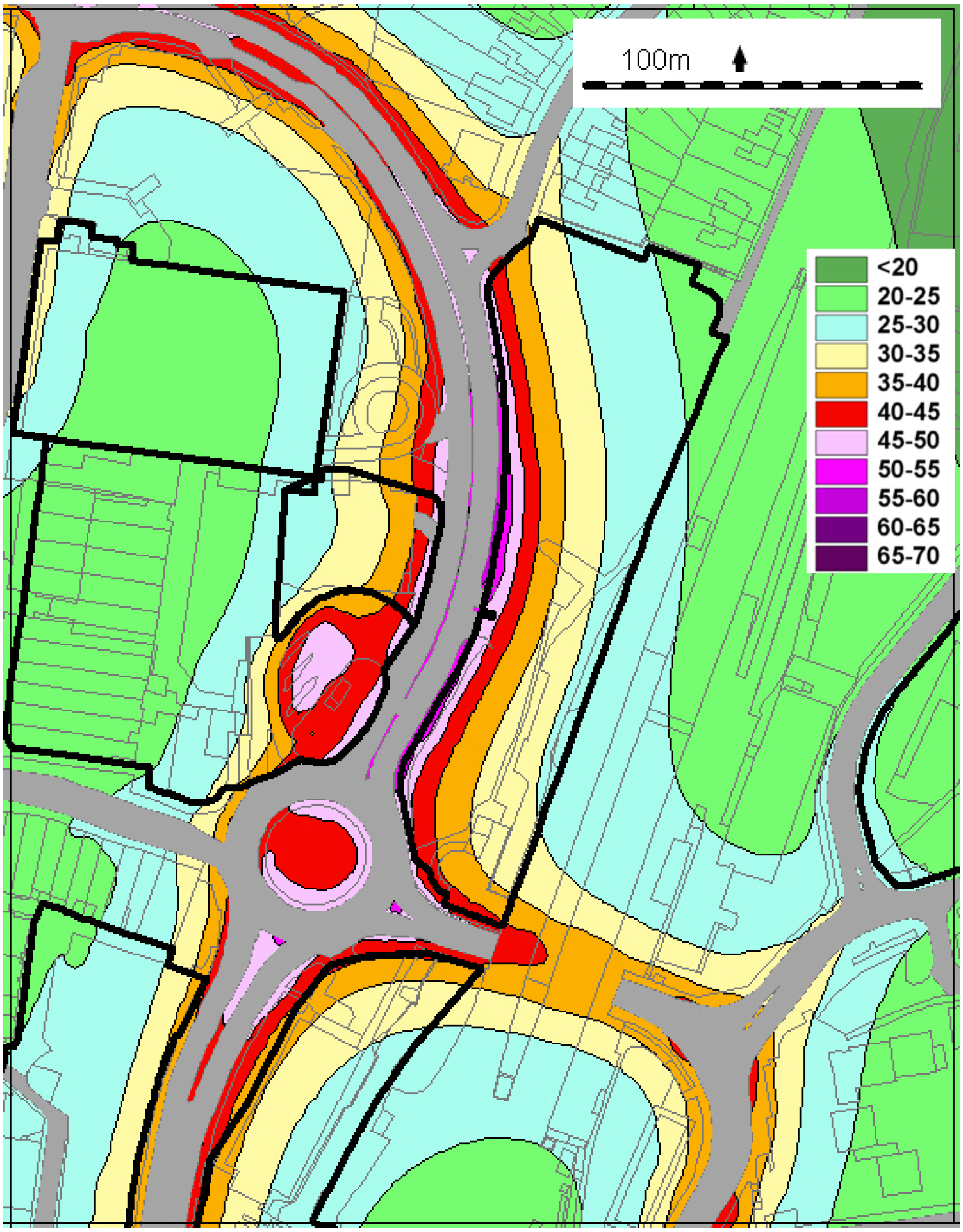


Figure 21: Predicted Annual Mean Nitrogen Dioxide Concentrations Across Area C in 2016 – With Development (µg/m^3)

