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Detailed Assessment of Nitrogen Dioxide in the Watford Air Quality Management Areas (2015)

Report for Watford Borough Council

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Executive summary

Ricardo Energy & Environment has been commissioned by Watford Borough Council to undertake a Detailed Assessment of Nitrogen Dioxide (NO_2) within the following Air Quality Management Areas (AQMA's) in Watford:

- Watford AQMA 1 (St Albans Road)
- Watford AQMA 2 (Vicarage Road)
- Watford AQMA 3A (Aldenham Road/Chalk Hill)
- Watford AQMA 5 (A405 / Horseshoe Lane)

The assessment has been undertaken to investigate the scale and extent of potential exceedances of the National Air Quality Objectives within each AQMA. This aims to provide Watford Borough Council with sufficient evidence to allow them to revoke any of the AQMA's; or otherwise confirm or revise the boundaries of the existing AQMA's

This report describes a dispersion modelling study of road traffic emission within the Watford AQMAs conducted to allow a detailed assessment of NO_2 concentrations. A combination of the available diffusion tube monitoring data and atmospheric modelling using ADMS-Roads has been used to conduct the study. The model utilises the latest available traffic and meteorological data for 2015.

The modelling study has indicated the following:

- In AQMA1 there are no predicted exceedances of the 40 µg/m^3 annual mean objective at any ground level or 1st floor height locations where there is relevant human exposure present. **Watford Borough Council may wish to consider revoking the boundary of AQMA1.**
- In AQMA2 the results indicate that there may be exceedances of the NO_2 annual mean objective at up to 7 residential properties at ground level, some of which are within the current AQMA boundary. The results also indicate that there are exceedances of the objective at locations on Vicarage Road and Banbury Street which are not within the existing AQMA boundary. **Watford Borough Council should consider revising the boundary of AQMA2 to include these locations.**
- In AQMA3A the results indicate that there may be exceedances of the NO_2 annual mean objective at up to 56 residential properties at both ground level and first floor height. Most of which are within the existing AQMA3A boundary with the exception of some properties on Lower High St, Pinner Road, Aldenham Road and Chalk Hill. **Watford Borough Council should consider revising the boundary of AQMA3A to include these locations.**
- In AQMA5 there are no predicted exceedances of the 40 µg/m^3 annual mean objective at any ground level or 1st floor height locations where there is relevant exposure. **Watford Borough Council may wish to consider revoking the boundary of AQMA5.**

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Appendices

1 Introduction

Ricardo Energy & Environment has been commissioned by Watford Borough Council to undertake a Detailed Assessment of Nitrogen Dioxide (NO_2) within the following Air Quality Management Areas (AQMA's) in Watford:

- Watford AQMA 1 (St Albans Road)
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The assessment has been undertaken to investigate the scale and extent of potential exceedances of the National Air Quality Objectives within each AQMA. This aims to provide Watford Borough Council with sufficient evidence to allow them to revoke any of the AQMA's; or otherwise confirm or revise the boundaries of the existing AQMA's

1.1 Policy Background

The Environment Act 1995 placed a responsibility on the UK Government to prepare an Air Quality Strategy (AQS) for England, Scotland, Wales and Northern Ireland. The most recent version of the strategy (2007) sets out the current UK framework for air quality management and includes a number of air quality objectives for specific pollutants.

The 1995 Act also requires that Local Authorities "Review and Assess" air quality in their areas following a prescribed timetable. The Review and Assessment process is intended to locate and spatially define areas where the AQS objectives are not being met. In such instances the Local Authority is required to declare an Air Quality Management Area (AQMA) and develop an Air Quality Action Plan (AQAP) which should include measures to improve air quality so that the objectives may be achieved in the future. The timetables and methodologies for carrying out Review and Assessment studies are prescribed in Defra's Technical Guidance – LAQM.TG(16).

Table 1 NO_2 Objectives included in the Air Quality Regulations and subsequent Amendments for the purpose of Local Air Quality Management the objectives relevant to this assessment that are included in the Air Quality Regulations 2000 and (Amendment) Regulations 2002 for the purposes of Local Air Quality Management (LAQM).

Table 1 NO_2 Objectives included in the Air Quality Regulations and subsequent Amendments for the purpose of Local Air Quality Management

Pollutant	Air Quality Objective Concentration	Measured as
Nitrogen dioxide	200 $\mu g.m^{-3}$ not to be exceeded more than 18 times a year	1 hour mean
	40 $\mu g.m^{-3}$	Annual mean

1.2 Locations where the objectives apply

When carrying out the review and assessment of air quality it is only necessary to focus on areas where the public are likely to be regularly present and are likely to be exposed over the averaging period of the objective.

Table 2 Examples of where the NO_2 Air Quality Objectives should and should not apply

Averaging period	Pollutant	Objectives should apply at…	Objectives should not apply at…
Annual mean	NO_2	Al locations where members of the public might be regularly exposed. Building facades of residential properties, schools, hospitals, care homes etc…	Building facades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short term.
1-hour mean	NO_2	All locations where the annual mean objectives apply. Hotels and gardens of residential properties (should represent parts of the garden where relevant public exposure is likely, local judgement should be applied). Kerbside sites (e.g. pavements of busy shopping streets). Those parts of car parks and railway stations etc. which are not fully enclosed. Any outdoor locations to which the public might reasonably be expected to have access.	Kerbside sites where the public would not be expected to have regular access.

1.3 Purpose of the Detailed Assessment

This study is a Detailed Assessment, which aims to assess the magnitude and spatial extent of any exceedances of the NO_2 annual mean objectives at locations where relevant human exposure may be present within the four AQMAs.

1.4 Overview of the Detailed Assessment

The general approach taken to this Detailed Assessment was:

- Collect and interpret data from previous Review and Assessment reports.
- Collect and analyse recent traffic, monitoring, meteorological and background concentration data for use in a dispersion modelling study.

- Use dispersion modelling to produce numerical predictions of NO_2 concentrations at points of relevant exposure.
- Use dispersion modelling to produce contour plots showing the expected spatial variation in annual mean NO_2 concentrations.
- Recommend if Watford Borough Council should revoke any of the AQMAs or suggest their spatial extent.
- The modelling methodologies provided for Detailed Assessments outlined in the Defra Technical Guidance LAQM.TG(16) were used throughout this study.

2 Detailed Assessment study areas

Watford is a town and Borough within Hertfordshire, located in the south east of England. The town is approximately 17 miles northwest of central London and inside the circumference of the M25 motorway.

This Detailed Assessment is concerned with road traffic emissions from the roads within the four following AQMAs:

- Watford AQMA 1 (St Albans Road)
- Watford AQMA 2 (Vicarage Road)
- Watford AQMA 3A (Aldenham Road/Chalk Hill)
- Watford AQMA 5 (A405 / Horseshoe Lane)

The assessment considers road traffic emissions where relevant exposure is present close to the roads.

2.1 Model domains

The study areas comprise of both residential, commercial and public properties with residential flats at first floor height above commercial properties at many locations within the AQMAs. The study areas, including the roads modelled and the extent of the detailed assessment are presented in Figure 1 to Figure 4. The size of each study area is shown in Table 3.

Table 3: Size of each study area

Study area	Size
Study area 1 – AQMA 1	600 m by 1,900 m
Study area 2 – AQMA 2	800 m by 850 m
Study area 3 – AQMA 3A	700 m by 600 m
Study area 4 – AQMA 5	200 m by 200m

Figure 1: Detailed Assessment Study Area 1 – AQMA1

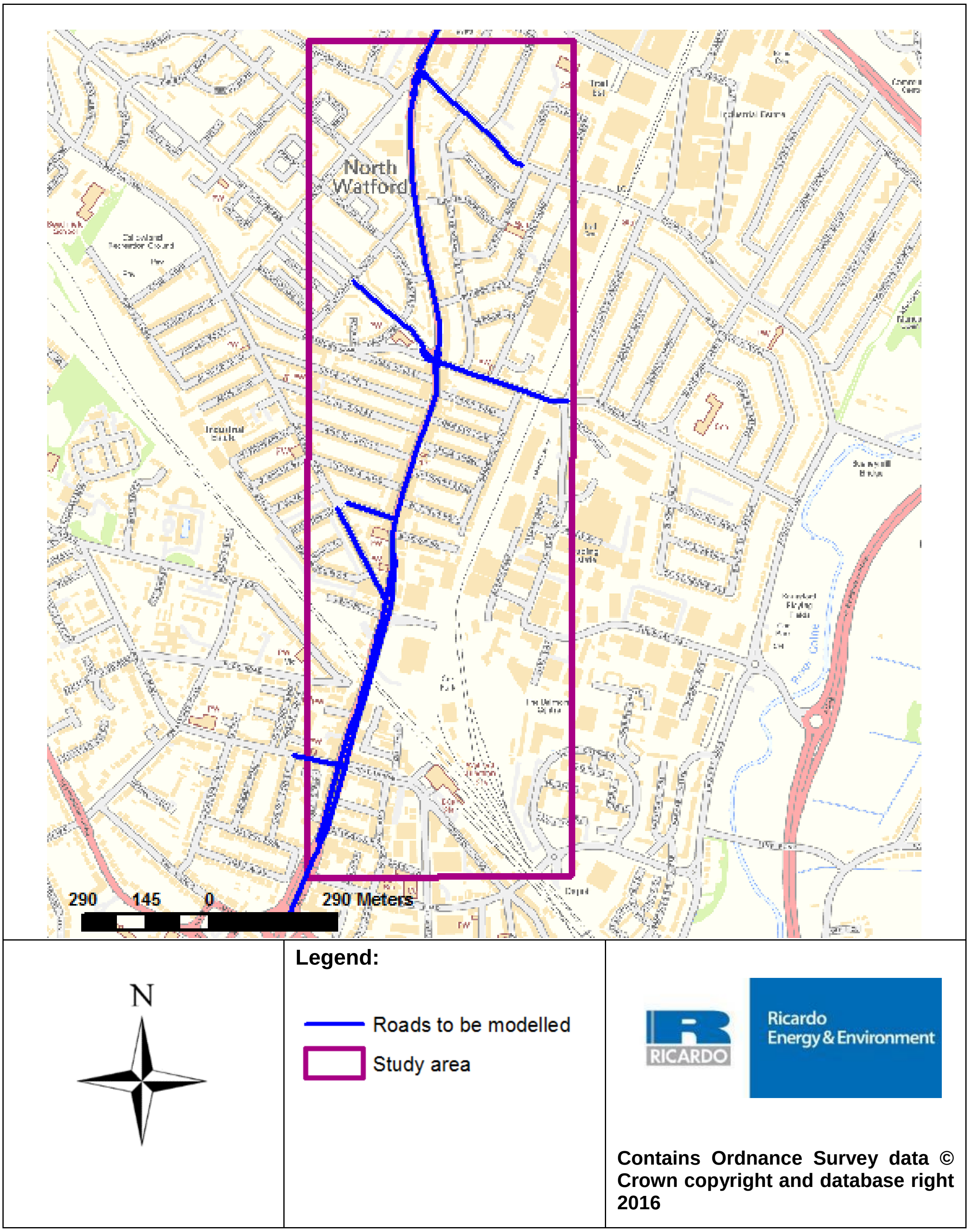
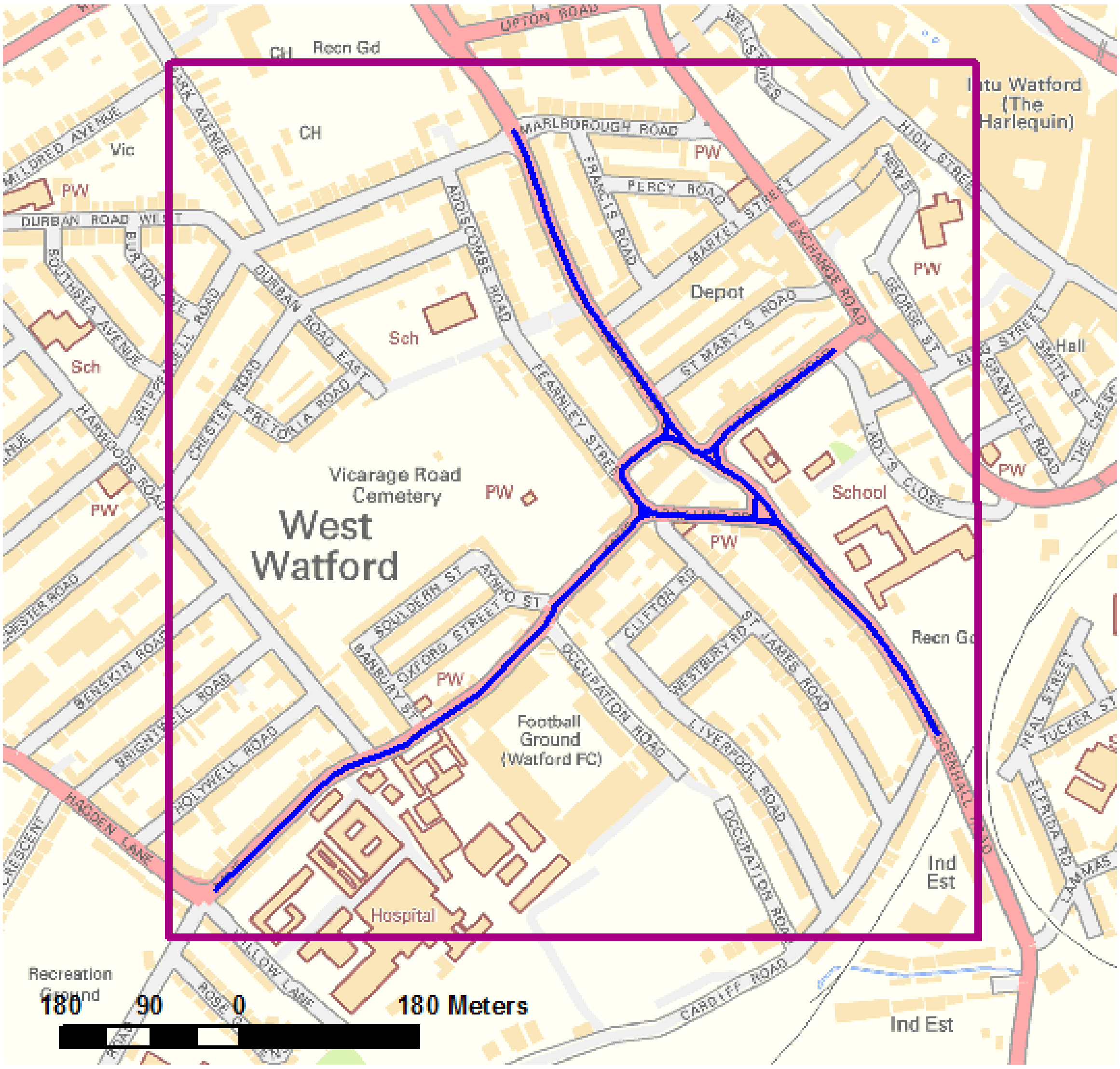


Figure 2: Detailed Assessment Study Area 2 – AQMA2



Legend:

- Roads to be modelled
- Study area

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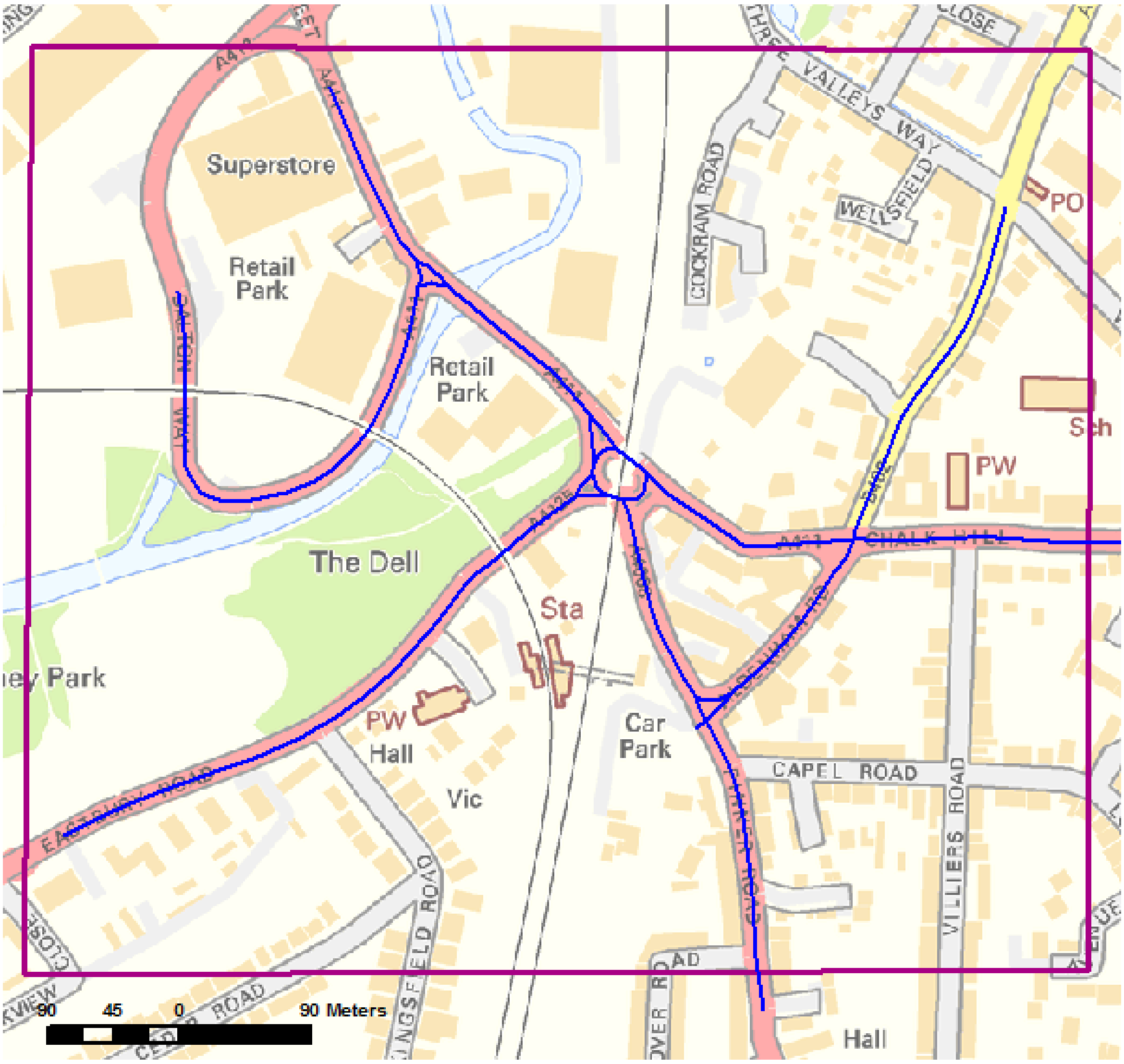
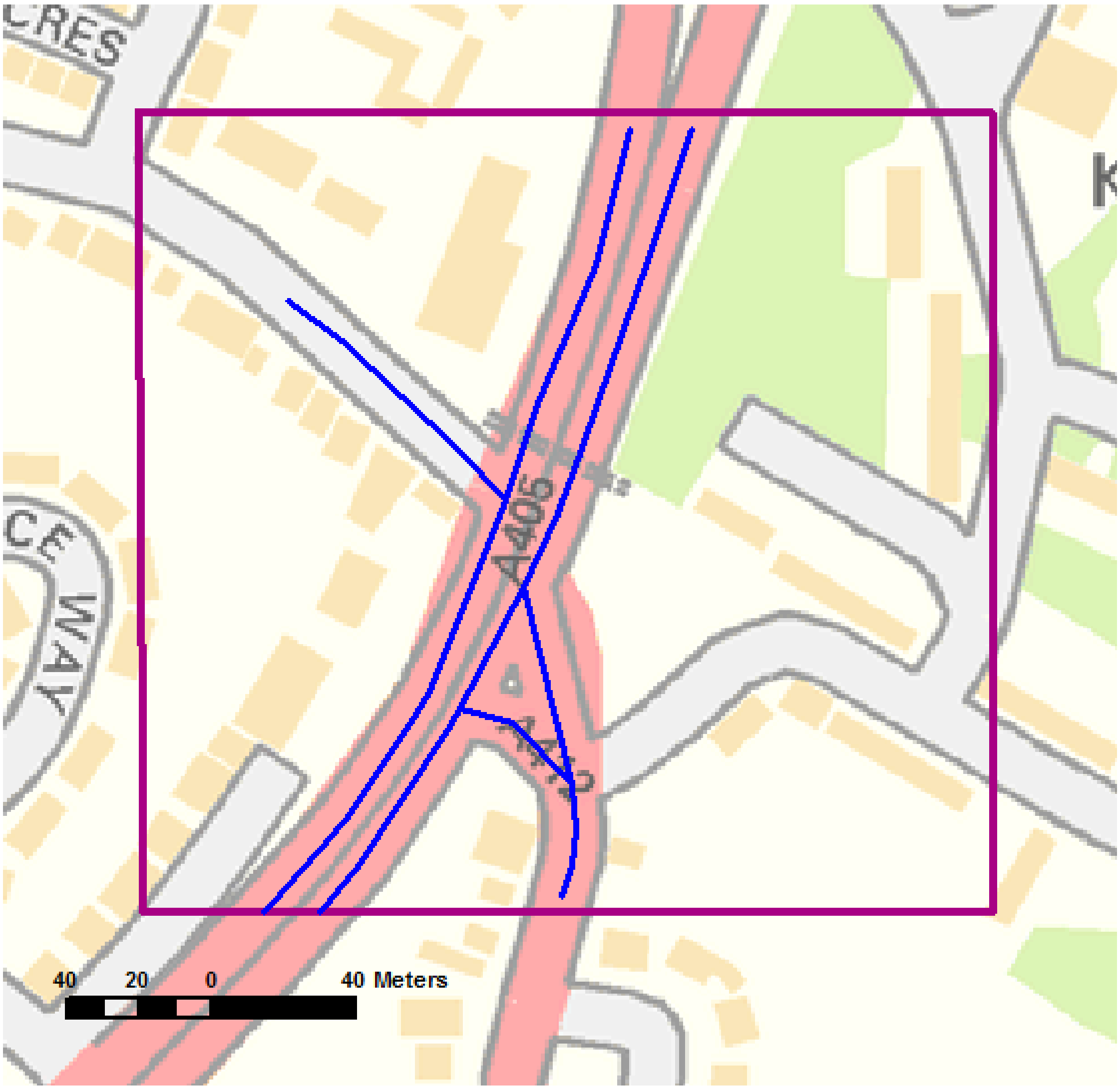
Figure 3: Detailed Assessment Study Area 3 – AQMA3A



Legend:

- Roads to be modelled
- Study area

Figure 4: Detailed Assessment Study Area 4 – AQMA4



Legend:

Roads to be modelled
Study area

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3 Information used for this assessment

3.1 Maps

Ordnance Survey based GIS data of the model domain and a road centreline GIS dataset were used in the assessment. This enabled accurate road widths and the distance of the housing to the kerb to be determined in ArcMap.