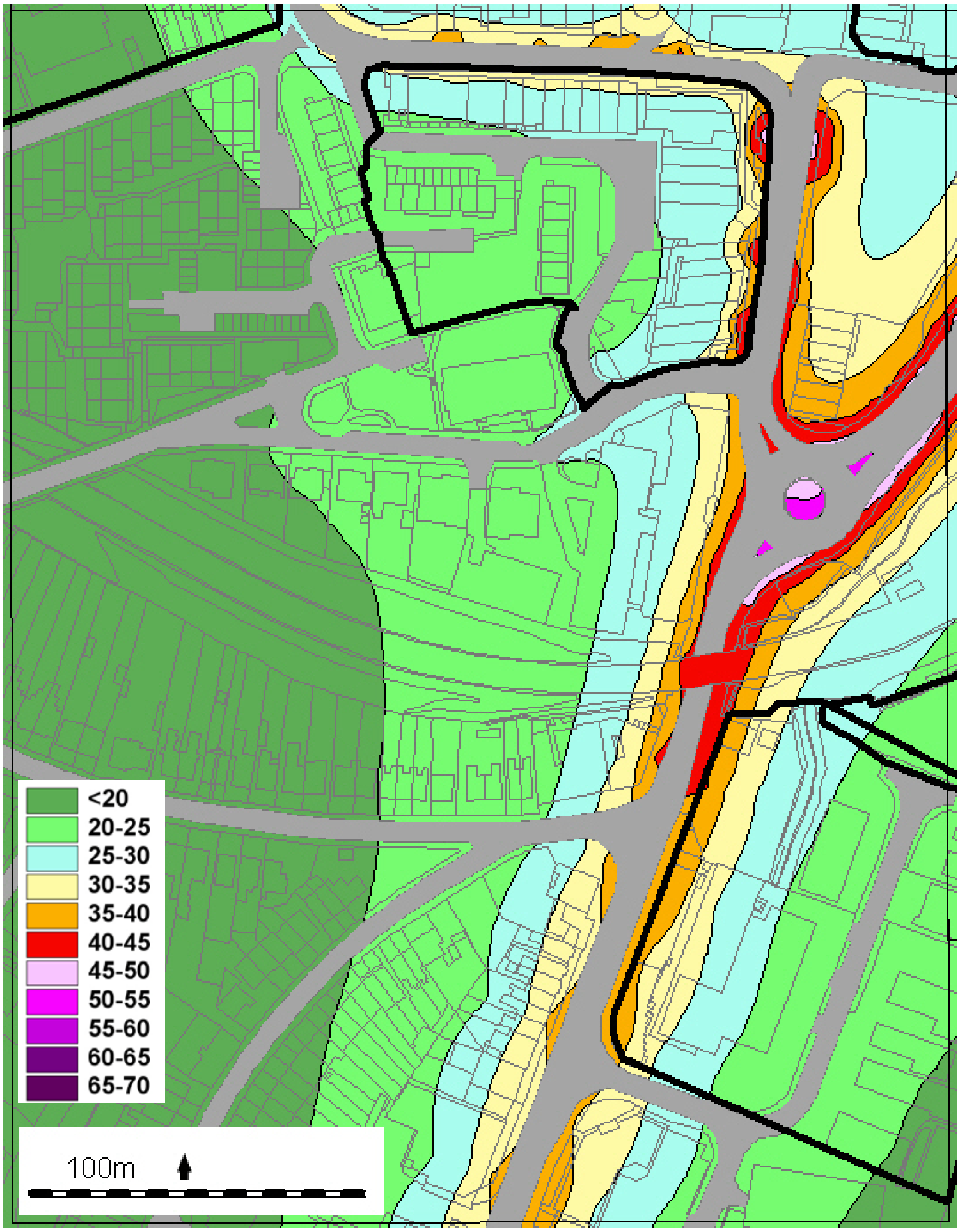


Figure 22: Predicted Annual Mean Nitrogen Dioxide Concentrations Across Area D in 2016 – With Development (µg/m^3)