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3.2 Road traffic data

3.2.1 Average flow, fleet split and speeds.

Traffic data from the London Atmospheric Emissions Inventory (LAEI)[1] were used for the assessment. 2015 data projected from a base year of 2010 has been used. That data includes annual average daily traffic (AADT) flows for the main roads in London split into five vehicle classifications. The dataset also provides average link speeds based on averaged speed data from GPS enabled vehicles. No assumptions have therefore been made with respect to average traffic speeds.

In addition to the LAEI data, traffic data from the local surveys carried out by Hertfordshire County Council within the Watford Borough boundaries were used where this was available to better reflect the local traffic.

More detail about the traffic data used is presented in Appendix 4.

It should be noted that traffic patterns in urban locations are complex and it is not possible to fully represent these in atmospheric dispersion models. By attempting to describe these complex traffic patterns using quite simple metrics (AADT, average speed and vehicle split composition) a degree of uncertainty is introduced into the modelling.

3.2.2 Congestion

During congested periods average vehicle speeds reduce when compared to the daily average; the combination of slower average vehicle speeds and more vehicles lead to higher pollutant emissions during peak hours; it's therefore important to account for this when modelling vehicle emissions to estimate pollutant concentrations.

No queue observation data are available in the LAEI data. The LAQM.TG(16) guidance states that the preferred approach to representing the resulting increase in vehicle emissions during these peak periods is to calculate the emission rate for the affected roads for each hour of the day or week, on the basis of the average speed and traffic flow for each hour of the day. The hourly specific emission rates can then be used to calculate a 24-hr diurnal emission profile which can be applied to that section of road. As no hourly speed data was available, a 24-hr diurnal emission profile could not be calculated.

No local diurnal traffic flow data was available either, therefore the 2014 traffic distribution by time of day on all roads in Great Britain has been used to calculate a diurnal traffic flow profile[2]. Peak periods in traffic flow were therefore accounted for in the model by applying the typical diurnal traffic flow profile to the average hourly emission rate assuming an average daily vehicle speed as available in the LAEI data.

[1] http://data.london.gov.uk/dataset/london-atmospheric-emissions-inventory-2010
[2] TRA0308 Traffic distribution on all roads by the time of day in Great Britain, https://www.gov.uk/government/statistical-data-sets/tra03-motor-vehicle-flow

3.2.3 Vehicle emission factors

The latest version of the Emissions Factors Toolkit[3] (EFT V6.0.2 November 2014 release) was used in this assessment to calculate pollutant emission factors for each road link modelled. The calculated emission factors were then imported into the ADMS-Roads model.

Parameters such as traffic volume, speed and fleet composition are entered into the EFT, and an emissions factor in grams of pollutant/kilometre/second is generated for input into the dispersion model. In the latest version of the EFT, NOx emissions factors previously based on DFT/TRL functions have been replaced by factors from COPERT 4 v10. These emissions factors are widely used for the purpose of calculating emissions from road traffic in Europe. Defra recognise these as the current official emission factors for road traffic sources when conducting local, regional and national scale dispersion modelling assessments.

The latest version of the EFT also includes addition of road abrasion emission factors for particulate matter; and changes to composition of the vehicle fleet in terms of the proportion of vehicle km travelled by each Euro standard, technology mix, vehicle size and vehicle category. Much of the supporting data in the EfT is provided by the Department for Transport (DfT), Highways Agency and Transport Scotland.

Vehicle emission projections are based largely on the assumption that emissions from the fleet will fall as newer vehicles are introduced at a renewal rate forecast by the DfT. Any inaccuracy in the projections or the COPERT IV emissions factors contained in the EFT will be unavoidably carried forward into this modelling assessment.

3.1 Ambient monitoring

During 2015 Watford Borough Council measured NO_2 concentration at twelve diffusion tube sites within the four study areas. Further details of these monitoring locations and recent measured concentrations are provided in Section 4.

3.2 Meteorological data

Hourly sequential meteorological data (wind speed, direction etc.) for 2015 measured at the Northolt Airport site was used for the modelling assessment. The meteorological measurement site is located approximately 12.5 km south of the study area and has good data quality for the period of interest.

Meteorological measurements are subject to their own uncertainty which will unavoidably carry forward into this assessment.

3.3 Background concentrations

Background pollutant concentrations for a dispersion modelling study can be accessed from either local monitoring data conducted at a background site or from the Defra background maps[4]. The Defra background maps are the outputs of a national scale dispersion model provided at a 1km x 1km resolution and are therefore subject to a degree of uncertainty.

In this case there are no urban background monitoring sites in Watford therefore the mapped background NOx concentrations for the relevant 1 km x 1km grid square were used. The mapped annual mean background NOx concentration for 2014 are shown for each study area in Table 4.

Table 4: 2014 Background concentrations in each study area

Study area	Background concentration ($\mu g.m^{-3}$)
Study area 1 – AQMA 1	30.5
Study area 2 – AQMA 2	30.8
Study area 3 – AQMA 3A	28.5

[3] http://laqm.defra.gov.uk/review-and-assessment/tools/emissions.html#eft
[4] Defra (2012) http://laqm1.defra.gov.uk/review/tools/background.php (accessed September 2012)

Study area 4 – AQMA 5	29.0

4 Monitoring data 2015

Watford Borough Council currently measures NO_2 concentrations within the study areas at 12 diffusion tube sites. The location of each diffusion tube is presented in Figure 5 to Figure 9.

Details of the NO_2 diffusion tube monitoring sites and the annual mean NO_2 concentrations measured during 2015 are presented in Table 5.

Annual mean NO_2 concentrations in excess of the 40 $\mu g.m^{-3}$ objective were measured during 2015 at 5 sites within AQMAs 2, 3A and 5. They are all located between 2 and 6 m of relevant exposure. For the past few years, NO_2 concentrations measured at these diffusion tube locations have been above the objective.

The national bias adjustment factor of 0.81 has been used to adjust the raw 2015 NO_2 measured concentrations at the diffusion tube locations. Further information on QA/QC of the measurements is provided in the 2015 LAQM Updating & Screening Assessment[5].

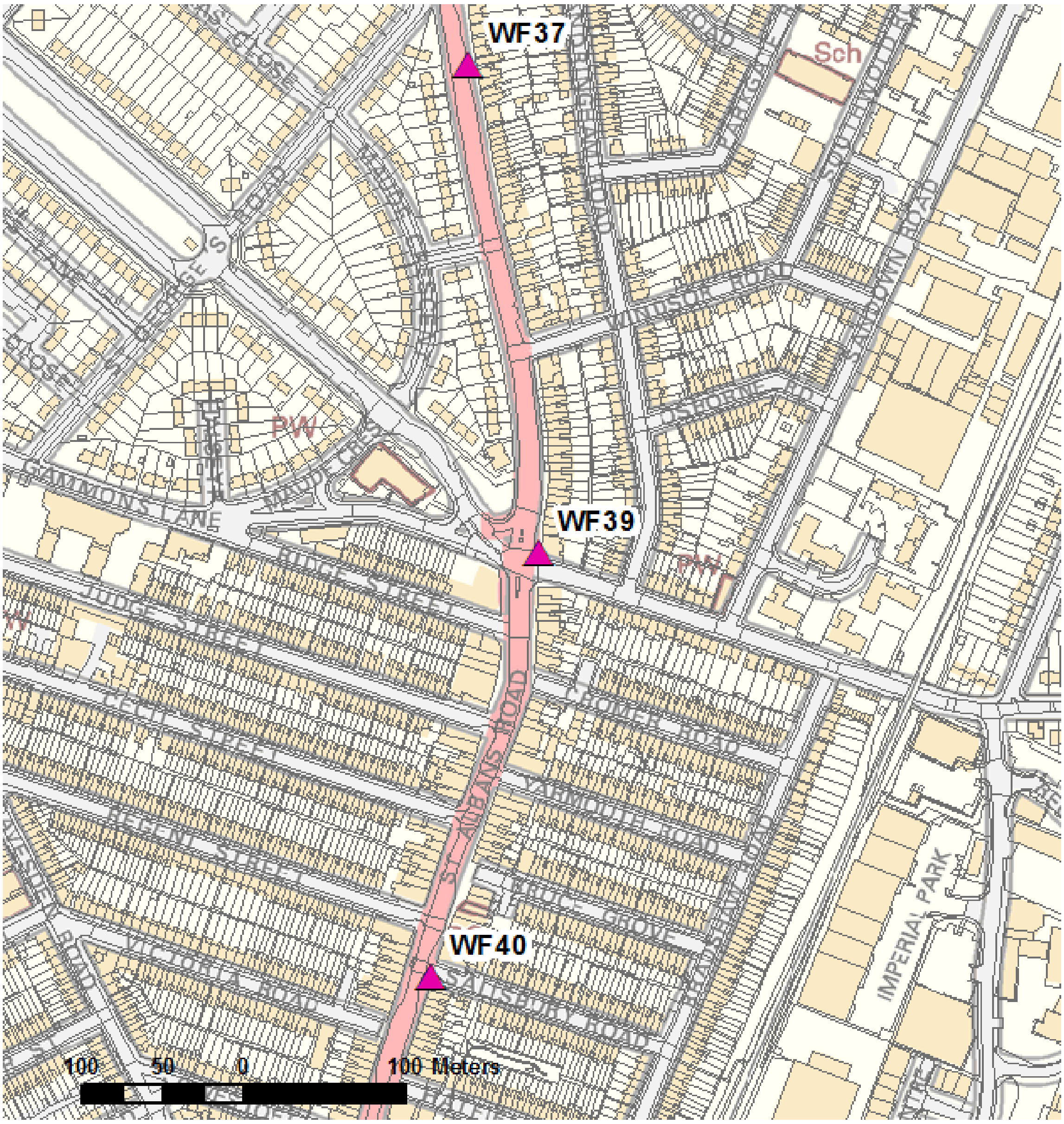
Table 5: NO_2 diffusion tube measurements 2015

Site	Type	Within AQMA	Easting	Northing	Data Capture 2015 (%)	Bias corrected (0.81) annual mean 2015 ($\mu.m^{-3}$)*
WF37	K	AQMA 1	510962	198589	75 %	32.2
WF39	K	AQMA 1	511004	198288	100 %	36.8
WF40	K	AQMA 1	510938	198026	100 %	33.5
WF41	K	AQMA 1	510869	197758	100 %	32.6
WF45	K	AQMA 1	510752	197235	100 %	32.0
WF03	K	AQMA 2	510568	195796	100 %	35.2
WF43	K	AQMA 2	510812	196014	100 %	**45.4**
WF47	R	AQMA 2	510335	195610	100 %	29.9
WF29	K	AQMA 3A	511947	195311	100 %	**48.8**
WF44	K	AQMA 3A	511919	195458	100 %	**71.6**
WF48	R	AQMA 3A	511731	195617	75 %	**45.0**
WF38	K	AQMA 5	511679	200700	100 %	**41.4**

Exceedances of the annual mean objective in rose cells
R – Roadside monitoring location, 1-5m from the kerb of a busy road
K – Kerbside monitoring location, within 1m of the kerbside of a busy road
***All concentration are non-distance corrected**

[5] Watford Borough Council (2015) LAQM Updating and Screening Assessment for Watford Borough Council, August 2015.

Figure 5: Diffusion tubes locations – Study Area 1 – AQMA 1 - 1

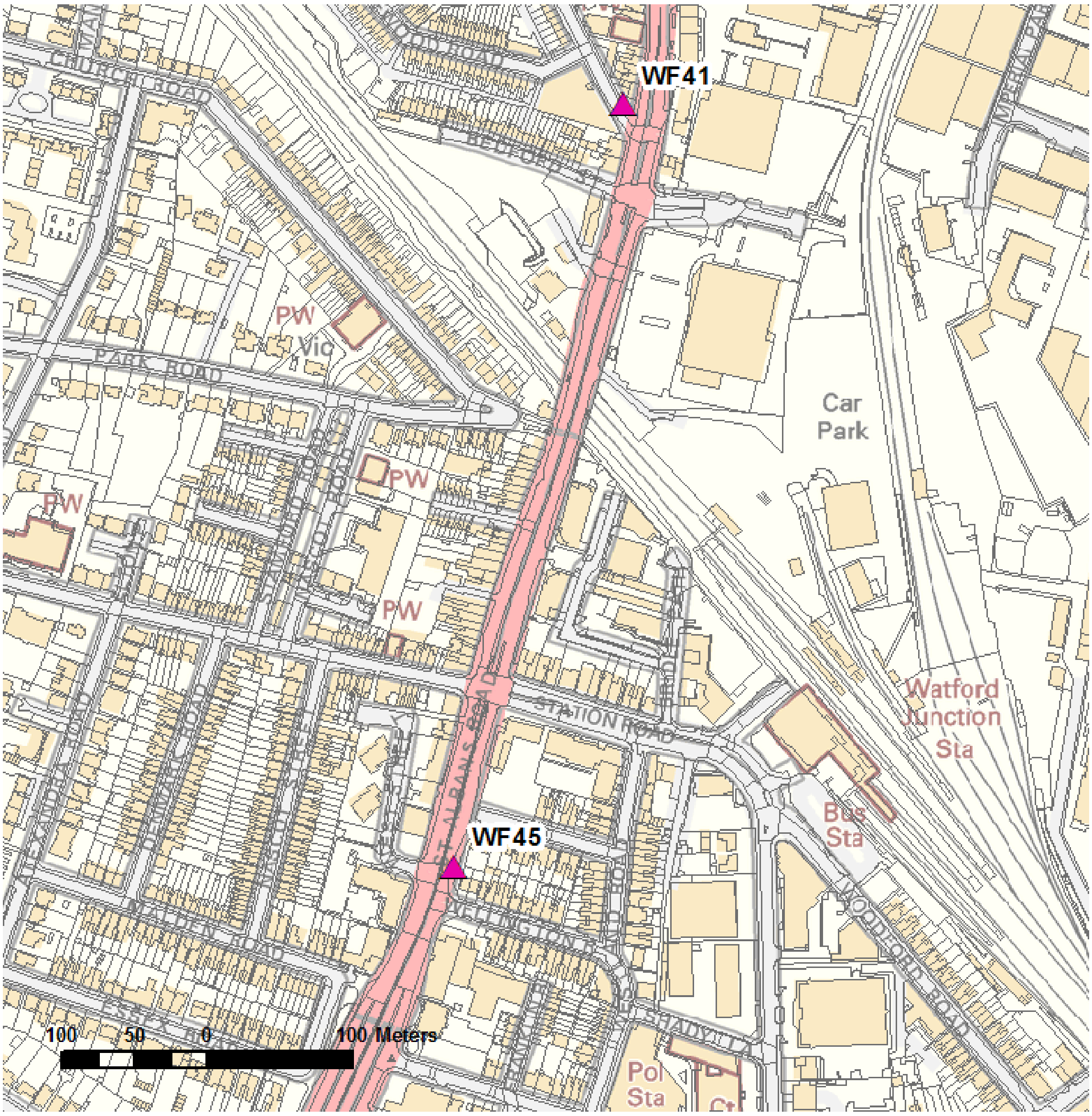


N

Legend:

▲ Monitoring sites

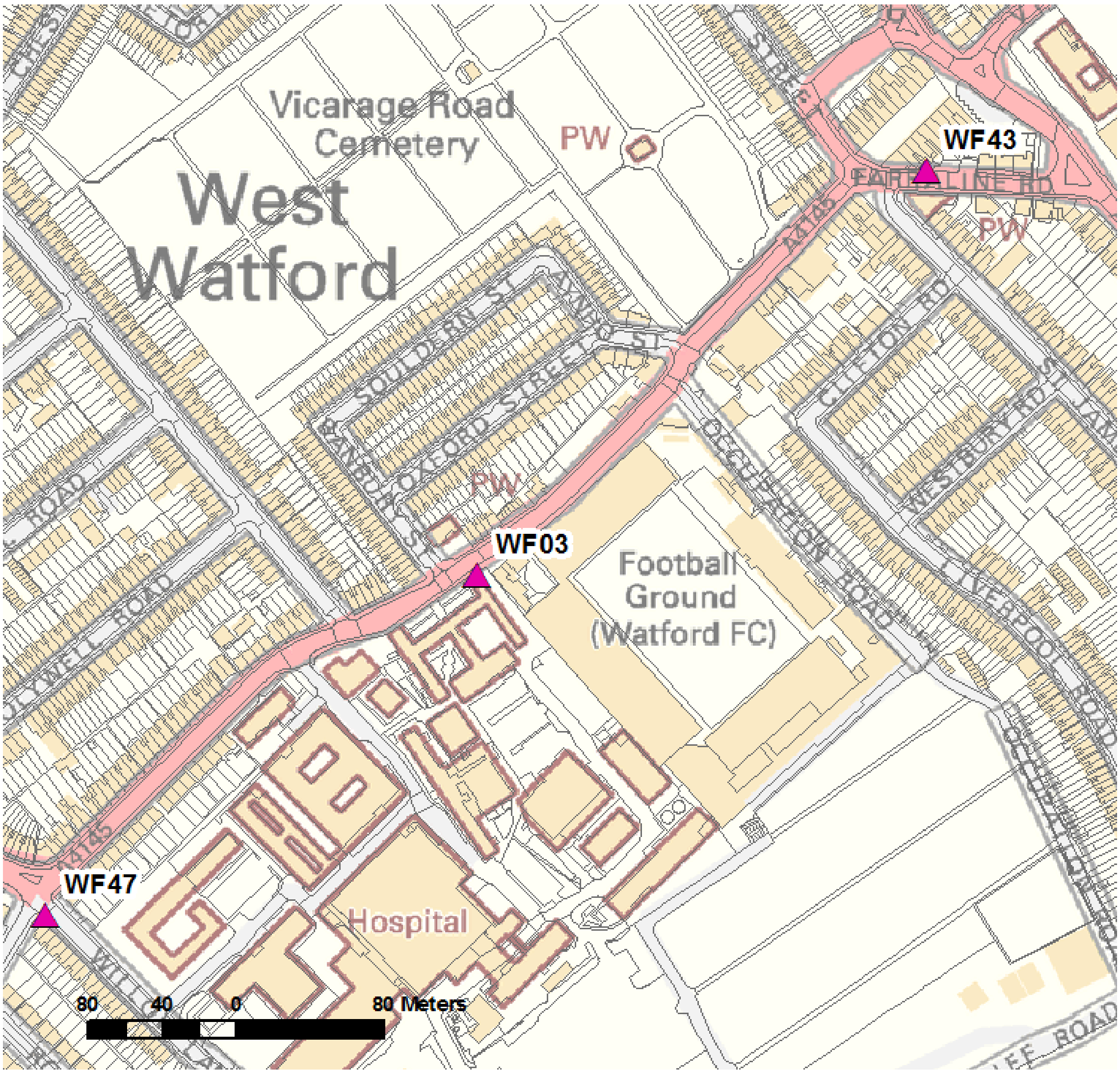
Figure 6: Diffusion tubes locations – Study Area 1 – AQMA 1 - 2



Legend:

Monitoring sites

Figure 7: Diffusion tubes locations – Study Area 2 – AQMA 2

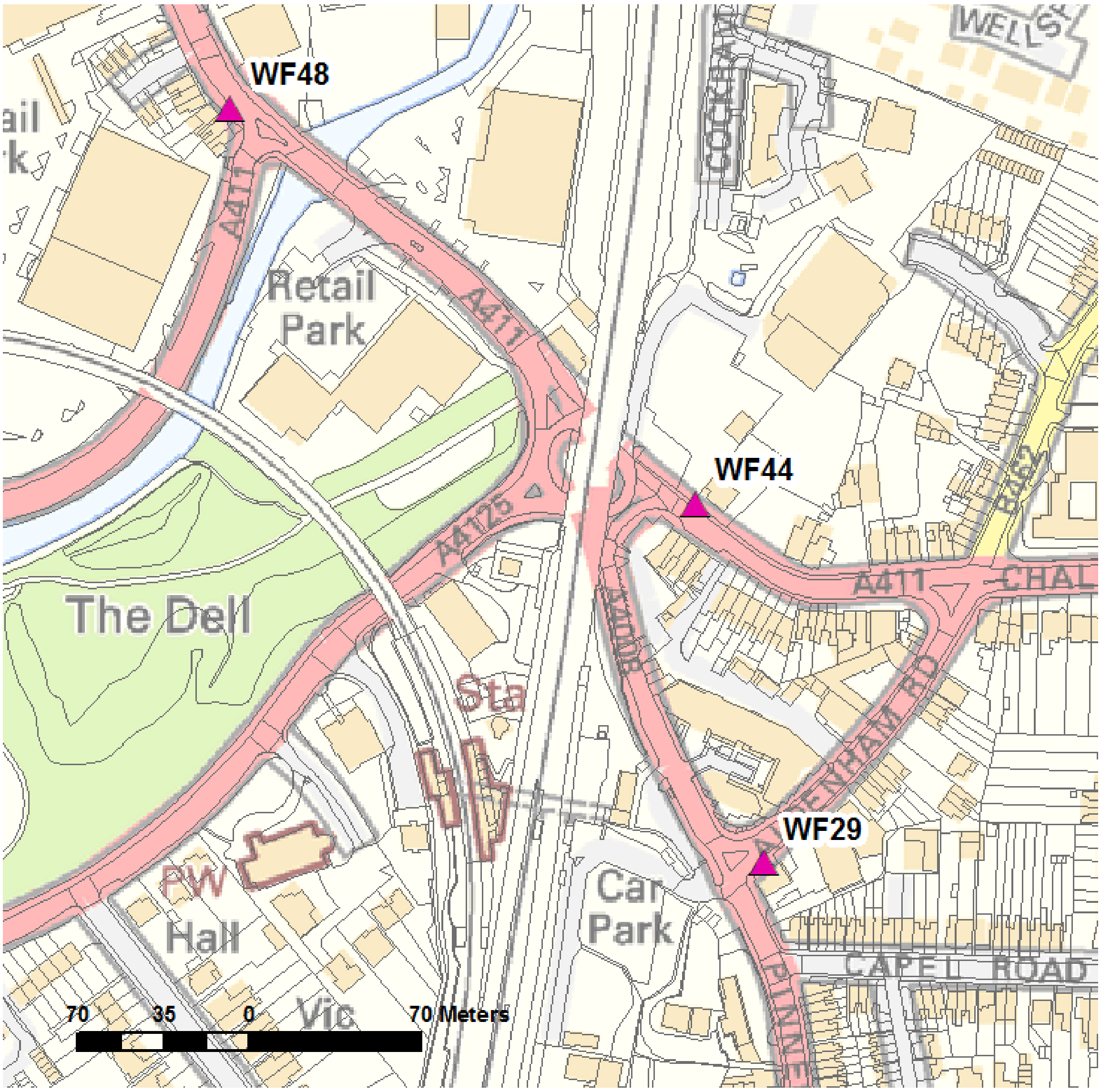


N

Legend:

Monitoring sites

Figure 8: Diffusion tubes locations – Study Area 3 – AQMA 3A

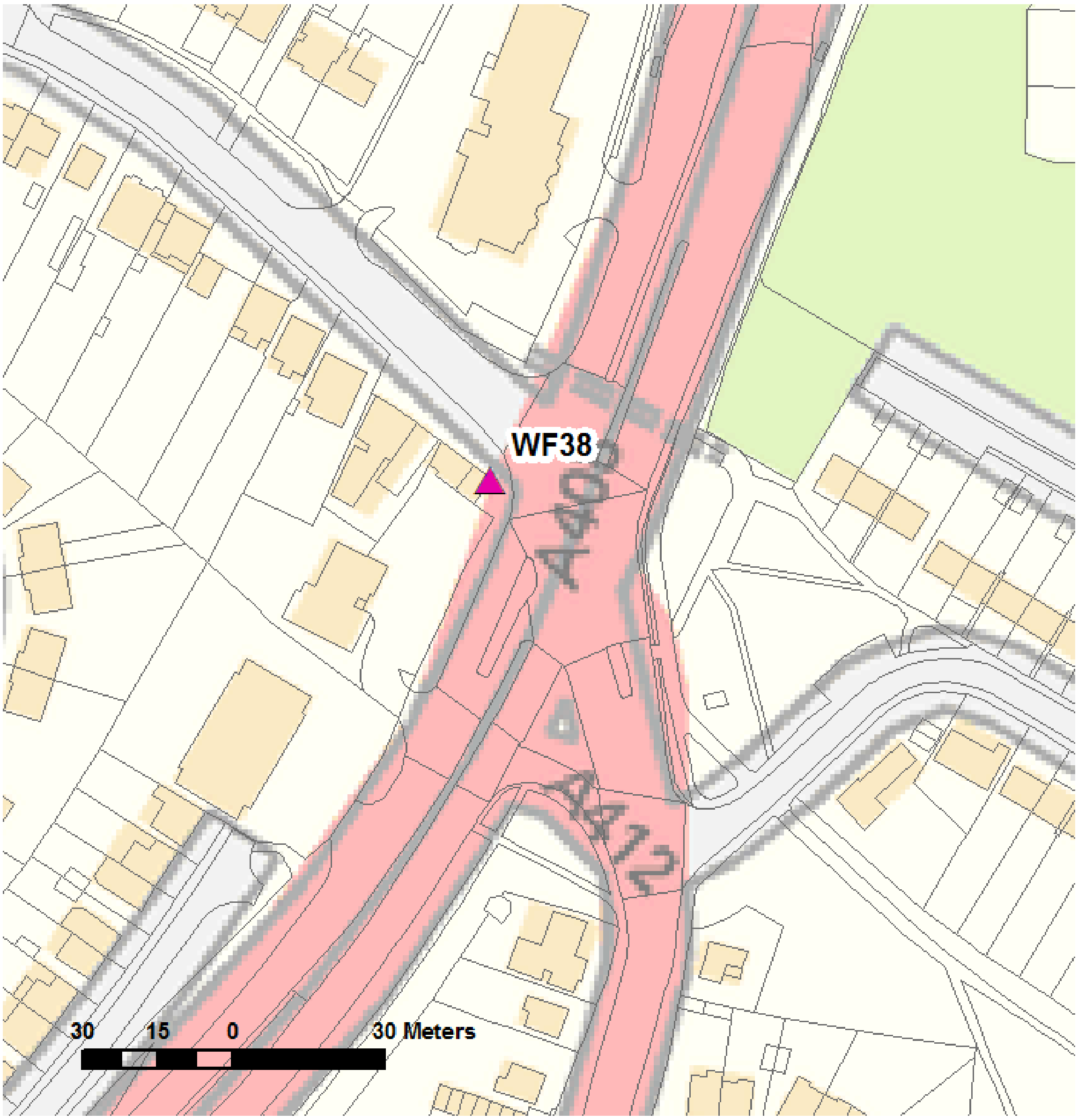


N

Legend:

Monitoring sites

Figure 9: Diffusion tubes locations – Study Area 4 – AQMA 5



Legend:

Monitoring sites

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5 Modelling methodology

NO_2 Annual mean concentrations during 2015 have been modelled within the study areas using the atmospheric dispersion model ADMS Roads (version 3.4).

The model has been verified by comparison of the modelled predictions of road NOx with local monitoring results. The available roadside and kerbside diffusion tube measurements within the study areas (described in Section 4 above) were used to verify the annual mean road NOx model predictions.

Following initial comparison of the modelled concentrations with the available monitoring data, refinements were made to the model input to achieve the best possible agreement with the diffusion tube measurements. Further information on model verification is provided in Section 6.1.1 and Appendix 2.

A surface roughness of 1 m was used in the modelling to represent the city conditions in the model domains. A limit for the Monin-Obukhov length of 30 m was applied to represent a city.

The source-oriented grid option was used in ADMS-Roads, this option provides finer resolution of predicted pollutant concentrations along the roadside, with a wider grid being used to represent concentrations further away from the road, the resolution of which is dependent upon the total size of the domain being modelled. The predicted concentrations were interpolated to derive values between the grid points using the Spatial Analyst tool in the GIS software ArcMap 10. This allows contours showing the predicted spatial variation of pollutant concentrations to be produced and added to the digital base mapping.

Queuing traffic was considered using the methodology described in Section 3.2 above; whereby a time varying emissions file was used in the model to account for daily variations in traffic.

It should be noted that any dispersion modelling study has a degree of uncertainty associated with it; all reasonable steps have been taken to reduce this where possible.

5.1 Treatment of modelled NOx road contribution

It is necessary to convert the modelled NOx concentrations to NO_2 for comparison with the relevant objectives.

The Defra NOx/NO_2 model[6] was used to calculate NO_2 concentrations from the NOx concentrations predicted by ADMS-Roads. The model requires input of the background NOx, the modelled road contribution and accounts for the proportion of NOx released as primary NO_2. For the Watford Borough area in 2014 with the "All other UK urban Traffic" option in the model, the NOx/NO_2 model estimates that 22.7% of NOx is released as primary NO_2.

5.2 Validation of ADMS-Roads

Validation of the model is the process by which the model outputs are tested against monitoring results at a range of locations and the model is judged to be suitable for use in specific applications; this is usually conducted by the model developer.

CERC have carried out extensive validation of ADMS applications by comparing modelled results with standard field, laboratory and numerical data sets, participating in EU workshops on short range dispersion models, comparing data between UK M4 and M25 motorway field monitoring data, carrying out inter-comparison studies alongside other modelling solutions such as DMRB and CALINE4, and carrying out comparison studies with monitoring data collected in cities throughout the UK using the extensive number of studies carried out on behalf of local authorities and Defra.

[6] Defra (2014) NOx NO_2 Calculator v4.1 released June 2014; Available at http://laqm.defra.gov.uk/review-and-assessment/tools/background-maps.html#NOxNO2calc

6 Model Results

6.1 Verification of the model

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. This helps to identify how the model is performing at the various monitoring locations. The verification process involves checking and refining the model input data to try and reduce uncertainties and produce model outputs that are in better agreement with the monitoring results. LAQM.TG(16) recommends making the adjustment to the road contribution of the pollutant only and not the background concentration these are combined with.

The modelled NOx concentrations were verified using the available 2015 NO_2 measurements. Of the available roadside and kerbside diffusion tube sites, two sites were excluded from model verification for the following reasons:

- Diffusion tube site WF47 as there was no available road traffic data at this location
- Diffusion tube site WF44 which was a clear outlier when compared with the model predictions. This may be as the tube appears to be sited within vegetation that has become overgrown, this does not correspond with the sampler siting recommendations in the LAQM technical guidance. We recommend that this tube should either be re-located or the vegetation cleared to allow sufficient air flow around the sampler.

Following various checking and refinements to the model input for each study area; the modelled Road NOx contribution required adjustment by a factor to bring the predicted NO_2 concentrations within close agreement of those results obtained from the monitoring data. The approach outlined in LAQM.TG(16) sections 7.508 – 7.534 (also in Box 7.14 and 7.15)has been used in this case.

The NOx adjustment factors used for each study area are presented in Table 6. These factors were applied to all Road NOx concentrations predicted by the model in each study area; the adjusted total NO_2 concentrations were then calculated using the Defra NOx/NO_2 calculator.

Table 6: Adjustment factors for each study area

Study area	Adjustment factor
Study area 1 – AQMA 1	1.2708
Study area 2 – AQMA 2	1.2254
Study area 3 – AQMA 3A	1.8467
Study area 4 – AQMA 5	2.0640

Following adjustment, the model is in reasonable agreement with the local NO_2 measurements so we are confident that the predicted spatial variation in NO_2 concentrations is also representative of local conditions.

After the NOx/NO_2 model was run no further adjustments were made to the data. Model agreement for the NO_2 monitoring data after adjustment is presented in Table 7. Full model verification data is provided in Appendix 2.

Model uncertainty can be estimated by calculating the root mean square error (RMSE). The RMSE for each study area are presented in Table 7. All of the RMSE calculated after adjustment are within the suggested value (10% of the objective being assessed) in LAQM.TG(16). The models have therefore performed sufficiently well for use within this assessment.

Verifying modelling data with diffusion tube monitoring data will always be subject to uncertainty due to the inherent limitations in such monitoring data (even data from continuous analysers has notable uncertainty). The models results should be considered in this context. Further information on the verification process including the linear regression analysis is provided in Appendix 2.

Table 7: Modelled vs. measured annual mean NO_2 concentrations 2015

Site	Measured (µg.m^{-3})	Modelled (µg.m^{-3})
Study area 1 - AQMA 1		
WF37	32.2	32.8
WF39	36.8	35.2
WF40	33.5	33.9
WF41	32.6	28.1
WF45	32.0	34.8
RMSE		**2.48**
Study area 2 – AQMA 2		
WF03	35.2	37.7
WF43	45.4	43.9
RMSE		**2.07**
Study area 3 – AQMA 3A		
WF29	48.8	49.1
WF48	45.0	44.6
RMSE		**0.37**
Study area 4 – AQMA 5		
WF38	41.4	41.4

6.2 Modelling results – contour plots

Annual mean NO_2 concentrations have been predicted across a grid of points covering each study area. The gridded point values have been interpolated to produce contour plots showing the spatial variation of predicted concentrations across the study area. The contours are presented in Figure 10 to Figure 24 and in Appendix 3.

Each grid has been modelled at heights of 1.5 m and 4 m to represent human exposure at ground and first floor level where commercial properties may be present at ground level.

6.2.1 Study Area 1 – AQMA1

In study area 1 there are no predicted exceedances of the 40 $\mu g.m^{-3}$ annual mean objective at any ground level or 1st floor height locations where there is relevant exposure.

Most of the properties within the existing AQMA boundary have shops at ground floor level with residential properties at 1st floor level, except at 1b – 1c Wellington Road where there are residential properties at ground floor level. Although there are exceedances of the 40 $\mu g.m^{-3}$ objective at ground floor, the 4 m height contour presented in Figure 16 and Figure 17 indicate that there are no exceedances at 1st floor level where there is relevant exposure.

6.2.2 Study Area 2 – AQMA 2

In study area 2 the contours indicate that the NO_2 annual mean objective is predicted to be exceeded at ground floor properties at the junction of Vicarage Road and the A4178. There may be exceedances of the objective at up to 7 residential properties at ground level, these are located at:

- Farraline Road. All of which is within the existing AQMA boundary
- 3 Merton Road which is within the existing AQMA
- 61 Vicarage Road which is within the existing AQMA
- 107 Vicarage Road which is not within the existing AQMA
- 1 Banbury Street which is not within the existing AQMA

There are ground level exceedances of the 40 $\mu g.m^{-3}$ objective at the following locations, however these are commercial properties with residential properties above. The contour at 4m height presented in Figure 20 indicates that there are no exceedances at these 1st floor residential properties:

- 32 – 58 and 91 – 101 Kings Parade which are within the existing AQMA
- The residential properties at the crossroad of Vicarage Road Precinct, Kings Parade and Fearnley Street.

At Merton Road which is within the existing AQMA boundary, the contours indicate that there are no exceedances of the 40 $\mu g.m^{-3}$ objective except at 3 Merton Road, as indicated above.

6.2.3 Study Area 3 – AQMA3A

In study area 3 the contours indicate that there are exceedances of the NO_2 annual mean objective occurring at up to 56 residential properties at both ground level and first floor height. Most of which are within the existing AQMA3A boundary with the exception of the following:

- 304 and 304a Lower High Street
- 28 – 52 and 1,2 and 3 Pinner Road and the section of Attenborough Court on Pinner Road
- 41 – 45, 1 and 44-46 Aldenham Road
- 12-16 Chalk Hill

At the junction of Aldenham road and Pinner Road there are residential properties at first floor height above shops at ground floor level. The 4m contour presented in Figure 22 indicates that there are no exceedances of the 40 $\mu g.m^{-3}$ objective at 1st floor level at this location.

The results should be considered in context with the model verification described above. The model is slightly over predicting at the junction of Aldenham Road with Pinner Road as shown in Table 7 the modelled concentration at the diffusion tube WF29 is slightly higher than the modelled concentrations by 0.3 µg.m^{-3}.

6.2.4 Study Area 4 – AQMA5

In study area 4 there are no predicted exceedances of the 40 µg/m^3 annual mean objective at any ground level or 1st floor height locations where there is relevant exposure.

The properties within the existing AQMA boundary all have shops at ground floor level with residential properties at 1st floor height. Although there are exceedances of the 40 µg.m^{-3} objective at ground floor, the 4 m height contour presented in Figure 24 indicates that there are no exceedances at 1st floor height.

6.3 Study Area Figures

The following sub-section provides the modelled annual average NO_2 concentrations for the 4 study areas. For clarity of the images, large format figures (in A3 scale) are provided in Appendix 3.

6.3.1 Study area 1 – AQMA 1

Figure 10: Modelled NO_2 annual mean concentrations 2015 at 1.5m height – Study area 1 - Northern section of St Albans Road

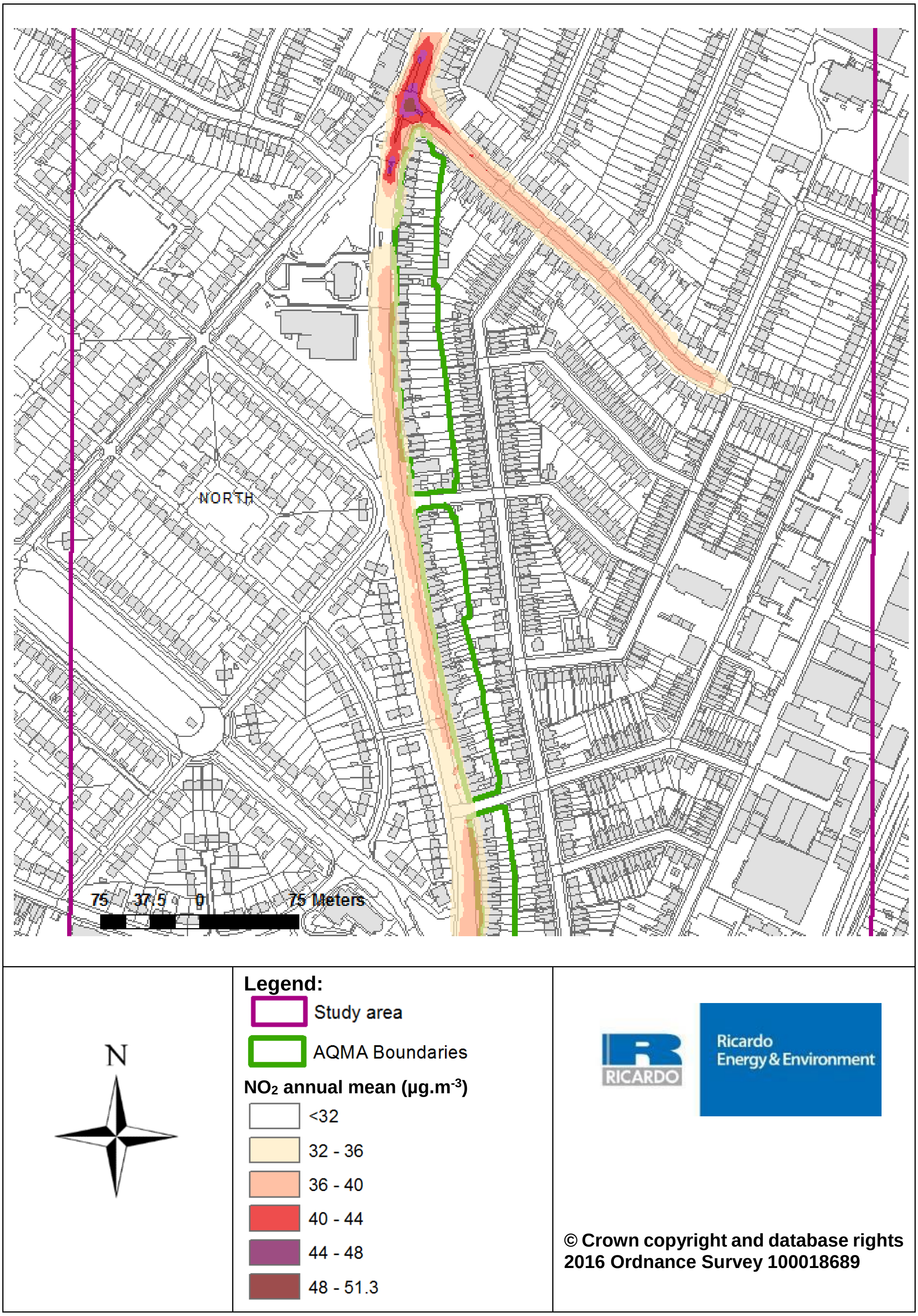


Figure 11: Modelled NO_2 annual mean concentrations 2015 at 1.5m height – Study area 1 - Middle section of St Albans Road

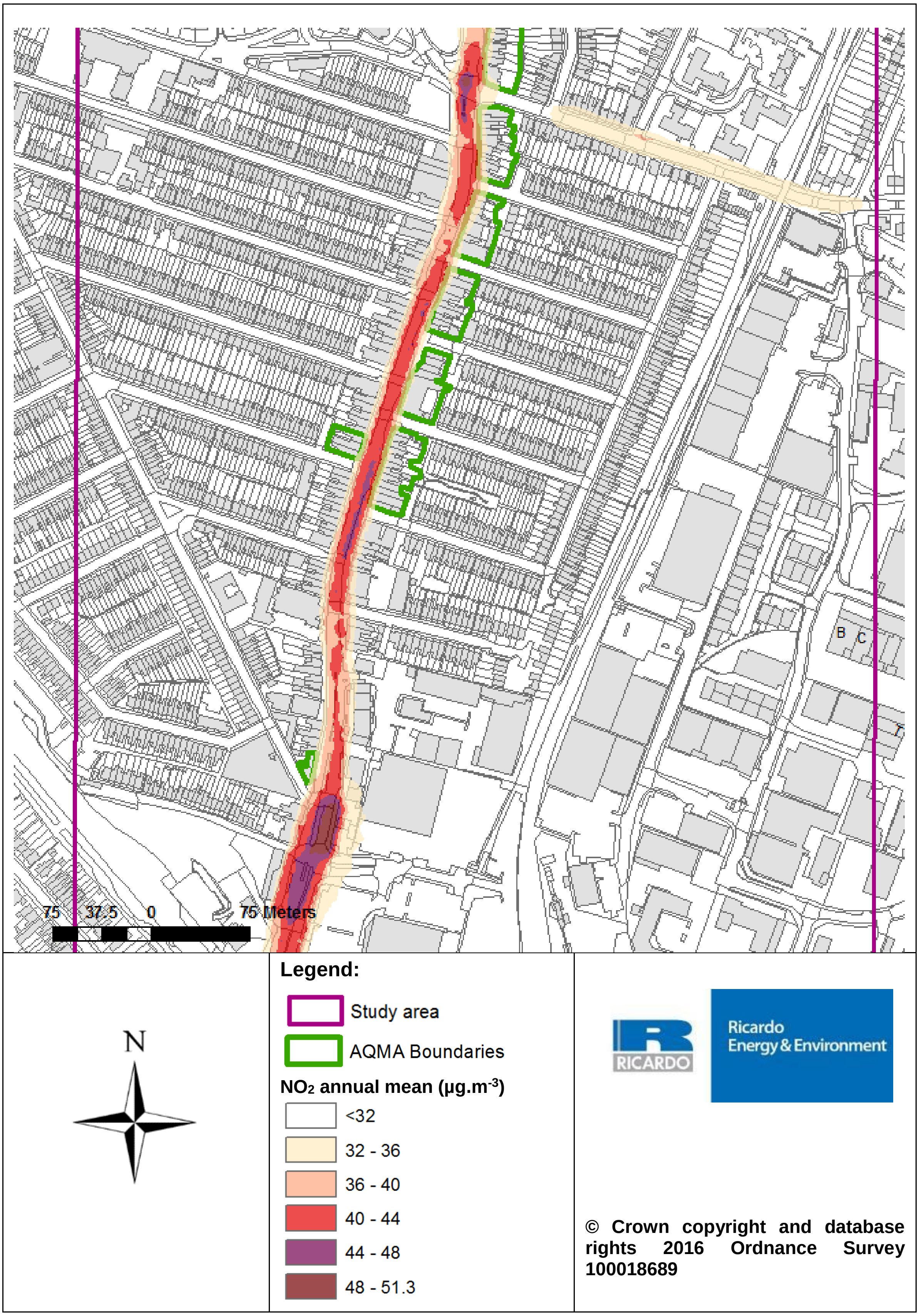


Figure 12: Modelled NO_2 annual mean concentrations 2015 at 1.5m height – Study area 1 - Southern section of St Albans Road

Legend:

Study area

AQMA Boundaries

NO_2 annual mean (µg.m^{-3})

<32

32 - 36

36 - 40

40 - 44

44 - 48

48 - 51.3

Figure 13: Modelled NO_2 annual mean concentrations 2015 at 1.5m height – Study area 1 – Hotspots 1