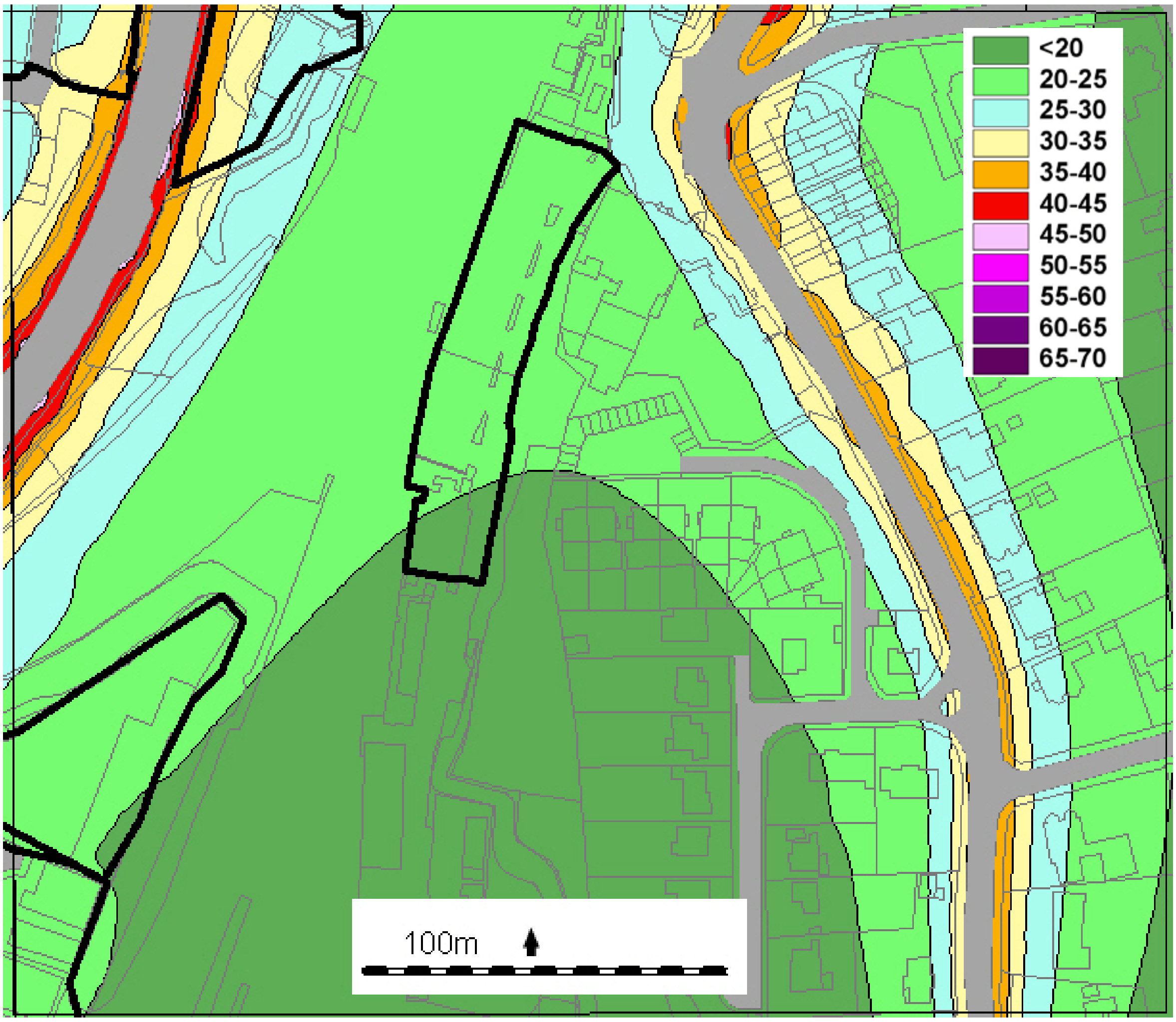


Figure 23: Predicted Annual Mean Nitrogen Dioxide Concentrations Across Area E in 2016 – With Development (µg/m³)

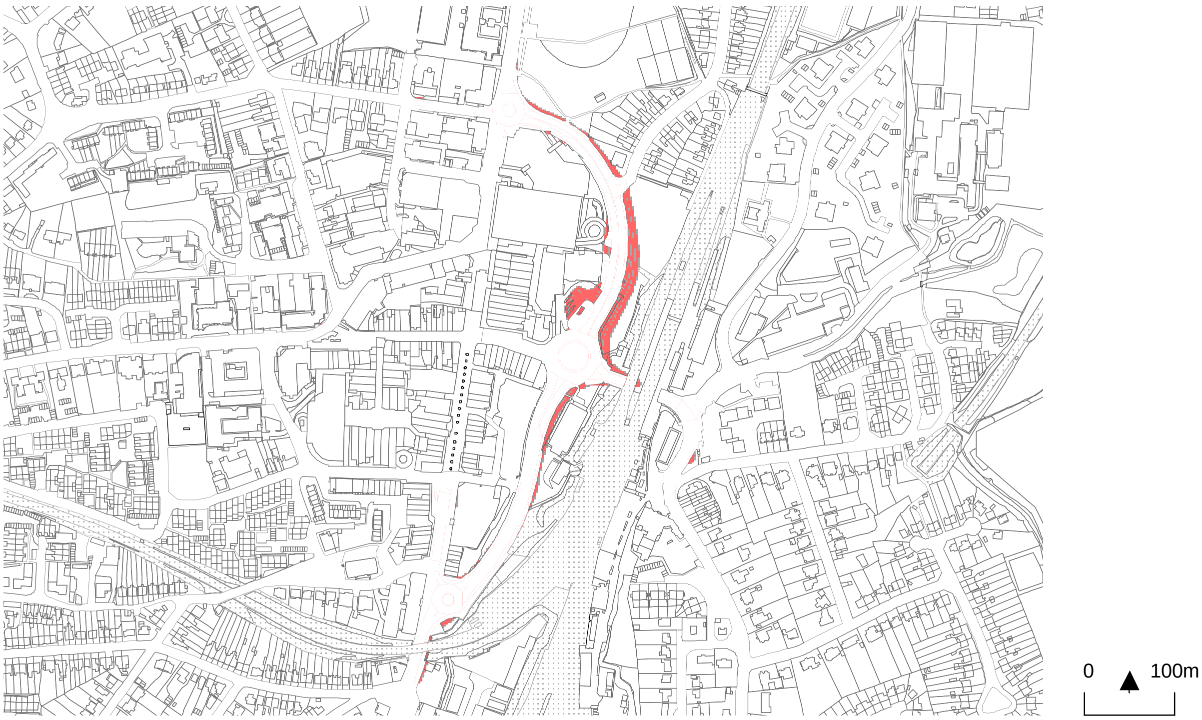


Figure 24: Predicted Exceedences of the 40 μg/m^3 Annual Mean Nitrogen Dioxide Concentration in 2016 in Redhill – With Development (μg/m^3)

A1 Appendix 1 – Summary of Health Effects of Nitrogen Dioxide

Table A1.1: Summary of Health Effects of Nitrogen Dioxide

Pollutant	Main Health Effects
Nitrogen Dioxide	Short-term exposure to high concentrations may cause inflammation of respiratory airways. Long term exposure may affect lung function and enhance responses to allergens in sensitised individuals. Asthmatics will be particularly at risk (Defra, 2007).

A2 Appendix 2 – Reigate Hill Dispersion Modelling Methodology

A2.1 Annual mean concentrations of nitrogen dioxide during 2009 have been modelled using the Atmospheric Dispersion Modelling System for Roads (ADMS Roads, version 2.3). ADMS Roads is one of the dispersion models accepted for modelling within the Government's Technical Guidance (Defra, 2009). A full year of hour-by-hour meteorological data from Gatwick Airport in 2009 was used in the model. Sources not included explicitly in the model were accounted for using the national maps of ambient background concentrations published by Defra during 2010 (Defra, 2010). Annual average emission rates were entered into ADMS. These emission rates were calculated using the Emission Factor Toolkit (EFT V4.1) published by Defra (2010), with the traffic flows described below.

A2.2 Traffic counts were carried out for the A217 in 2009, and these data have been used in the model. Diurnal profiles for the average weekday, Saturday and Sunday were defined from the count data. In addition, data for Rushworth Road, London Road and Castlefield Road to the south of the study area were provided for 2002. The data were projected to the assessment years (2009 and 2015) using growth factors derived from the National Transport Model and associated guidance (DfT, 2007), adjusted to local conditions using the TEMPRO System v6.2 (DfT, 2009). Speeds have been estimated from local speed restrictions, and take account of the proximity to a junction. Information provided on barrier down times for the level crossing were used to determine an average queue length in order to determine a more accurate estimate of speed either side of the level crossing. The traffic data used in the assessment for Reigate Hill are presented in Table A2.1.

Model Verification

A2.3 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 road-NOx concentration during 2009 at the diffusion tube site (RB125) shown in Figure 2.

Table A2.1: AADT Traffic Data[a]

Road Link	2009	2015
A217 north of Raglan Road	22,126 (2.7%)	24,801 (2.6%)
A217 south of Raglan Road	19,485 (3.9%)	21,958 (3.9%)
Castlefield Road	20,738 (3.5%)	23,338 (3.3%)
London Road	21,167 (3.3%)	23,784 (3.0%)
Rushworth Road	5,674 (1.9%)	6,394 (1.9%)

[a] Values in parentheses are proportion Heavy Duty Vehicles

A2.4 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 concentration and the predicted background NO_2 concentration using the recently updated NOx from NO_2 calculator available on the Air Quality Archive website (Defra, 2010).