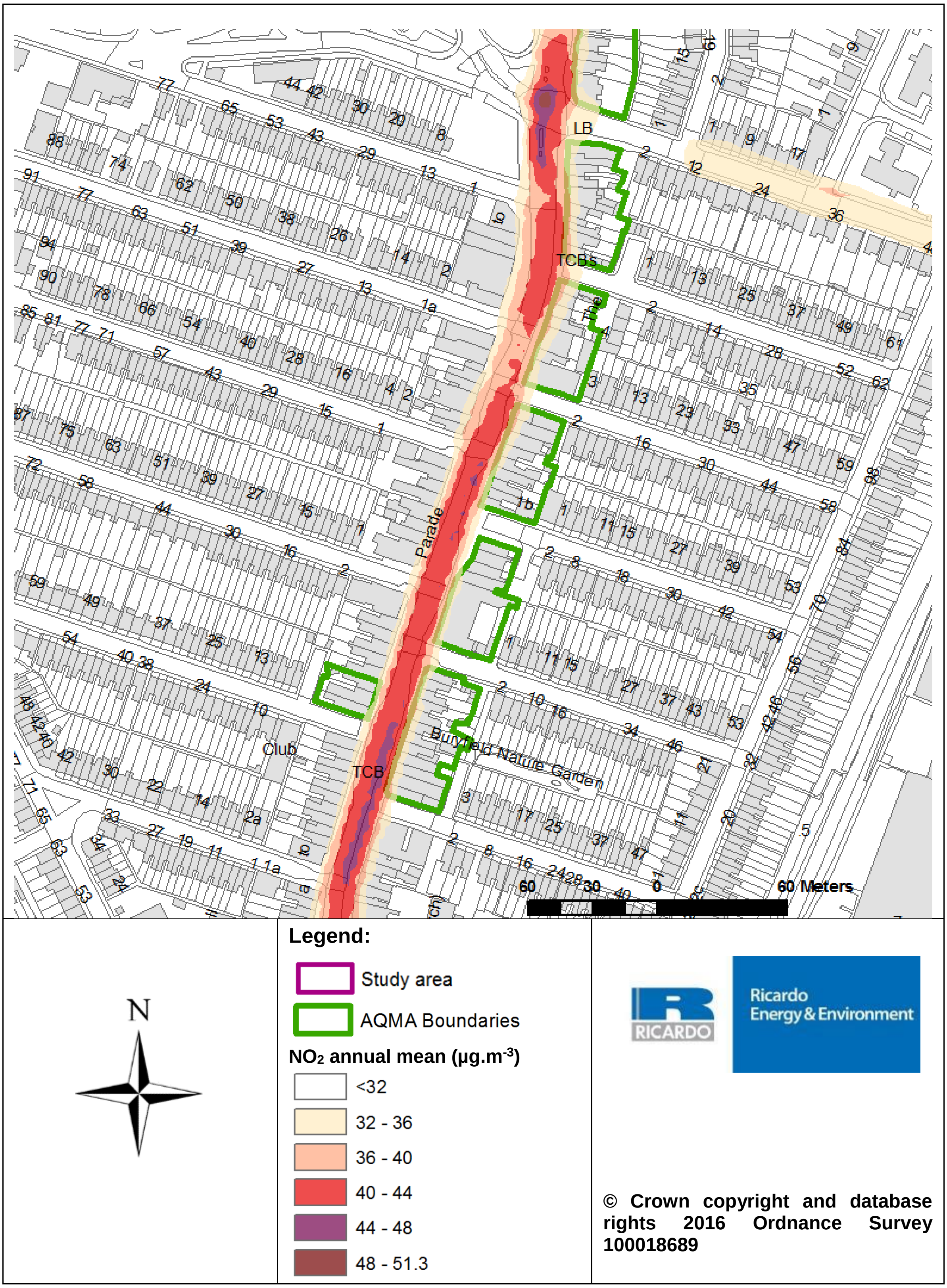


Figure 14: Modelled NO_2 annual mean concentrations 2015 at 1.5m height – Study area 1 – Hotspots 2

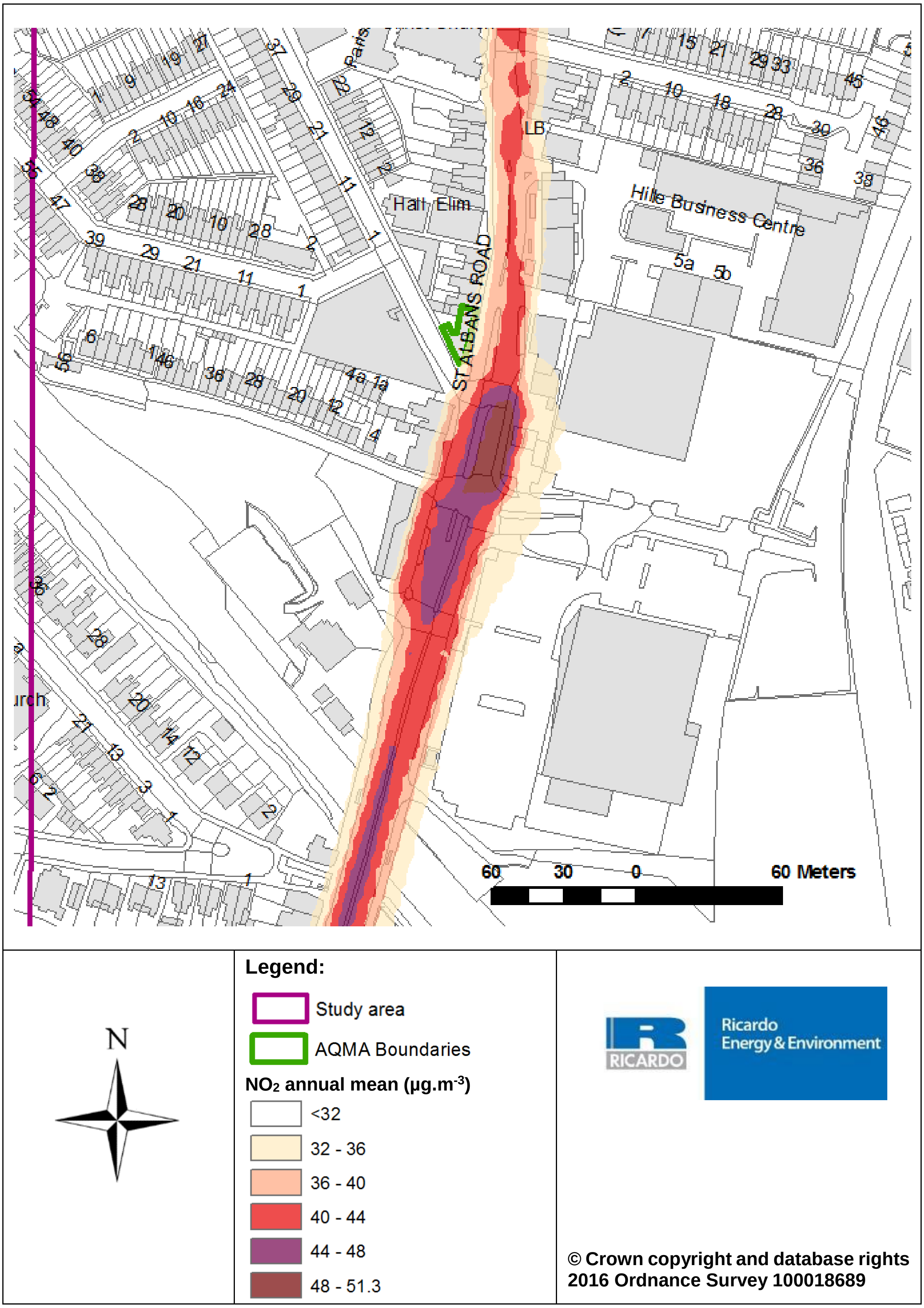


Figure 15: Modelled NO_2 annual mean concentrations 2015 at 1.5m height – Study area 1 – Hotspots 3

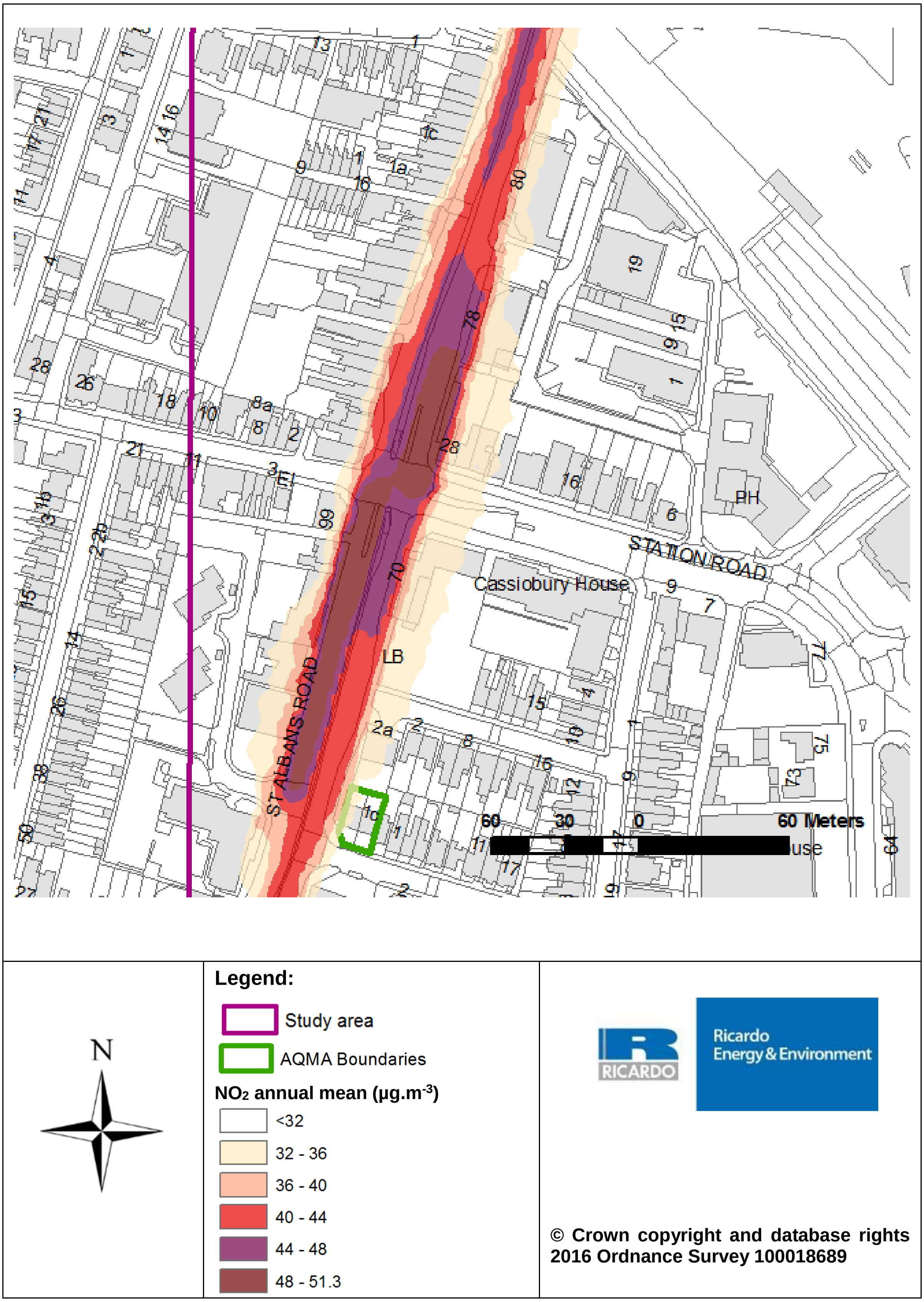


Figure 16: Modelled NO_2 annual mean concentrations 2015 at 4m height – Study area 1 - Northern section of St Albans Road

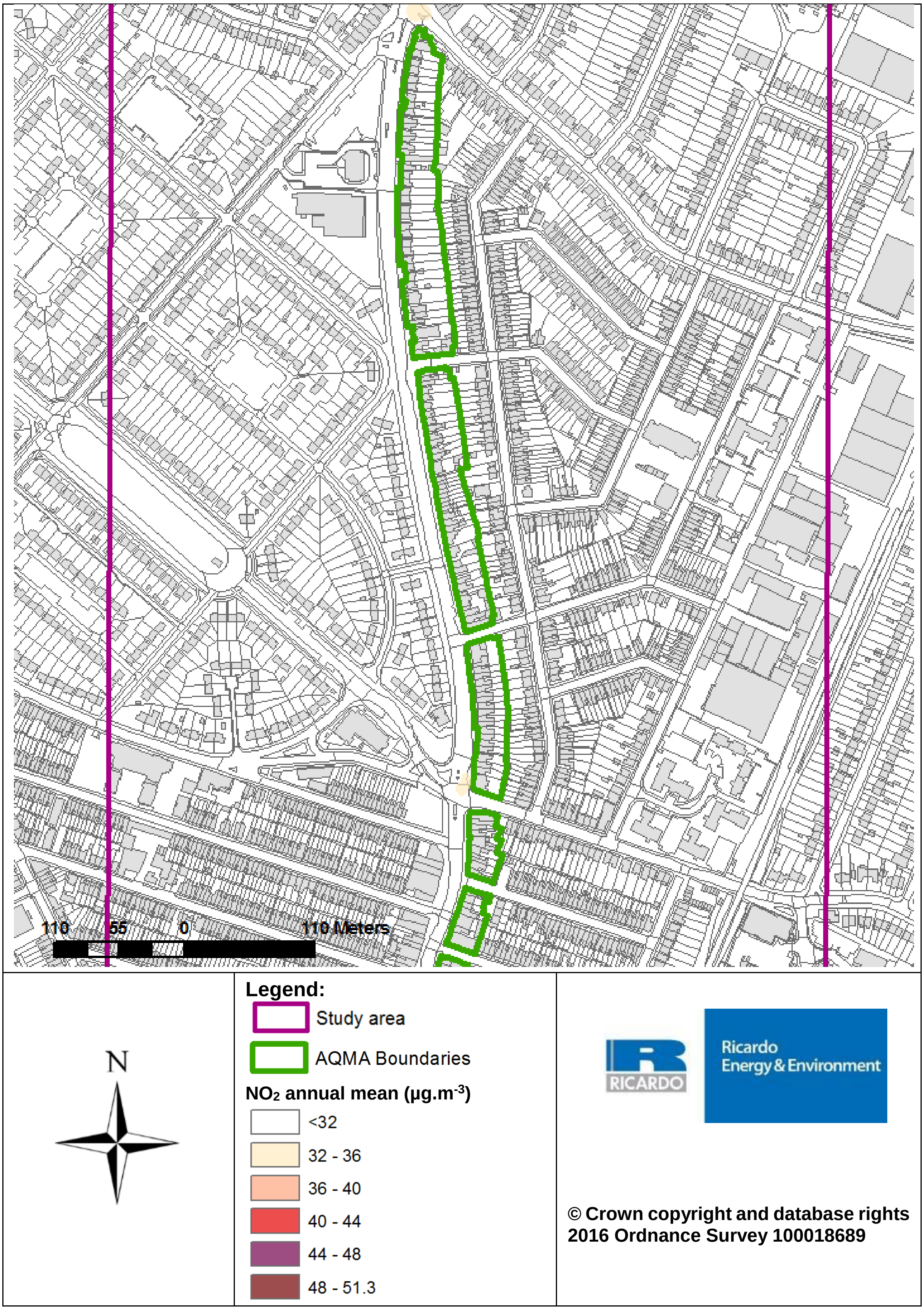
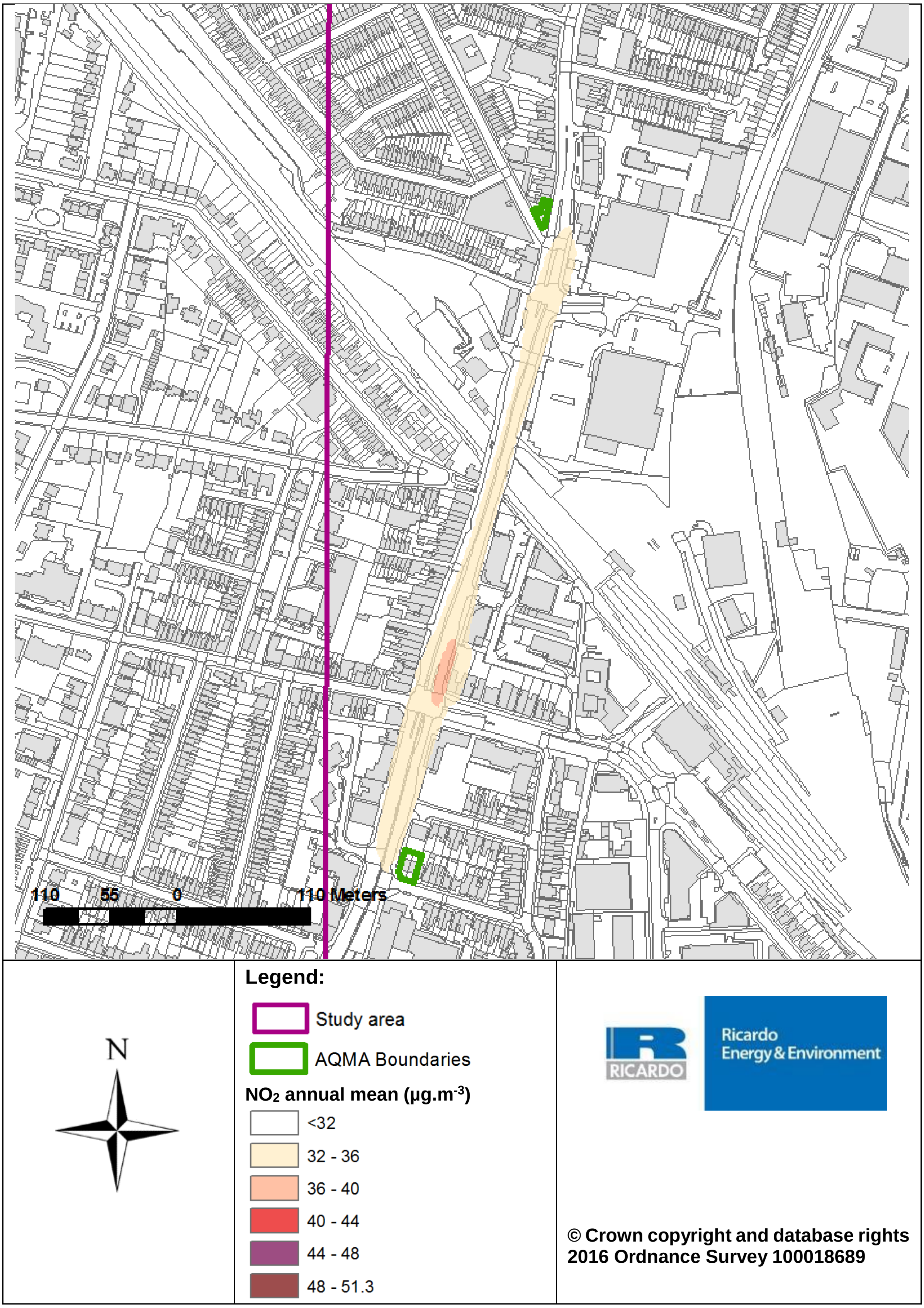


Figure 17: Modelled NO_2 annual mean concentrations 2015 at 4m height – Study area 1 - Southern section of St Albans Road



6.3.2 Study area 2 – AQMA 2

Figure 18: Modelled NO_2 annual mean concentrations 2015 at 1.5m height – Study area 2

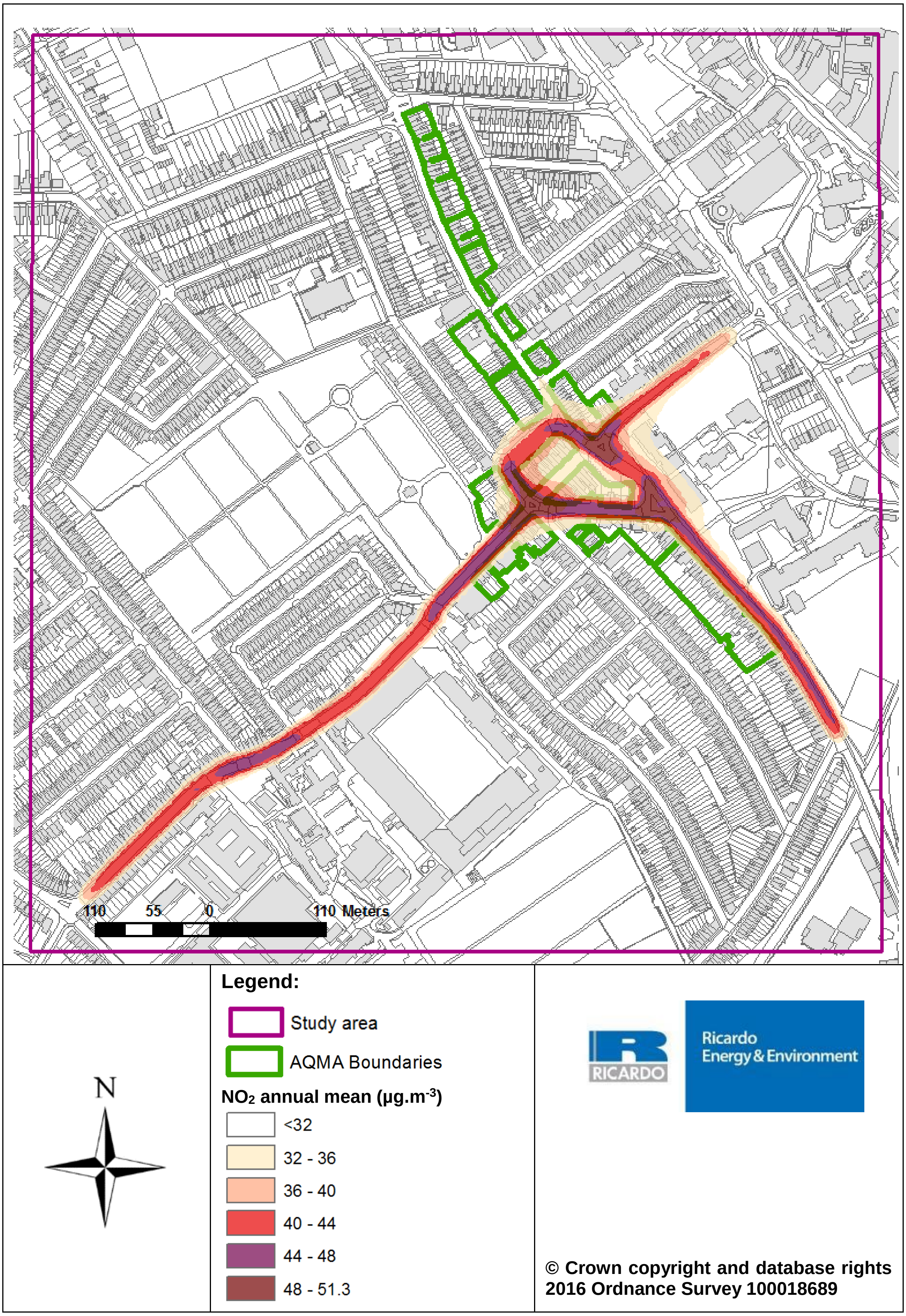


Figure 19: Modelled NO_2 annual mean concentrations 2015 at 1.5m height – Study area 2 - Hotspots

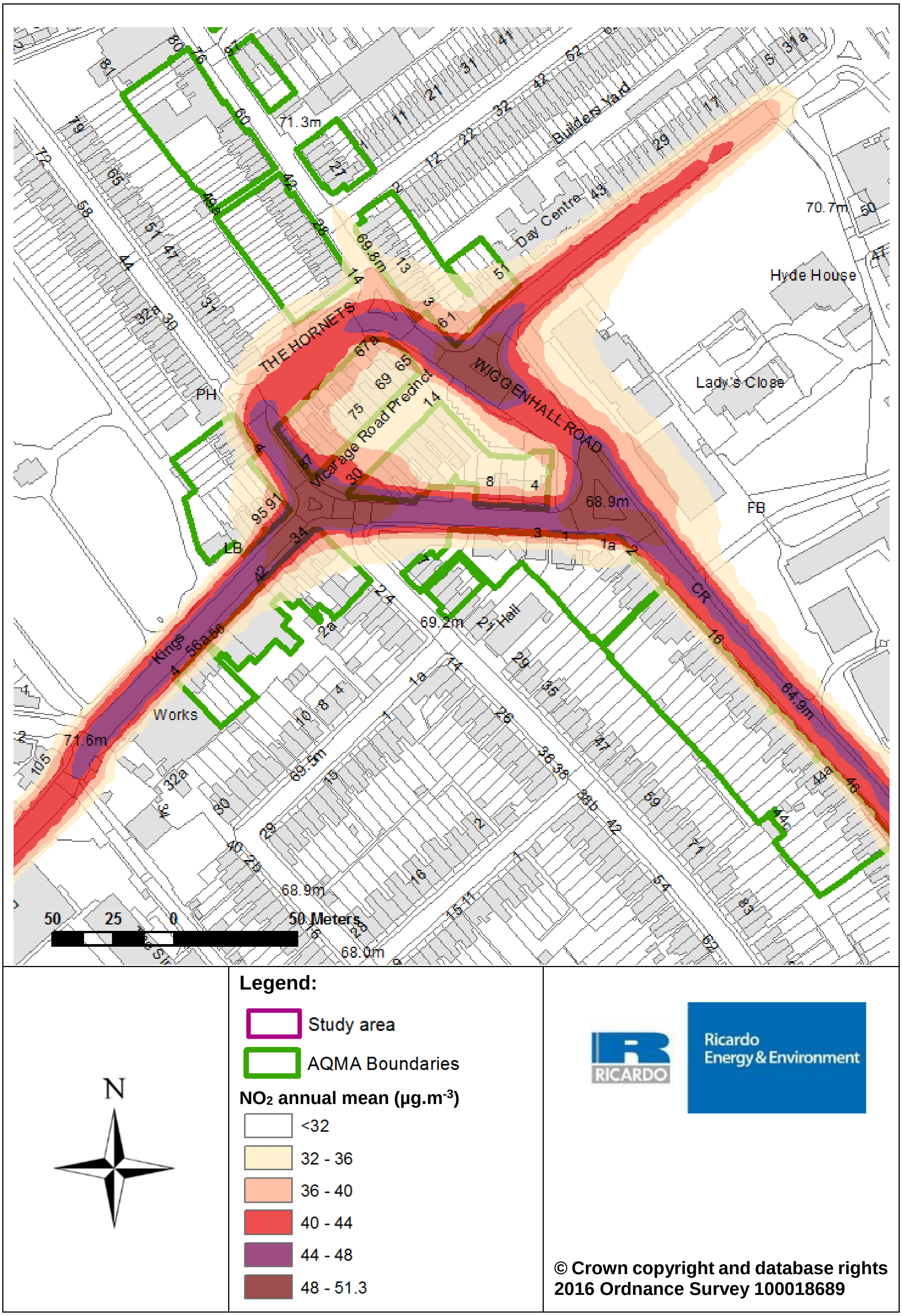
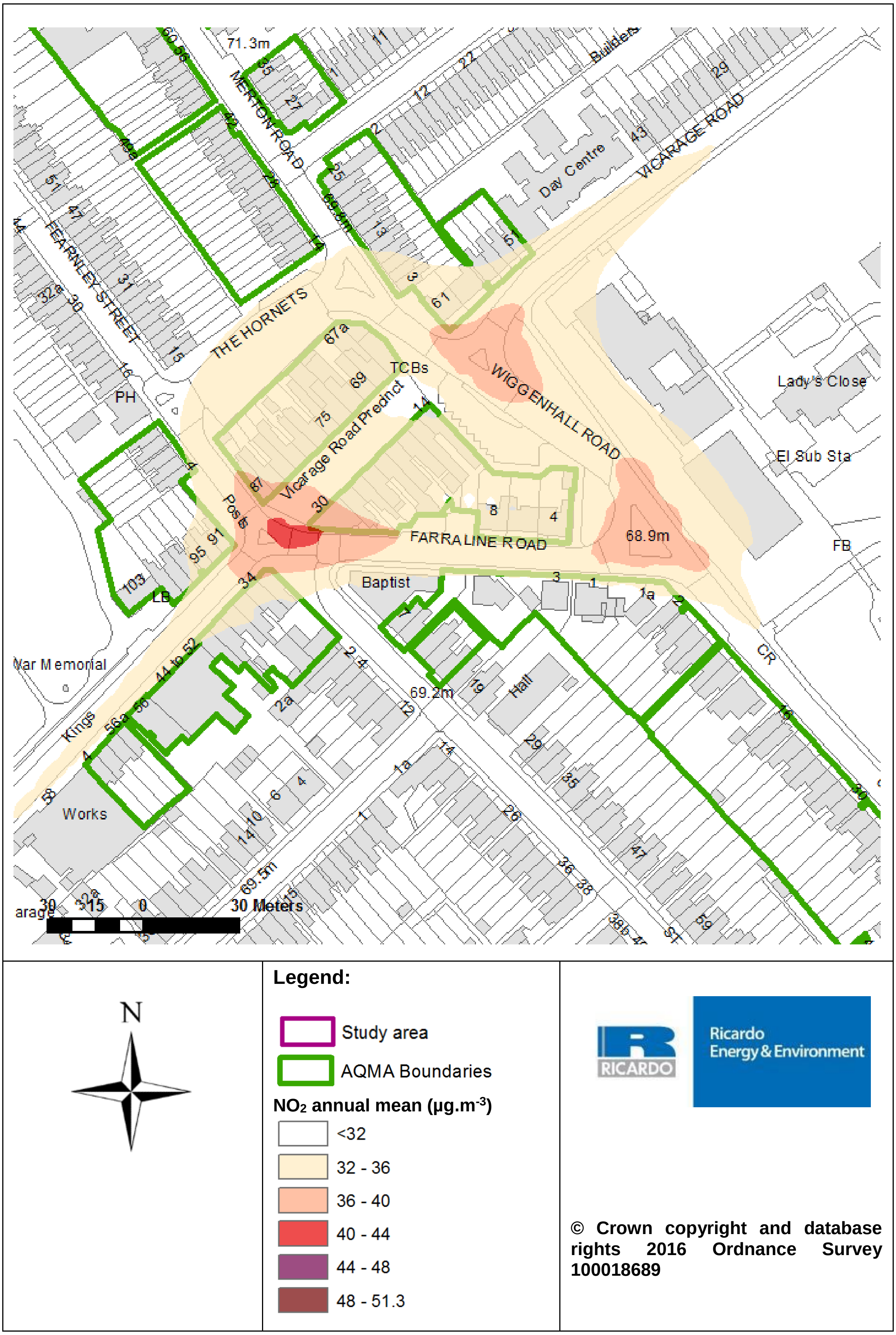


Figure 20: Modelled NO_2 annual mean concentrations 2015 at 4m height – Study area 2



6.3.3 Study area 3 – AQMA 3A

Figure 21: Modelled NO_2 annual mean concentrations 2015 at 1.5m height – Study area 3

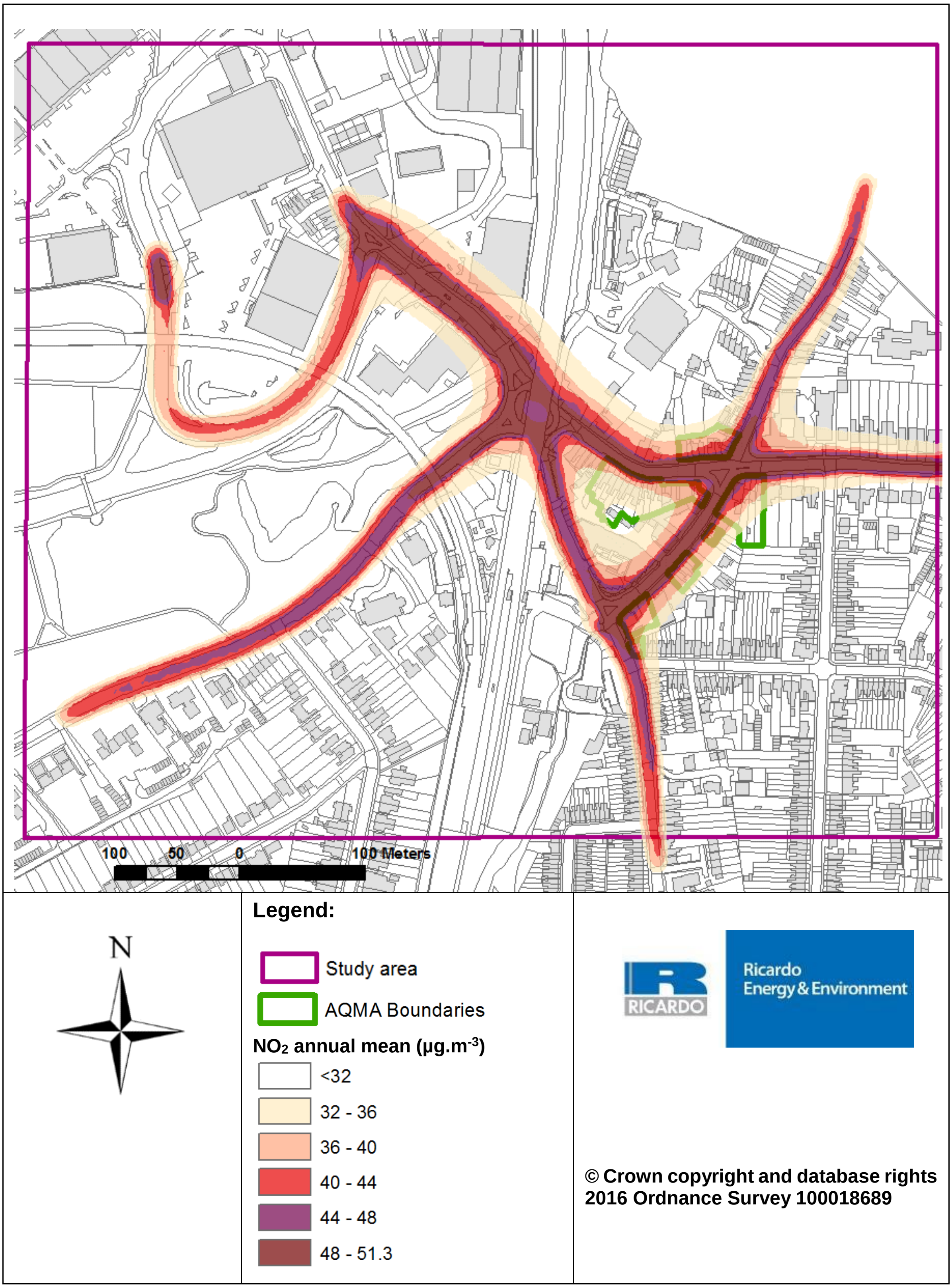
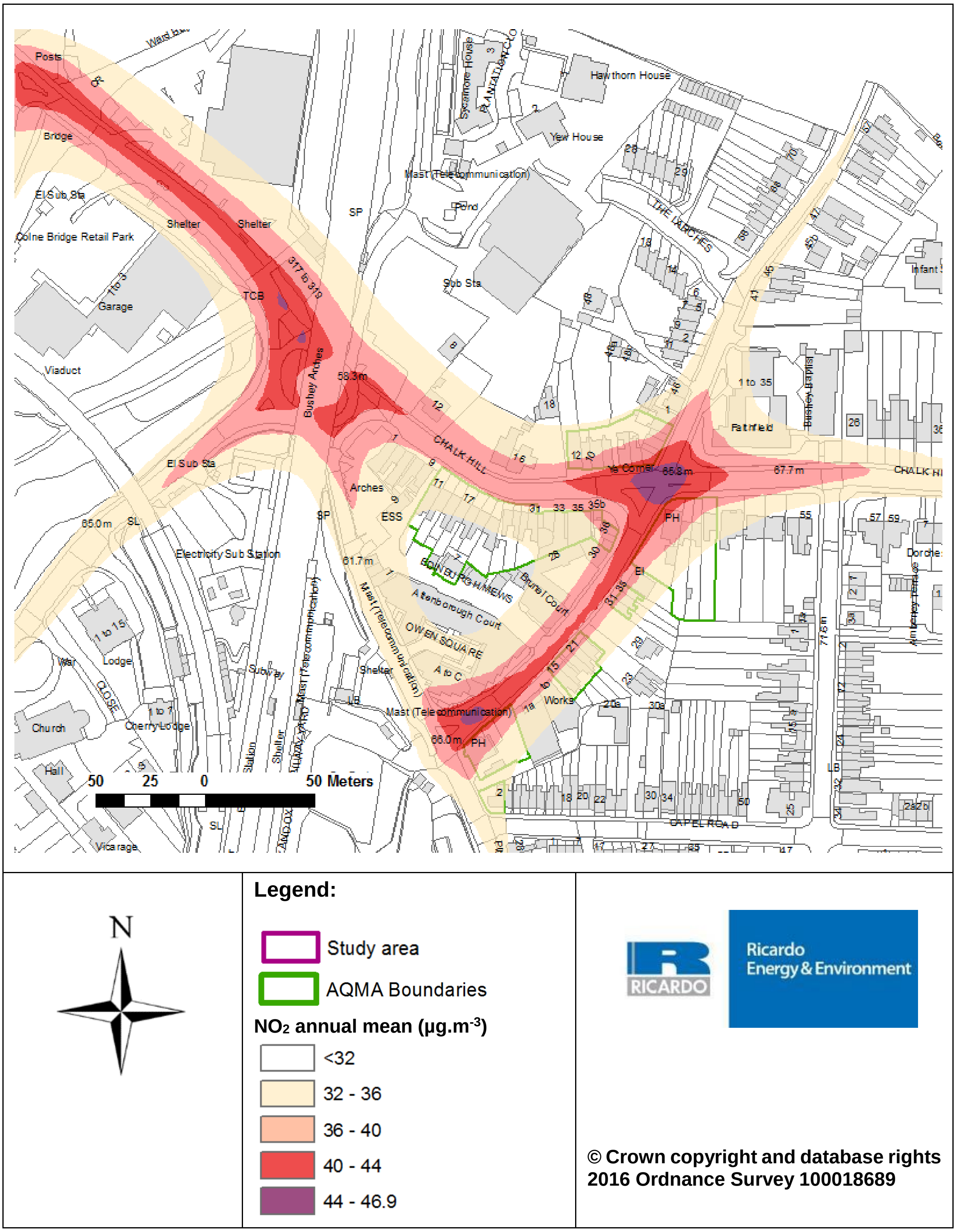


Figure 22: Modelled NO_2 annual mean concentrations 2015 at 4m height – Study area 3



6.3.4 Study area 4 – AQMA 5

Figure 23: Modelled NO_2 annual mean concentrations 2015 at 1.5m height – Study area 4

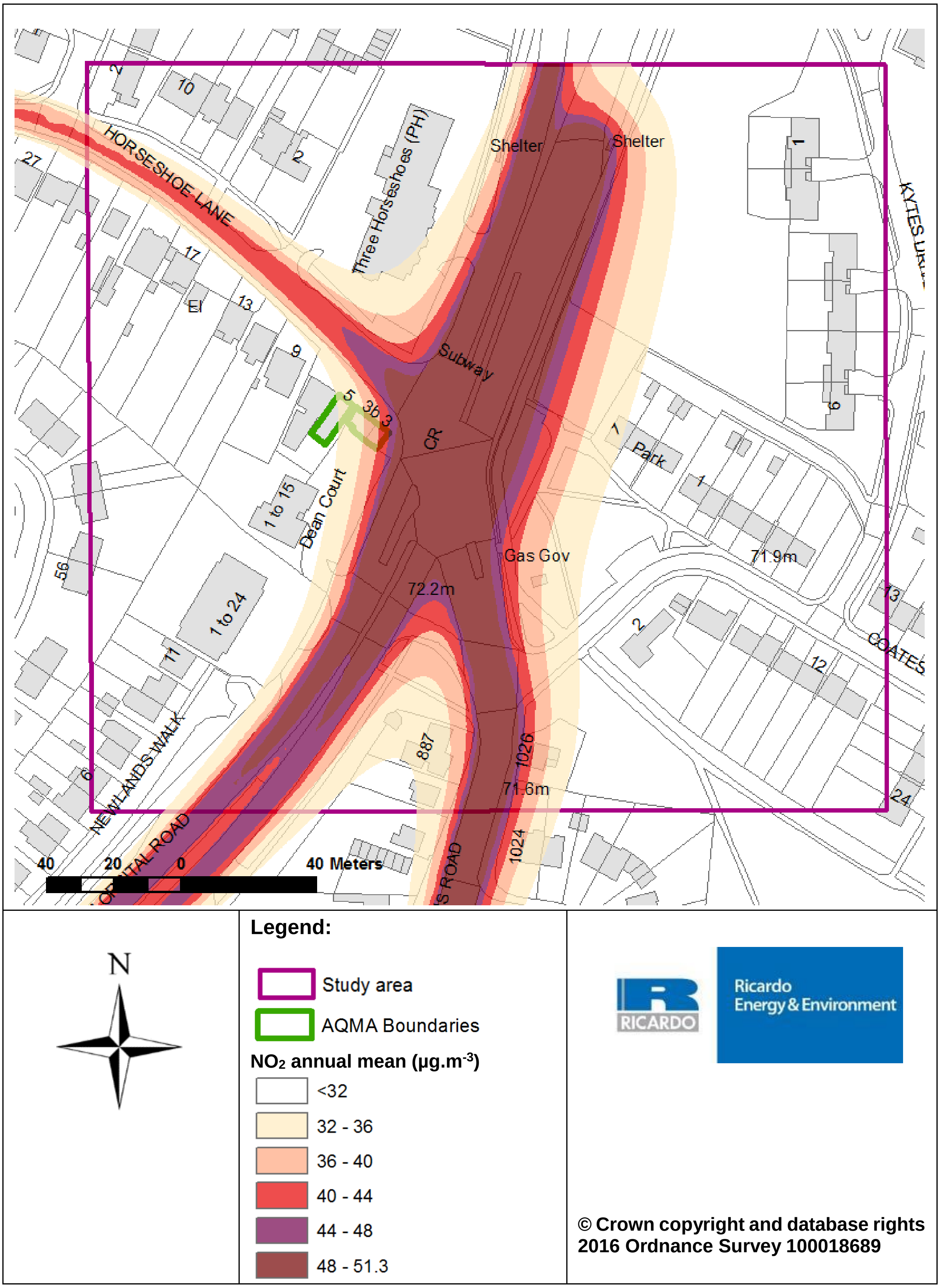
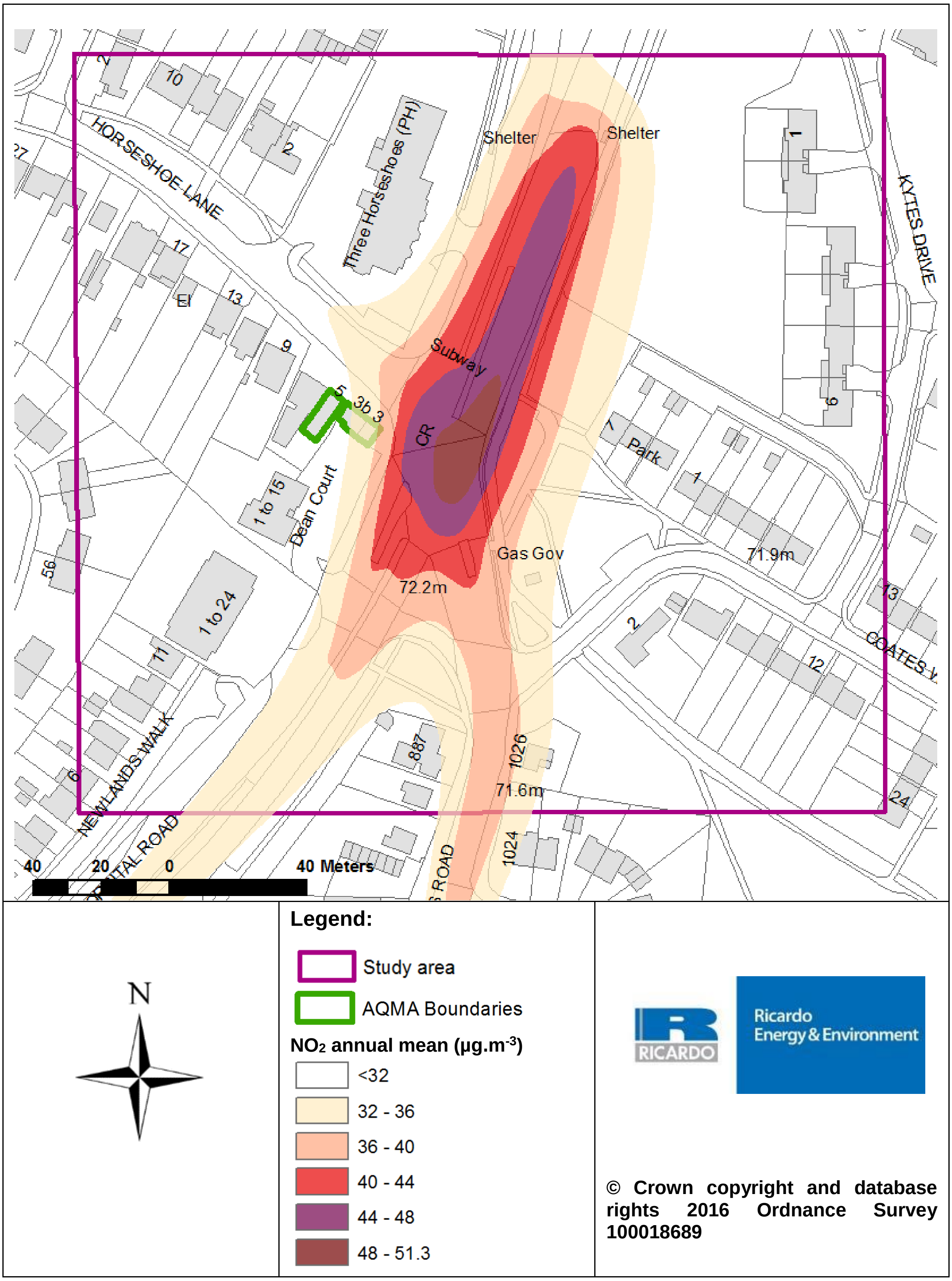


Figure 24: Modelled NO_2 annual mean concentrations 2015 at 4m height – Study area 4



7 Summary and conclusions

This report describes the detailed dispersion modelling and assessment of NO_2 concentrations at each of the Air Quality Management Areas in Watford.

The study used a combination of the available diffusion tube monitoring data and atmospheric dispersion modelling using ADMS-Roads to determine predicted concentrations of NO_2 for the year 2015.