A2.5 An adjustment factor was determined as the ratio of the 'measured' road contribution and the model derived road contribution. 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 recently updated NOx from NO_2 calculator available on the Air Quality Archive website (Defra, 2010).

A2.6 The data used to calculate the adjustment factor are provided below:

- Measured NO_2: 39.4 μg/m^3
- 'Measured' road-NOx (from NOx to NO_2 calculator): 57.69 μg/m^3
- Modelled road-NOx = 13.16 μg/m^3
- Road-NOx adjustment factor: 57.7/13.2 = **4.383**

A2.7 The factor implies that the model is under-predicting the road-NOx contribution. This is a common experience with this and most other models.

A3 Appendix 3 – Redhill Dispersion Modelling Methodology

A3.1 Road sources were modelled using ADMS-Roads V2.3, while area and volume sources were modelled using ADMS-4.2. As with Reigate Hill, sources not included explicitly were accounted for using the national maps of ambient background concentrations published by Defra during 2010 (Defra, 2010). These maps are published on a 1km x 1km grid resolution. For the Redhill work, these concentrations were interpolated across the study area before a site-specific background value being assigned to each receptor location and intelligent grid point.

A3.2 As with Reigate Hill, a full year of hour-by-hour meteorological data from Gatwick Airport in 2009 were used in the model.

Traffic Data

A3.3 RBBC provided the results from Surrey County Council's micro-simulation traffic model for 2007. The model provided the hourly flow, the proportion of cars, light goods vehicles, heavy goods vehicles, and buses and coaches, as well as modelled hourly average speeds. These data were provided for the following time periods:

- Weekday AM peak hour
- Weekday PM peak hour
- Saturday peak hour

A3.4 For each remaining hour of the week, traffic volumes were interpolated from the modelled data based upon the results of traffic counts carried out on key roads in the town. Speeds during other hours were interpolated from the modelled speeds based upon the typical urban diurnal speed profile published in the 2008 edition of the Department for Transport's Regional Transport Statistics (DfT, 2008)[2].

A3.5 These traffic flows for 2007 were factored to represent 2009 conditions using the average ratio of change from two long-term traffic counters situated on key routes into Redhill which provided counts in both 2007 and 2009. It was assumed that flows into and out of the car parks and bus station did not change between 2007 and 2009.

A3.6 The micro-simulation model did not include flows around Hatchlands Roundabout. These were calculated using annual average daily traffic (AADT) flows for the three roads serving the roundabout (Station Road, Hatchlands Road and Linkfield Lane)[3]. The AADT flow for Station Road was taken from the micro-simulation model (with modelled flows used to calculate AADT

[2] This information is not yet available for subsequent years.

[3] Apportioning turning movements to the link flows based upon the relative volumes on each link. While this is an approximation, it is unlikely to add significant additional error to the assessment.

following the approach given in paragraph A3.4). The flows for Hatchlands Road and Linkfield Lane were taken from short-term (12-hour and 7-day respectively) counts conducted in 2005, factored to represent conditions in 2009 using the approach recommended by the Review and Assessment helpdesk website (using a combination of the National Traffic Model and TEMPRO (DfT 2007 and 2009)).

Emissions Calculations

A3.7 As explained for Reigate Hill, nitrogen dioxide is predominantly a secondary pollutant and emissions are more conveniently quantified in terms of nitrogen oxides (which is the sum of nitrogen dioxide and nitric oxide). For most of the road network, emissions of nitrogen oxides from each road link during each hour of the week (i.e. each hour was treated separately) were calculated using EFT V4.1. For road links in and around Hatchlands roundabout (for which only AADT flows were available), annual average emission rates were calculated using EFT V4.1.

ADMS Model Set-up

Inputting Emissions into ADMS

A3.8 The hour-by-hour emissions data described in paragraph A3.7 were used to calculate an annual average hourly emission, and a weekly diurnal **emissions** profile for each link. The annual average hourly emissions for each link were input directly into ADMS-Roads V2.3. The link-specific diurnal emissions profiles were assigned within ADMS using ".fac" files. For the links around Hatchlands roundabout, the annual average emission rate was accompanied in the model by a national diurnal flow profile published in the 2008 edition of the Department for Transport's Regional Transport Statistics (DfT, 2008)[2].

A3.9 Emissions from vehicles using car parks were calculated assuming an average speed of 5 kph across the distances described in paragraph A3.13. It was assumed that all of the vehicles exiting car parks would have cold engines. Emissions from these vehicles were thus adjusted using the new EXEMPT tool for cold-start emissions which is published by Defra (2010). These aggregated emissions were then spread equally across the area and volume sources described in paragraph A3.13.

A3.10 For the bus station, the traffic model predicted the number of buses entering and exiting the station. It was assumed that on average buses would spend 5 minutes in the bus station with their emissions equivalent to those of a bus travelling at 5kph. Since emissions (expressed as grammes per second) are likely to be considerably lower from an idling bus than from one travelling at 5kph, this assumption may have caused emissions from the bus station to be over-predicted.

ADMS Source Geometry

A3.11 Each road link in the traffic model was assigned a real-world geometry using Ordnance Survey Mastermap data. Road widths were determined using a combination of Ordnance Survey data and aerial photographs. Canyon heights were estimated based on details of the number of storeys of each roadside building provided by Reigate and Banstead BC.

A3.12 Redstone Hill was estimated to have a gradient of 6.25% and the emissions for this road were adjusted to account for this following the method set out by Defra (2009). None of the other roads are sufficiently steep for this method to be required.

A3.13 Emissions from surface car parks and top floors of multi-storey car parks were modelled as area sources. Emissions from other storeys of multi-storey car parks were modelled as volume sources with an initial dispersion depth of 2m positioned along those edges of the carparks which are not enclosed. The traffic model provided flows into, and out of, each car park. A number of assumptions were made regarding the relative proportion of vehicles accessing each floor, and the distance travelled by a typical car on each floor. These assumptions were based on observations made by RBBC, details of car park surveys provided by RBBC, a detailed examination of aerial photographs, and experience of other multi-storey car parks. The assumptions made were specific to each car park and professional experience suggests that they will have had a negligible impact on the predicted concentrations. They are thus not set out in detail.

A3.14 The bus station was entered into the model as an area source, with the emissions described in paragraph A3.10 spread evenly.

Model Verification

A3.15 The model has been run to predict the annual mean NOx concentrations during 2009 at all of the Redhill diffusion tube monitoring sites described in the main report. The model was set up differently around Hatchlands Roundabout than across the rest of the model domain (i.e. AADT flows and speeds were used instead of hour-by-hour flows and speeds). The results were first tested separately (i.e. comparing the model results for diffusion tube site RB141, which is on Hatchlands Roundabout, separately from the other sites). In the end, it was found that site RB141 fits very well with all of the other data and a single verification approach was used across the entire Redhill model domain.

A3.16 The model output of road-NOx (i.e. the component of total NOx coming from road traffic entered into the model as road sources but not including the car parks and bus station which were modelled as area and volume sources) has been compared with the 'measured' road-NOx. Measured road-NOx was calculated first by calculating measured local-NOx (i.e. road-NOx, car park NOx and bus station NOx) from the measured NO_2 concentrations and the predicted background NO_2 concentration using the recently updated NOx from NO_2 calculator available on the Air Quality Archive website (Defra, 2010). Car park NOx and bus station NOx were then both subtracted from the calculated local-NOx to give the measured road-NOx.

A3.17 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 A3.1). This factor was then applied to the modelled road-NOx concentration for each receptor to provide adjusted modelled road-NOx concentrations. Car park and bus station NOx was then added to the adjusted road-NOx to give total modelled local-NOx. The total nitrogen dioxide concentrations were then determined by combining the adjusted modelled local-NOx concentrations with the background NO_2 concentration within the recently updated NOx from NO_2 calculator available on the Air Quality Archive website (Defra, 2010). 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 A3.2).

A3.18 The following primary and secondary adjustment factors have been applied to all modelled nitrogen dioxide data:

Primary adjustment factor : 2.1354

Secondary adjustment factor: 0.9954

A3.19 The results imply that the model was under-predicting the road-NOx contribution. This is a common experience with this and most other models. The final NO_2 adjustment is minor.