The modelling study has indicated the following:

- In AQMA1 there are no predicted exceedances of the 40 $\mu g/m^3$ annual mean objective at any ground level or 1st floor height locations where there is relevant exposure. **Watford Borough Council may wish to consider revoking the boundary of AQMA1.**
- In AQMA2 the results indicate that there may be exceedances of the NO_2 annual mean objective at up to 7 residential properties at ground level. Some of which are within the current AQMA boundary. The results also indicate that there are exceedances of the objective at locations on Vicarage Road and Banbury Street which are not within the existing AQMA boundary. **Watford Borough Council should consider revising the boundary of AQMA2 to include these locations.**
- In AQMA3A the results indicate that there may be exceedances of the NO_2 annual mean objective at up to 56 residential properties at both ground level and first floor height. Most of which are within the existing AQMA3A boundary with the exception of some properties on Lower High St, Pinner Road, Aldenham Road and Chalk Hill. **Watford Borough Council should consider revising the boundary of AQMA3A to include these locations.**
- In AQMA5 there are no predicted exceedances of the 40 $\mu g/m^3$ annual mean objective at any ground level or 1st floor height locations where there is relevant exposure. **Watford Borough Council may wish to consider revoking the boundary of AQMA5.**

Appendices

Appendix 1: Meteorological Dataset

Appendix 2: Model verification

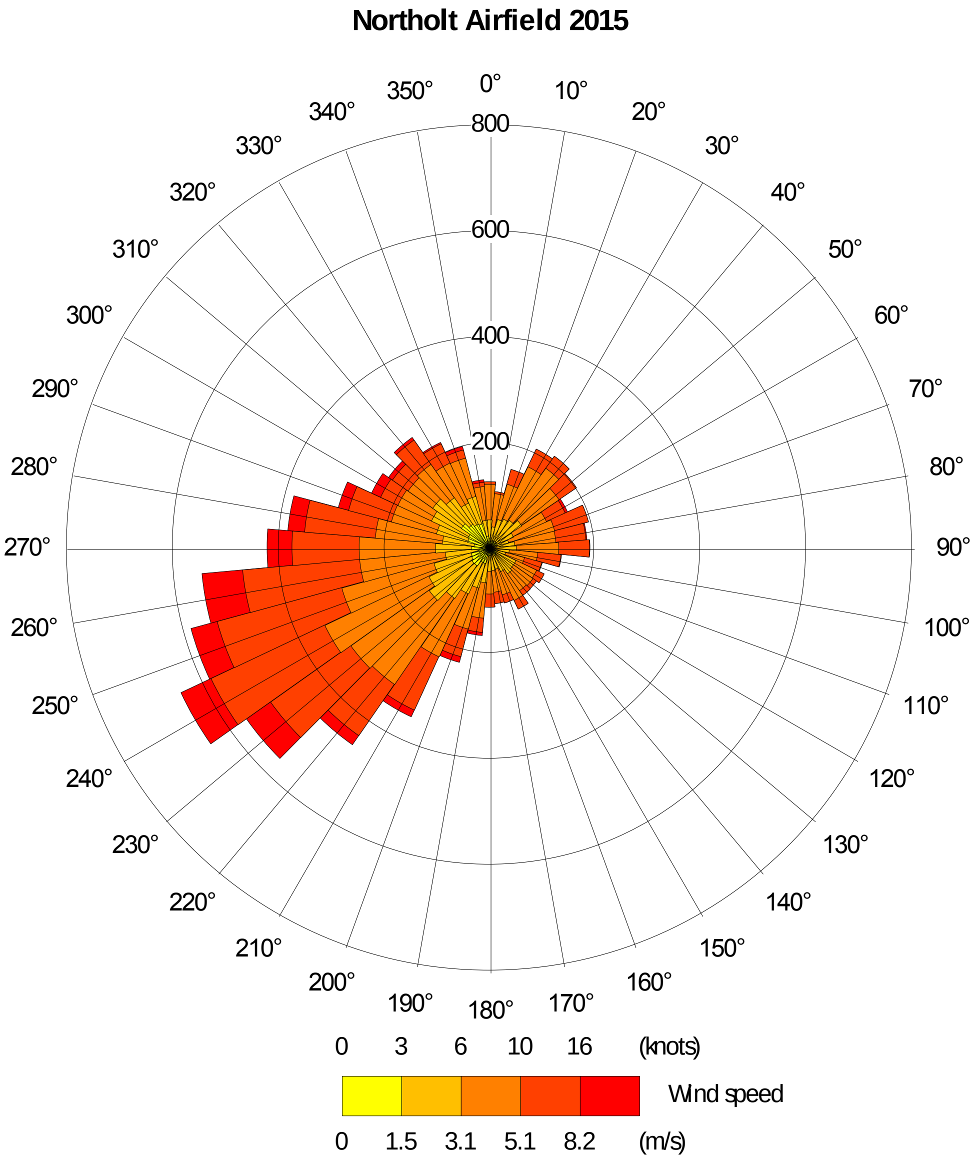
Appendix 3: Figures (large scale format (A3))

Appendix 4: Traffic data

Appendix 1 – Meteorological Dataset

The wind rose for the Northolt Airfield meteorological measurement site is presented in Figure A1.1.

Figure 1.1: Meteorological dataset wind rose



Appendix 2 – Models Verification

Verification of the model involves comparison of the modelled results with any local monitoring data at relevant locations. This helps to identify how the model is performing at the various monitoring locations. The verification process involves checking and refining the model input data to try and reduce uncertainties and produce model outputs that are in better agreement with the monitoring results. LAQM.TG(16) recommends making the adjustment to the road contribution of the pollutant only and not the background concentration these are combined with.

The approach outlined in LAQM.TG(16) section 7.508 – 7.534 (also in Box 7.14 and 7.15) has been used in this case.

As stated in Section 6.1 above, the models were verified using annual mean NO_2 measurements from the various NO_2 diffusion tube sites within the study areas. Of the available roadside and kerbside diffusion tube sites, two sites were excluded from model verification for the following reasons:

- Diffusion tube site WF47 as there was no available road traffic data at this location
- Diffusion tube site WF44 which was a clear outlier when compared with the model predictions. This may be as the tube appears to be sited within vegetation that has become overgrown, this does not correspond with the sampler siting recommendations in the LAQM technical guidance. We recommend that this tube should either be re-located or the vegetation cleared to allow sufficient air flow around the sampler.

It is appropriate to verify the ADMS Roads models in terms of primary pollutant emissions of nitrogen oxides ($NOx = NO + NO_2$). The models have been run to predict annual mean Road NOx concentrations during the 2015 calendar year at the diffusion tube sites. The models output of Road NOx (the total NOx originating from road traffic) have been compared with the measured Road NOx, where the measured Road NOx contribution is calculated as the difference between the total NOx and the background NOx value. Total measured NOx for each diffusion tube was calculated from the measured NO_2 concentration using the latest version of the Defra NOx/NO_2 calculator.

The initial comparison of the modelled vs measured Road NOx identified that al the models were under-predicting the Road NOx contribution.

For each study area, the gradient of the best fit line for the modelled Road NOx contribution vs. measured Road NOx contribution was then determined using linear regression and used as the adjustment factor for the respective model. This factor was then applied to the modelled Road NOx concentration for each modelled point to provide adjusted modelled Road NOx concentrations within each study area. A linear regression plot comparing modelled and monitored Road NOx concentrations before and after adjustment are presented in Figure A2.1 to Figure A2.4.

The primary adjustment factor for each model are presented in Table A2.1 and are based on model verification using 2015 monitoring results. This relevant primary adjustment factor to each study are was then applied to all modelled Road NOx data prior to calculating an NO_2 annual mean. Plots comparing modelled and monitored NO_2 concentrations before and after adjustment are presented in Figure A2.5 to Figure A2.9.

Following adjustment, the model is in reasonable agreement with the local NO_2 measurements so we are confident that the predicted spatial variation in NO_2 concentrations is also representative of local conditions.

Table A2.1: Adjustment factors for each study area

Study area	Adjustment factor
Study area 1 – AQMA 1	1.2708
Study area 2 – AQMA 2	1.2254
Study area 3 – AQMA 3A	1.8467
Study area 4 – AQMA 5	2.0640

Model uncertainty can be estimated by calculating the root mean square error (RMSE). The RMSE after adjustment are presented in Table A2.2 for each study area. They are all within the suggested value (10% of the objective being assessed) in LAQM.TG(16). The models have therefore performed sufficiently well for use in this assessment.

Table A2.2: RMSE for each study area

Study area	RMSE ($\mu g.m^{-3}$)
Study area 1 – AQMA 1	2.48
Study area 2 – AQMA 2	2.07
Study area 3 – AQMA 3A	0.37

Figure A2.1: Comparison of modelled Road NOx Vs Measured Road NOx – Study area 1

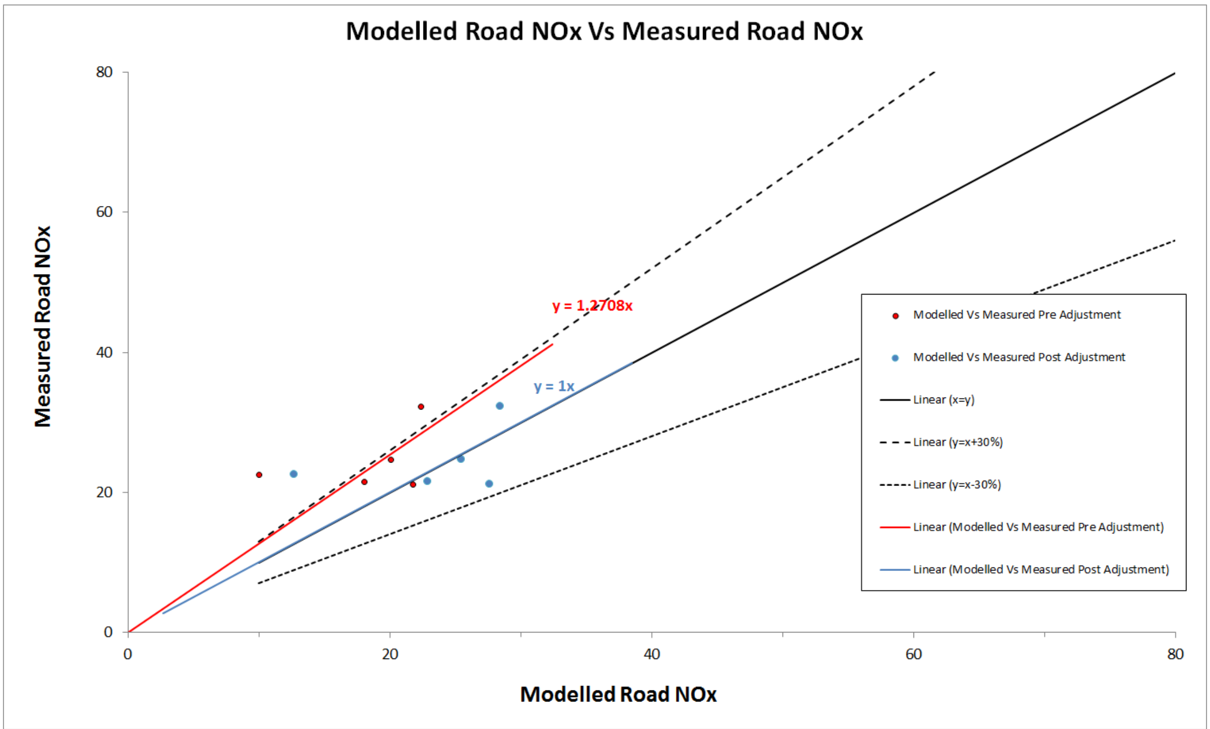


Figure A2.2: Comparison of modelled Road NOx Vs Measured Road NOx – Study area 2

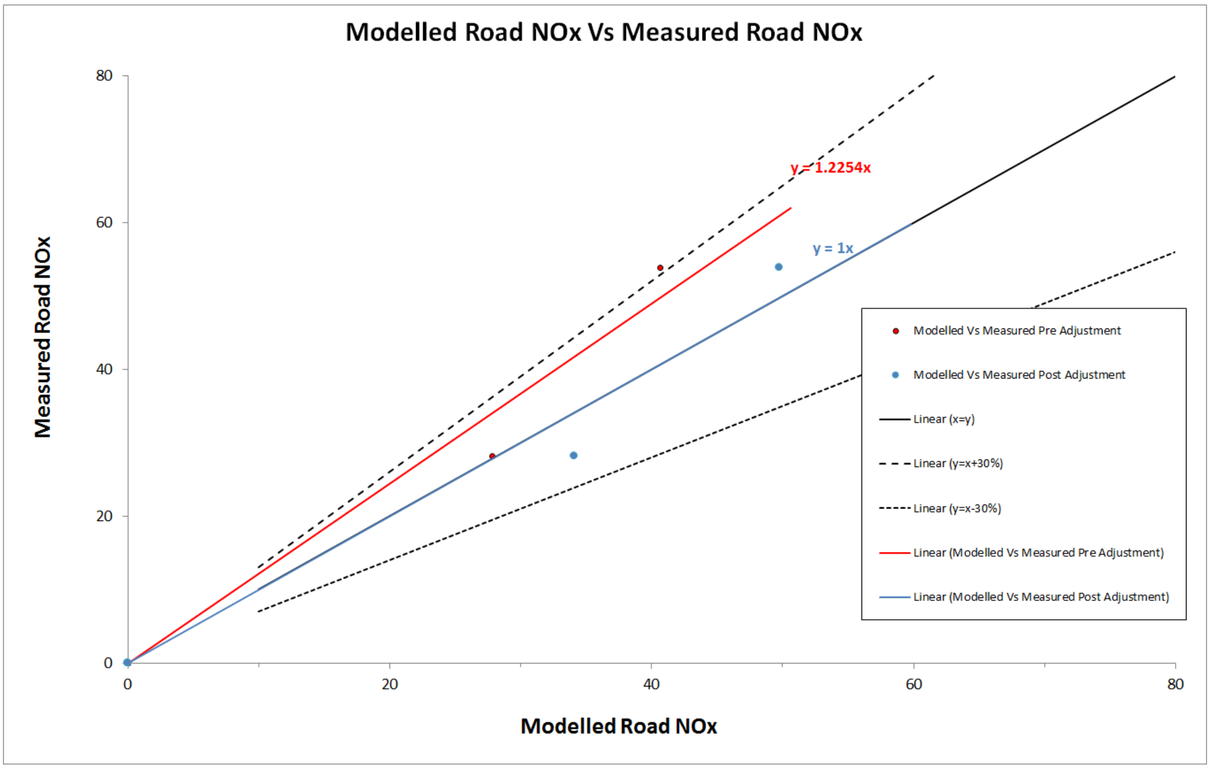


Figure A2.3: Comparison of modelled Road NOx Vs Measured Road NOx – Study area 3

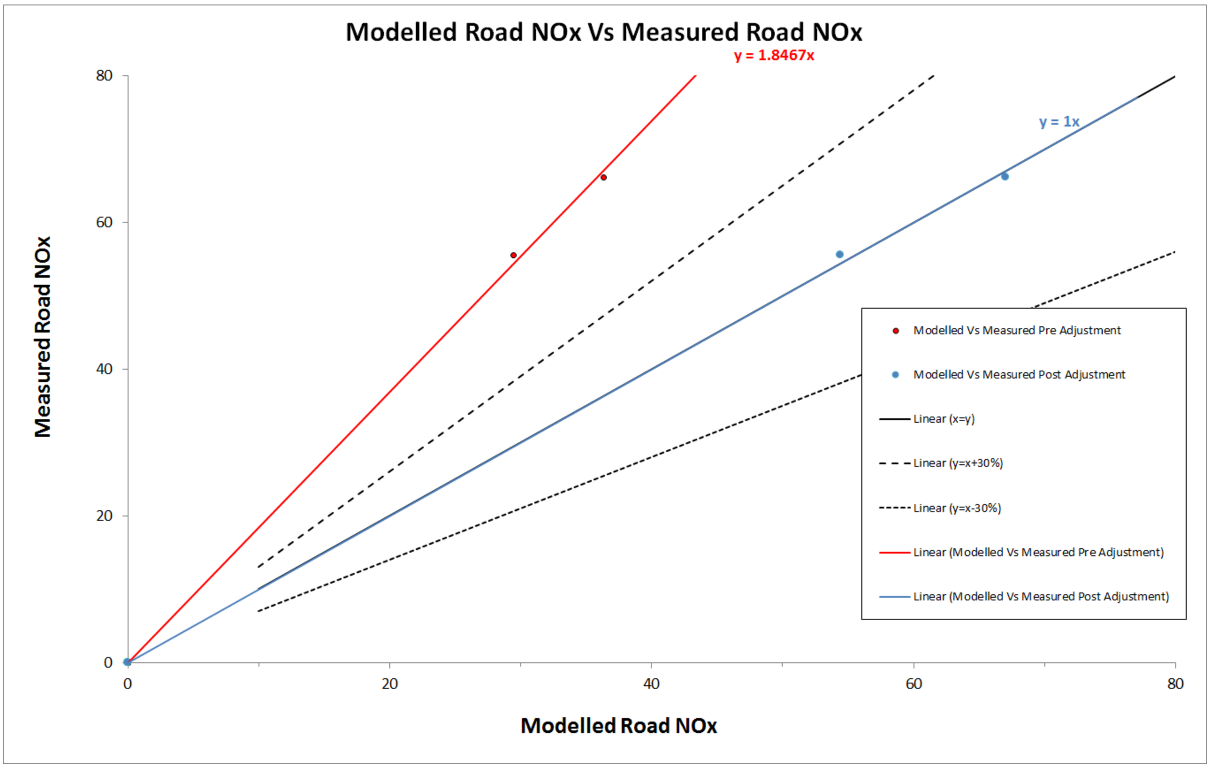


Figure A2.4 Comparison of modelled Road NOx Vs Measured Road NOx – Study area 4

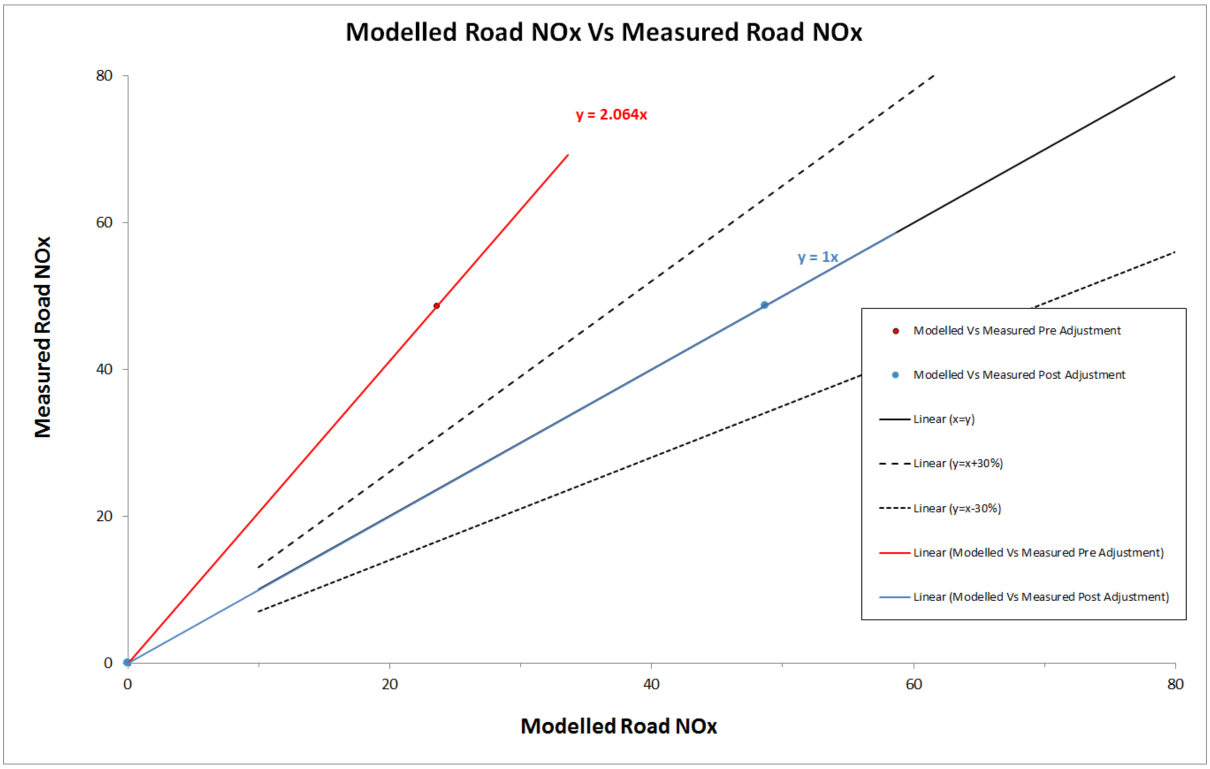


Figure A2.5: Comparison of modelled Vs Monitored NO_2 annual mean 2015 – Study area 1

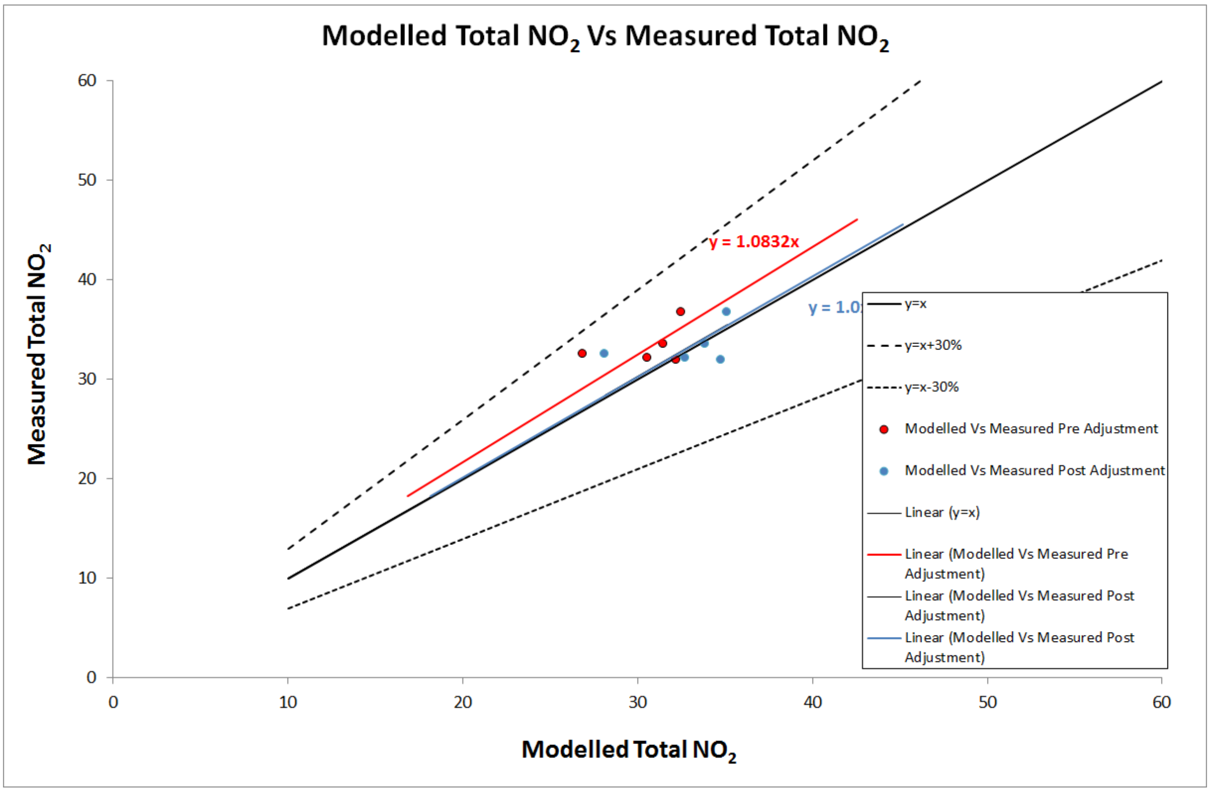


Figure A2.6: Comparison of modelled Vs Monitored NO_2 annual mean 2015 – Study area 2

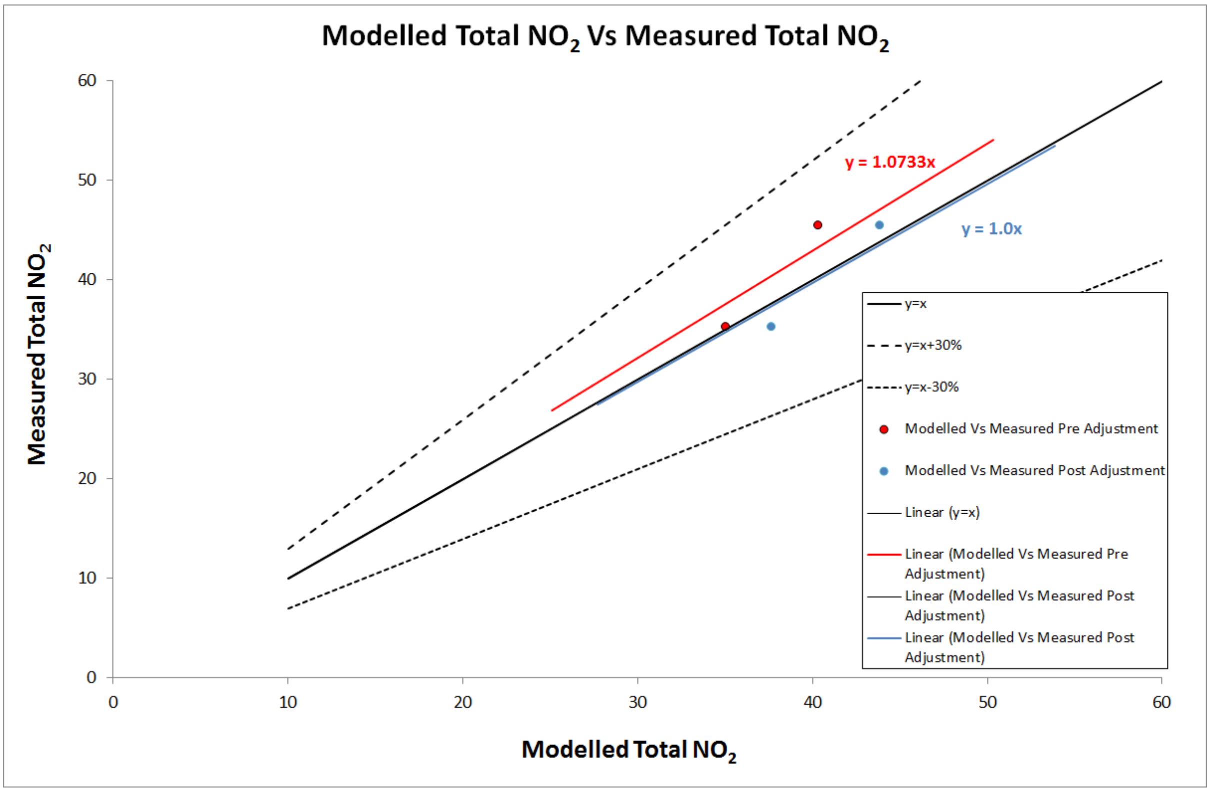


Figure A2.7: Comparison of modelled Vs Monitored NO_2 annual mean 2015 – Study area 3

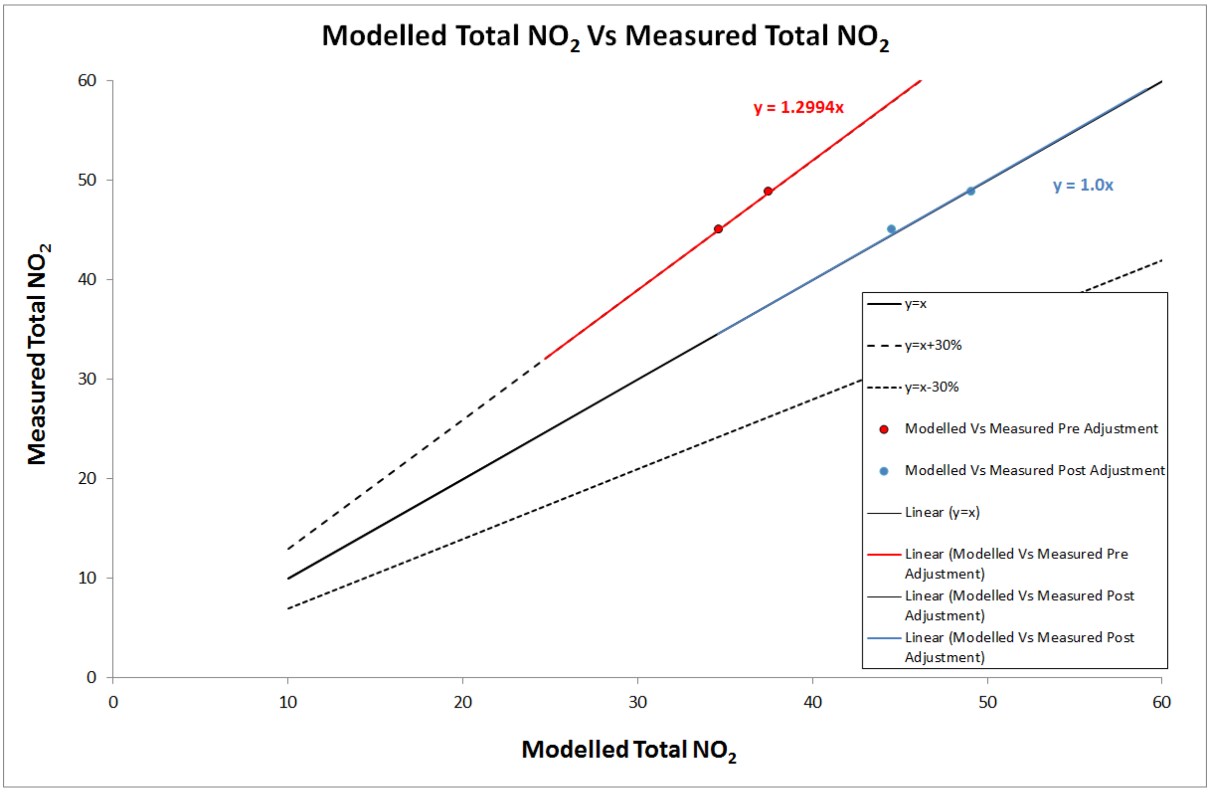
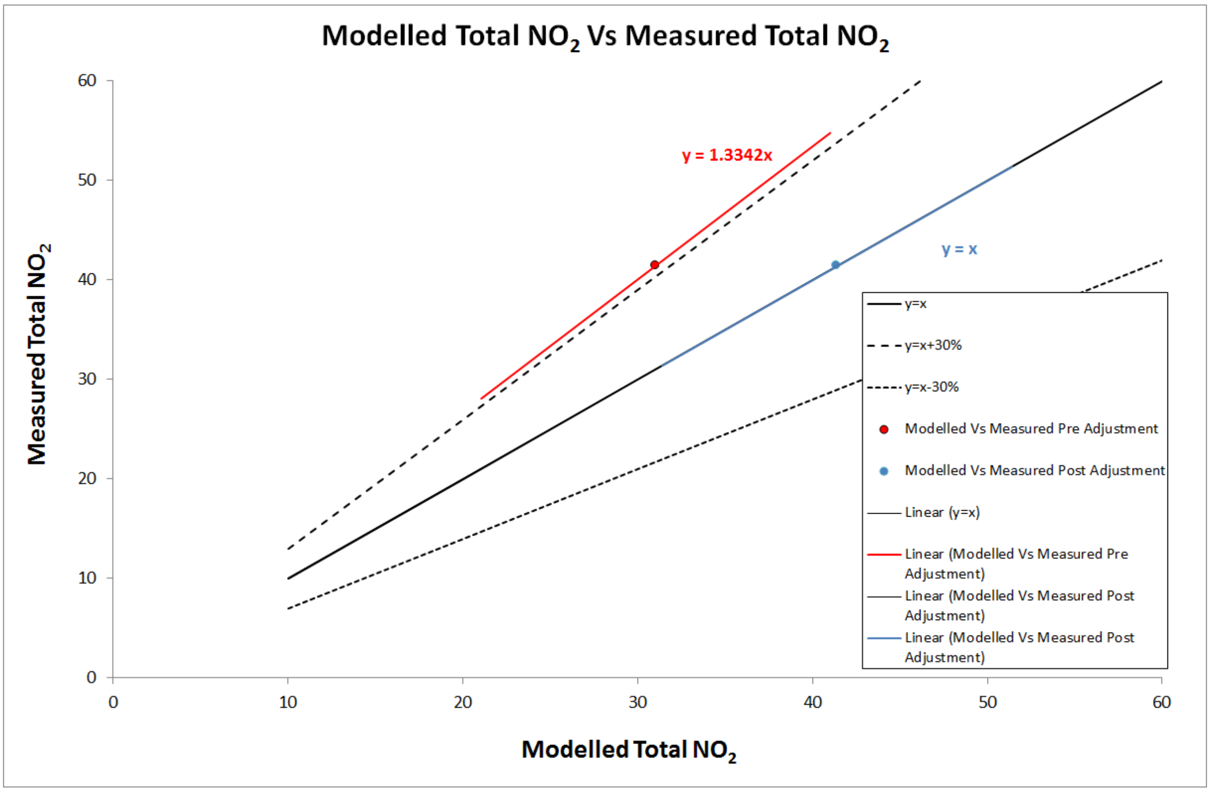
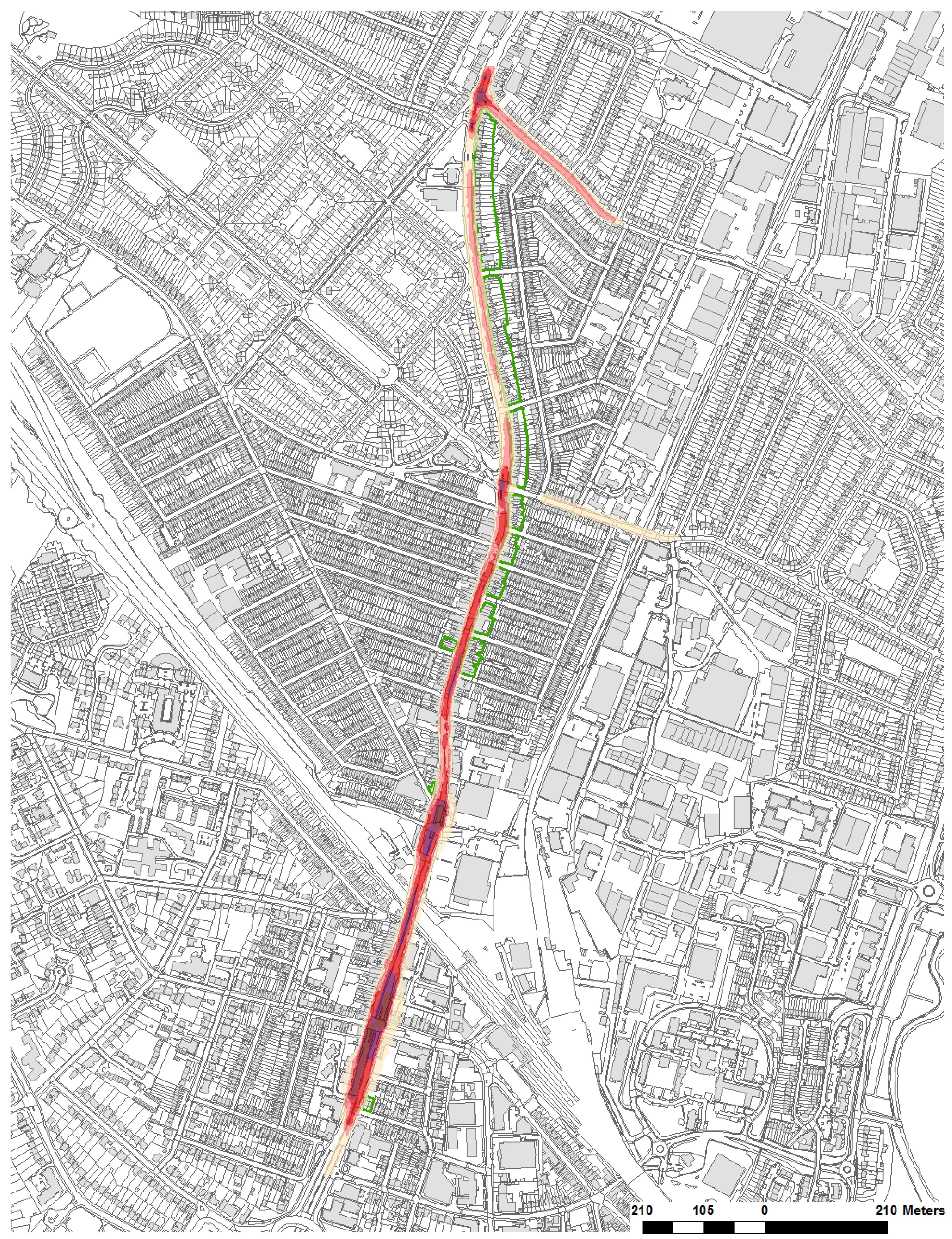


Figure A2.8: Comparison of modelled Vs Monitored NO_2 annual mean 2015 – Study area 4



Appendix 4 – Figures (large scale format(A3))



Legend

AQMA Boundaries
- AQMA Boundaries

NO_2 Annual Mean (µg/m^3)
- <32
- 32 - 36
- 36 - 40
- 40 - 44
- 44 - 48
- 48 - 55.4

Figure 3.1 - AQMA 1 Predicted NO_2 Annual Mean at ground floor level

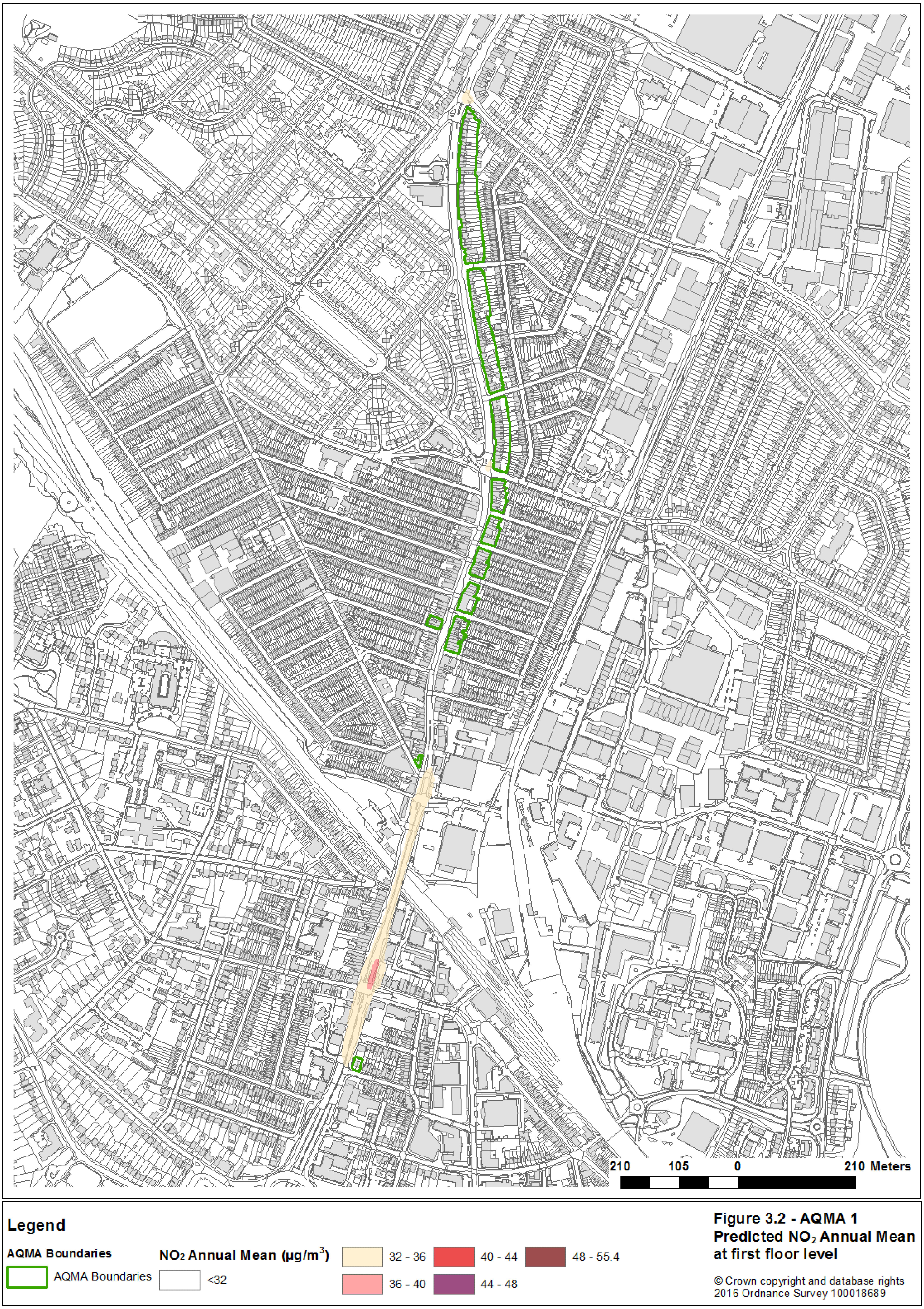


Figure 3.2 - AQMA 1 Predicted NO_2 Annual Mean at first floor level

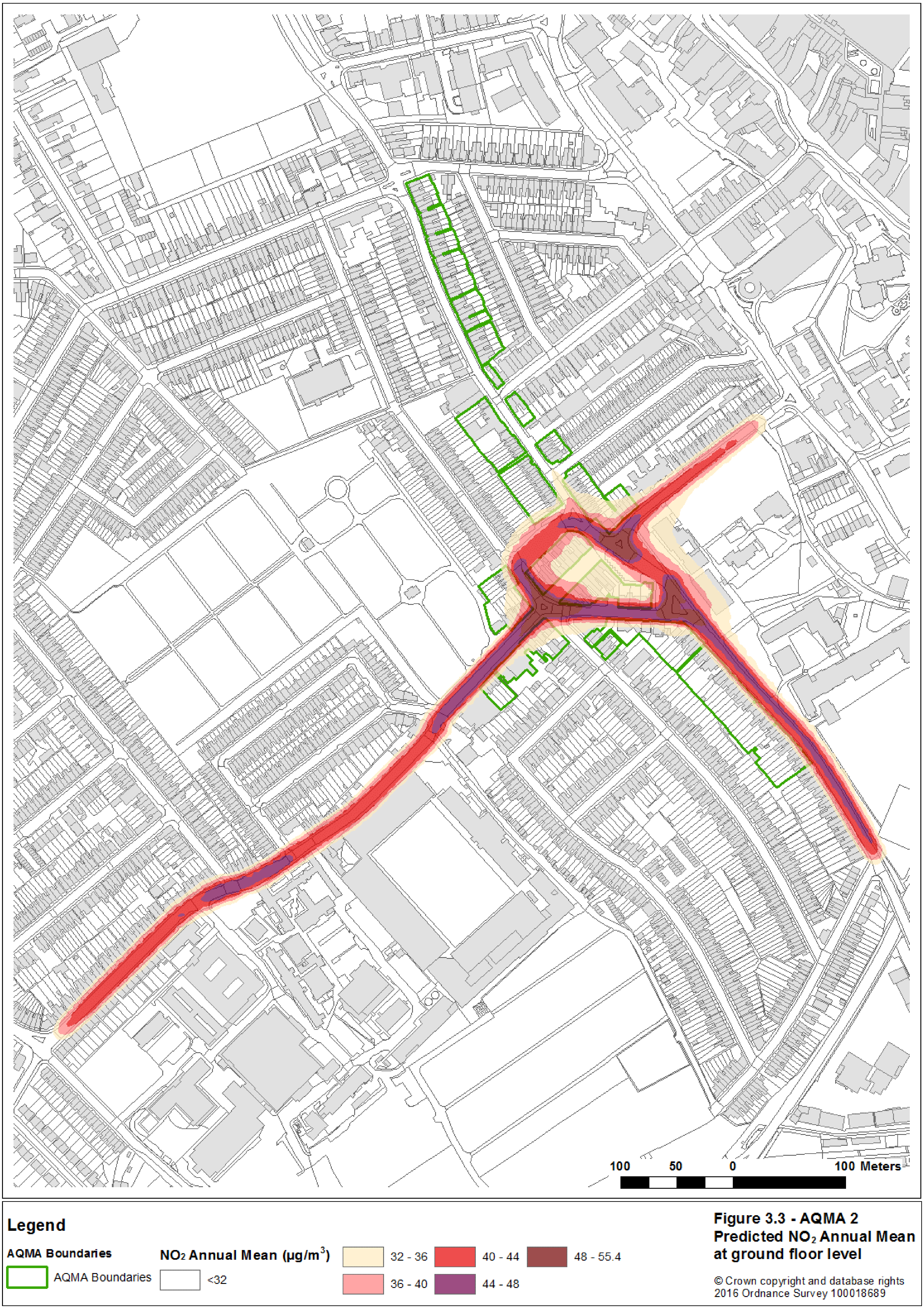
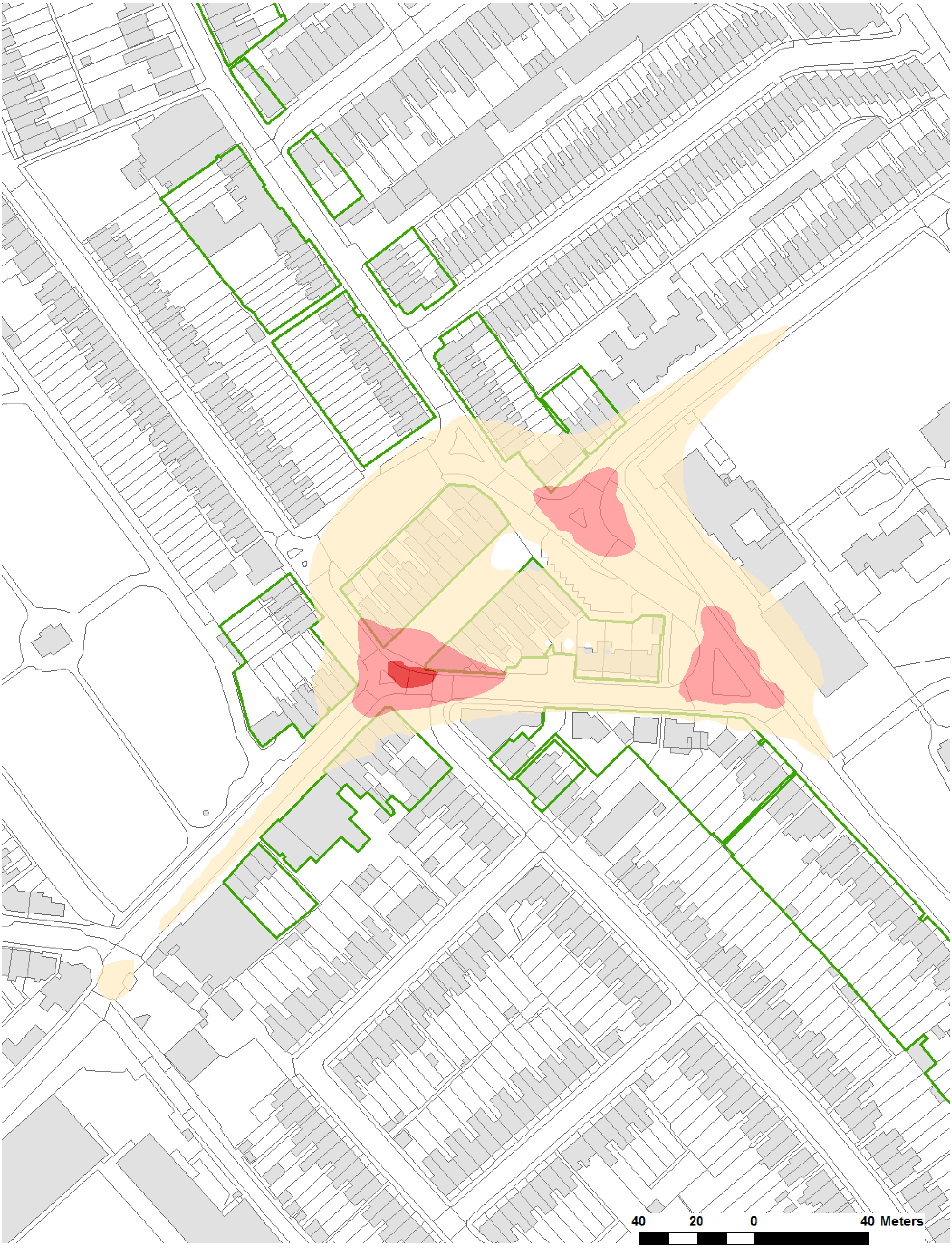


Figure 3.3 - AQMA 2 Predicted NO_2 Annual Mean at ground floor level



Legend

AQMA Boundaries

AQMA Boundaries

NO_2 Annual Mean (µg/m^3)

<32

32 - 36

36 - 40

40 - 44

44 - 48

48 - 55.4

Figure 3.4 - AQMA 2 Predicted NO_2 Annual Mean at first floor level

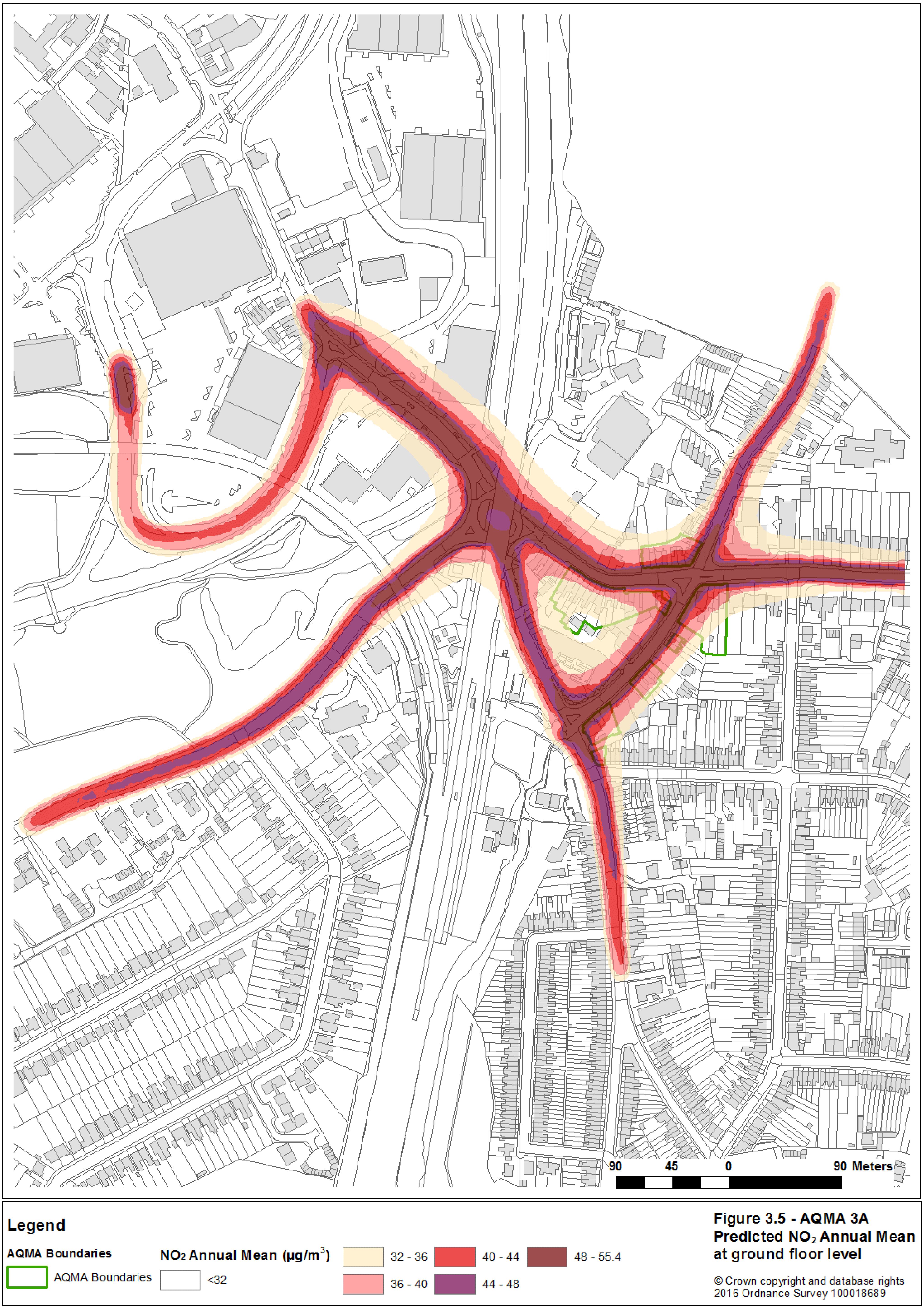
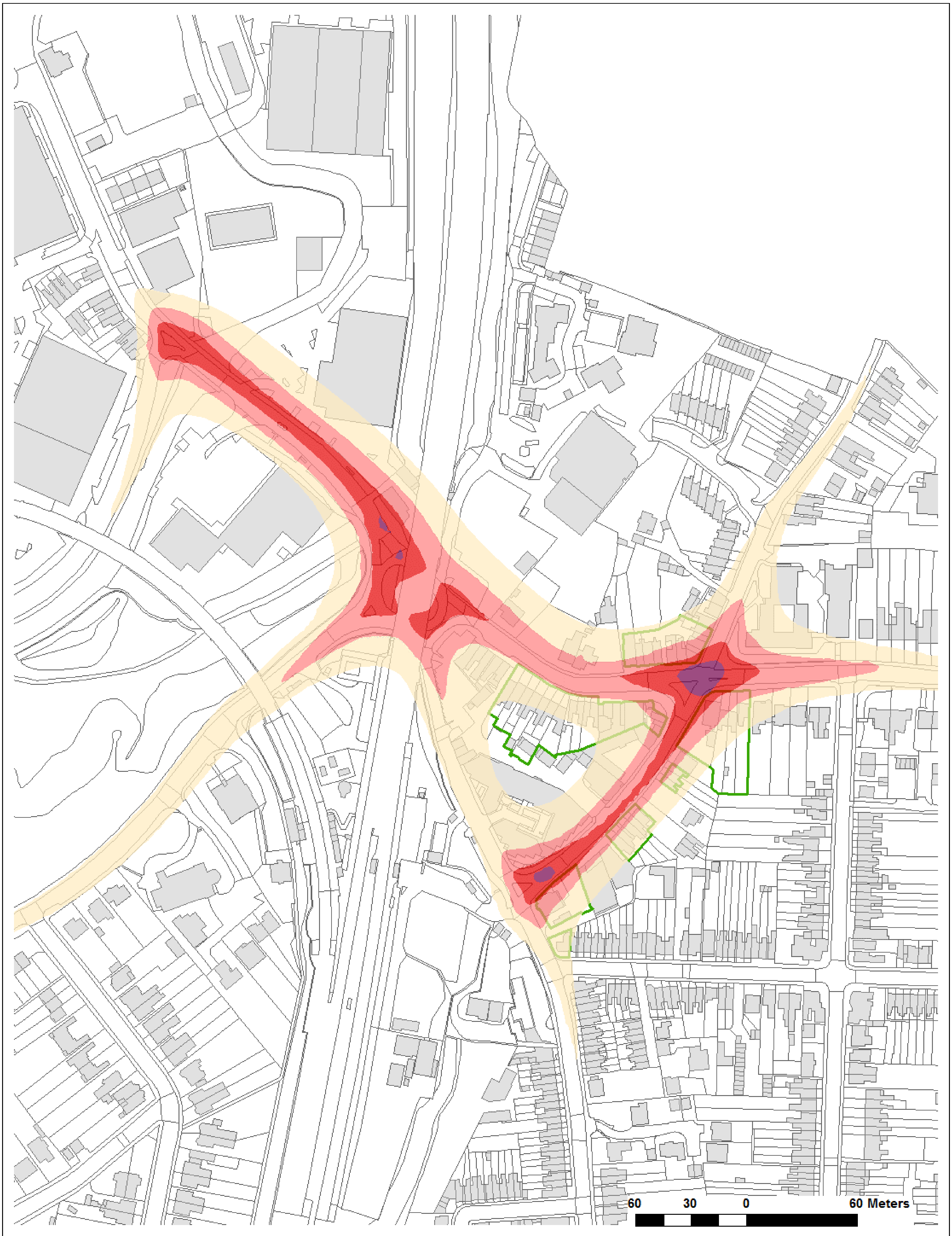


Figure 3.5 - AQMA 3A Predicted NO_2 Annual Mean at ground floor level



Legend

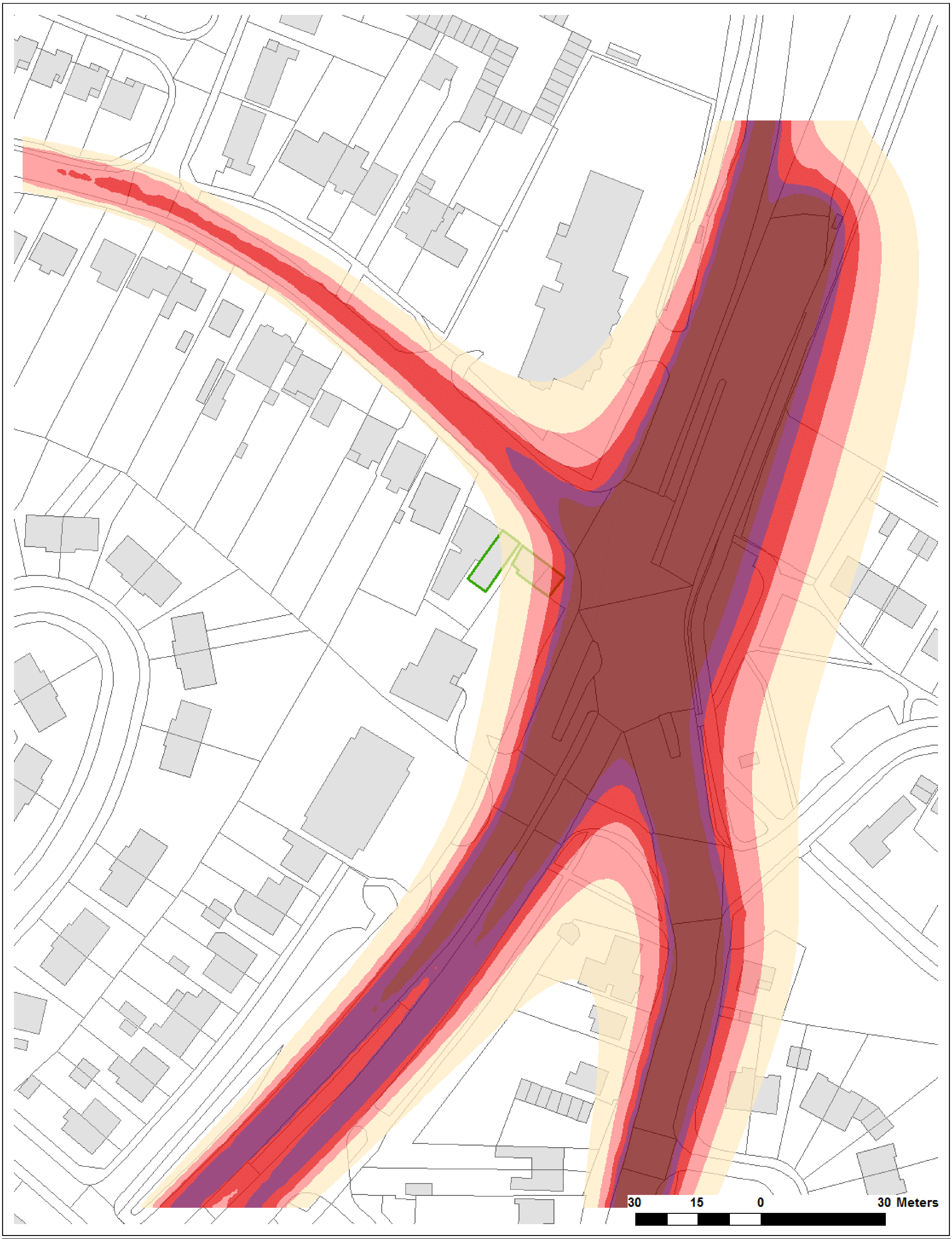
AQMA Boundaries

AQMA Boundaries

NO_2 Annual Mean (µg/m^3)

<32	32 - 36
36 - 40	40 - 44
44 - 48	48 - 55.4

Figure 3.6 - AQMA 3A Predicted NO_2 Annual Mean at first floor level



Legend

AQMA Boundaries

AQMA Boundaries

NO2 Annual Mean (µg/m3)

<32

32 - 36

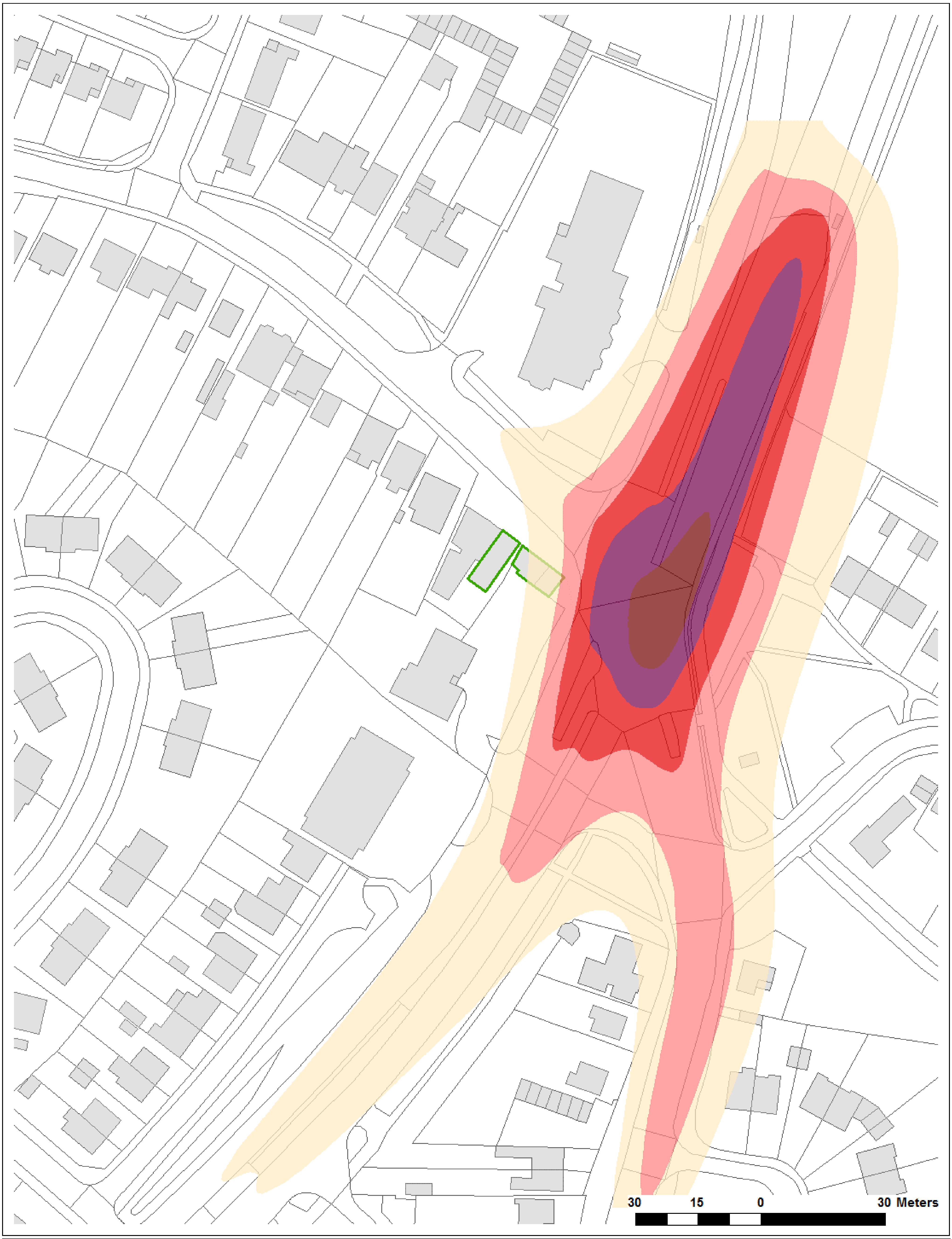
36 - 40

40 - 44

44 - 48

48 - 55.4

Figure 3.7 - AQMA 5 Predicted NO_2 Annual Mean at ground floor level



Legend

AQMA Boundaries

AQMA Boundaries

NO_2 Annual Mean ($\mu g/m^3$)

<32

32 - 36

36 - 40

40 - 44

44 - 48

48 - 55.4

Figure 3.8 - AQMA 5 Predicted NO_2 Annual Mean at first floor level

Appendix 4 – Traffic data

Table 4.1 to 4.4 summarise the Annual Average Daily Flows (AADF) of traffic and fleet compositions used within the model for each road link. The London Atmospheric Emission Inventory (LAEI) data along with data from local surveys carried out by Hertfordshire Count Council have been used.

Table 4.1 AQMA 1 - Annual Average Daily Flows

Street	AADF	%Cars	%Taxi	%LGV	%Rigid HGV	%Artic HGV	%Bus	%Motorcycle
The Harebreaks	1,445	83.2	1.4	9.3	4.5	0.3	0.0	1.3
St Albans Road – north of Leavesden Road	13,138	82.0	1.3	9.9	2.2	0.3	3.2	1.2
St Albans Road – south of Leavesden Road	26,802	82.0	1.3	9.9	2.2	0.3	3.2	1.2
Leavesden Road	30	0.0	0.0	0.0	0.0	0.0	100.0	0.0
Busshey Mill Lane	11,478	79.8	1.7	8.9	6.6	1.5	0.0	1.5
Langley Road	2,073	85.5	2.0	9.5	1.4	0.0	0.0	1.5
Balmoral Road	10,397	82.1	1.8	9.1	4.5	1.0	0.0	1.5

Table 4.2 AQMA 2 - Annual Average Daily Flows

Street	AADF	%Cars	%Taxi	%LGV	%Rigid HGV	%Artic HGV	%Bus	%Motorcycle
Wiggenhall Road	26,170	85.2	1.3	8.8	2.9	0.1	0.6	1.0
Cassio Road	11,495	82.3	1.8	9.2	3.9	0.9	0.5	1.5
Vicarage Road - south of junction	18,416	82.6	1.2	11.8	2.1	0.2	1.7	0.4
Junction between Vicarage Rd and Merton Rd	13,429	86.8	1.4	7.8	1.4	0.1	1.7	0.8
Farraline Road	13,085	85.2	1.3	8.8	2.9	0.1	0.6	1.0
Vicarage Road - north of junction	13,429	86.8	1.4	7.8	1.4	0.1	1.7	0.8
Merton Road	5,894	84.4	0.0	12.9	1.5	0.1	0.1	1.0

Table 4.3 AQMA 3A - Annual Average Daily Flows

Street	AADF	%Cars	%Taxi	%LGV	%Rigid HGV	%Artic HGV	%Bus	%Motorcycle
Aldenham Road - north of Chalk Hill	10,174	85.2	1.9	9.5	1.5	0.3	0.0	1.6
Aldenham Road - south of Chalk Hill	16,543	83.2	1.8	9.3	2.4	0.6	1.2	1.6
Eastbury Road	17,639	83.4	1.3	10.7	2.0	0.1	1.5	1.0
Pinner Road	14,134	87.2	1.4	8.3	1.5	0.2	0.7	0.7
Dalton Way	17,425	85.4	1.3	10.7	1.2	0.3	0.4	0.7

Table 4.4 AQMA 5 - Annual Average Daily Flows

Street	AADF	%Cars	%Taxi	%LGV	%Rigid HGV	%Artic HGV	%Bus	%Motorcycle
Horseshoe Lane	7,883	81.7	1.8	9.1	4.8	1.1	0.0	1.5
St Albans Road Southbound north of junction	16,447	84.1	1.3	10.0	2.2	0.7	1.3	0.5
St Albans Road Southbound south of junction	9,880	86.2	1.3	8.0	2.2	0.8	0.8	0.7
St Albans Road Northbound north of junction	16,447	84.1	1.3	10.0	2.2	0.7	1.3	0.5
St Albans Road Northbound south of junction	9,880	86.2	1.3	8.0	2.2	0.8	0.8	0.7
St Albans Road east of junction	15,005	80.0	1.2	10.2	3.0	1.0	3.5	1.1

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