A3.20 Figure A3.3 compares final adjusted modelled total NO_2 at each of the monitoring sites, to measured total NO_2, and shows a 1:1 relationship. As noted above, the model performs well at site RB141, despite Hatchlands Roundabout using different traffic data than the rest of the model domain. The model over-predicts concentrations at site RB140 but the difference is less than 25% and overall the adjusted model is considered to perform very well.

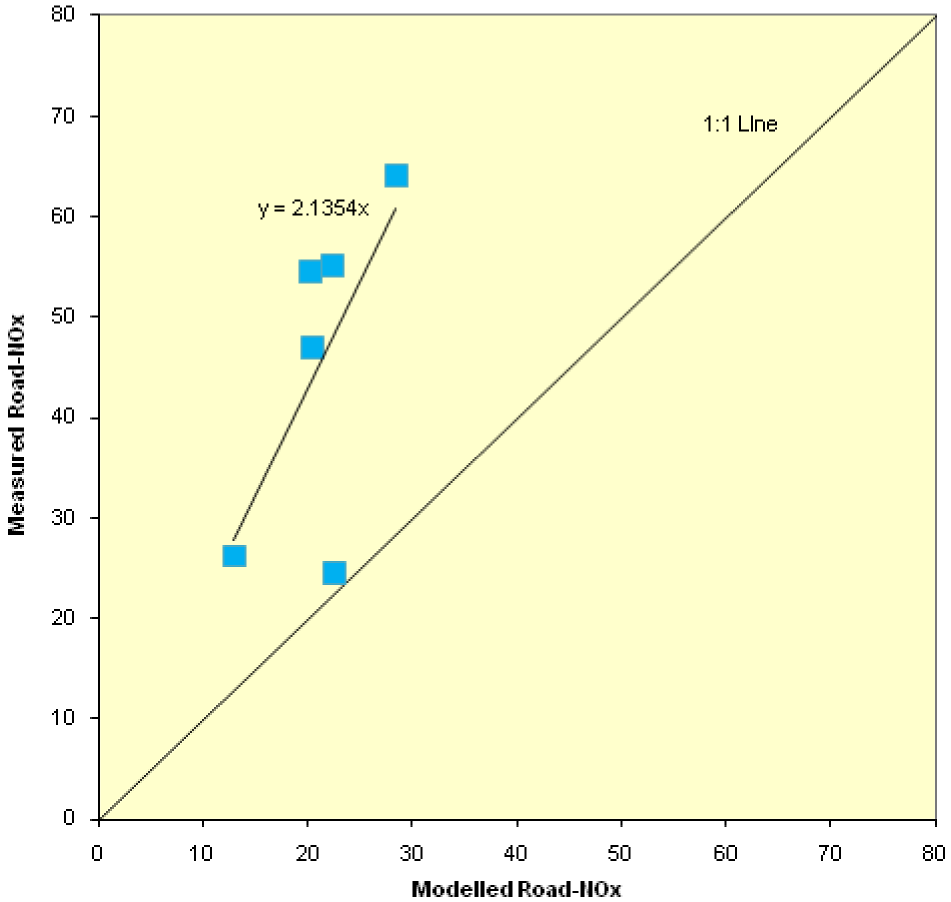


Figure A3.1: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations

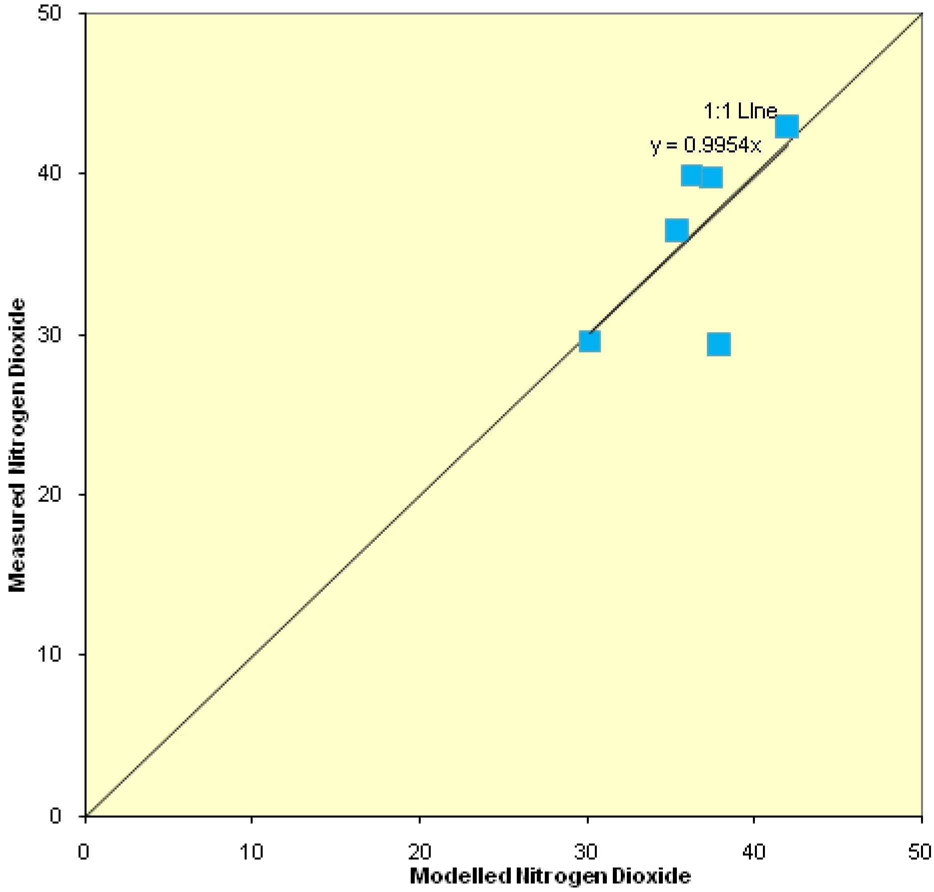


Figure A3.2: Comparison of Measured Total NO_2 to Primary Adjusted Modelled Total NO_2 Concentrations

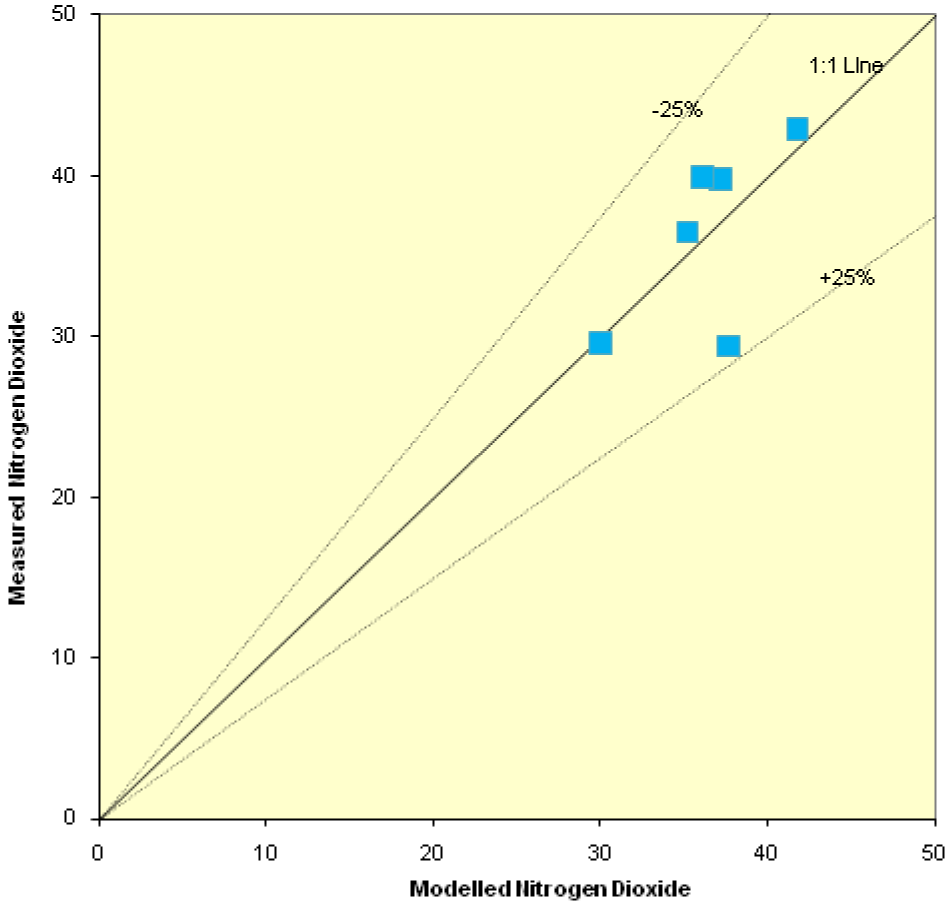


Figure A3.3: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations