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Air quality modelling to support the Elmbridge Local Plan - future scenarios (2037)

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1 Summary

Elmbridge Borough Council is preparing a Local Plan to guide development in the Borough until 2037. CERC was commissioned to carry out air dispersion modelling to identify the current baseline air quality profile across the area and to assess three future (2037) scenarios, with and without proposed developments in the Elmbridge Local Plan in place.

The first part of the air quality assessment, provided in a separate report *Air quality modelling to support the Elmbridge Local Plan – current baseline (2017),* determined the current baseline (2017) levels of NO_2, PM_{10} and $PM_{2.5}$ across the area.

This is the second part of the assessment, in which levels of NO_2, PM_{10} and $PM_{2.5}$ in the scheme area have been assessed for three future (2037) scenarios: Scenario 1, the future baseline; Scenario 2, the Urban Growth Strategy scenario; and Scenario 3, Urban Growth Strategy scenario with mitigation. Scenario 1 will be used as the 'do nothing' scenario against which Scenario 2 and Scenario 3 will be assessed.

Air quality modelling was carried out using ADMS-Urban software to determine concentrations of each modelled pollutant. The model set-up and emissions data, including traffic data and traffic emission factors relevant to modelling air quality, were updated to 2037. Emissions from other roads and sources across Surrey were updated to 2037. All other emissions and model inputs were the same as for the current baseline (2017) modelling.

The modelling used transport activity data provided by Elmbridge Borough Council, together with emission factors from the EFT (Emission Factor Toolkit) version 10.1, published by Defra and the CREAM (Calculator for Road Emissions of Ammonia), published by Air Quality Consultants. Emissions from traffic flows across Surrey, used as input into the current baseline (2017) modelling, were projected to 2037 and modelled as part of the aggregated grid source. Emissions data from other sources were taken from the National Atmospheric Emissions Inventory (NAEI). Additional emissions from planned developments were included for Scenario 2 and Scenario 3.

1.1 Human health impacts

For the assessment of human health impacts, the model was run to produce contour plots of annual mean NO_2, 99.79th percentile of hourly mean NO_2, annual mean PM_{10}, 90.41st percentile of 24-hourly mean PM_{10} and annual mean $PM_{2.5}$ concentrations.

For all three 2037 scenarios, modelled concentrations of NO_2, PM_{10} and $PM_{2.5}$ are all below the relevant limit values. Difference plots show that the introduction of the Local Plan, as represented by Scenario 2 and Scenario 3, is likely to have a small impact on annual average pollutant concentrations along some roads in the borough.

Local mortality burden calculations were carried out by coupling population data, by Lower Layer Super Output Areas (LSOA), with the modelled annual mean concentrations of NO_2 and $PM_{2.5}$. This includes deaths attributable to air pollution, the associated life-years lost and economic cost.

The combined health impacts of NO_2 and $PM_{2.5}$ for Elmbridge were calculated to be:

- in the range of 547 and 748 life-years lost for Scenario 1;
- in the range of 548 and 749 life-years lost for Scenario 2; and
- in the range of 548 and 749 life-years lost for Scenario 3.

For each of the three 2037 scenarios, the life years lost equate to an economic cost for chronic mortality between £35 million and £48 million.

1.2 Sensitive habitats impacts

For the assessment of impacts on sensitive habitats:

- annual average NO_x concentrations were calculated at the area of each SPA within Elmbridge for comparison with the critical level of 30 $\mu g/m^3$; and
- annual Nitrogen deposition rates were calculated at the area of each SPA within Elmbridge for comparison with site-specific critical loads.

For all three 2037 scenarios, the model-predicted annual average NO_x concentrations across the South West London Waterbodies SPA and Thames Basin Heaths SPA are below the NO_x critical level of 30 $\mu g/m^3$.

For South West London Waterbodies SPA, for all three 2037 scenarios, the nitrogen deposition falls below the critical load range of 20 – 30 kg N ha^{-1} yr^{-1}.

For all three 2037 scenarios, the calculated nitrogen deposition exceeds the critical load range of 10 – 20 kg N ha^{-1} yr^{-1} for the short vegetation habitats at Thames Basin Heaths SPA, calculated using grassland deposition velocities.

As tall vegetation habitats are not an interest feature of the SPA, deposition results calculated using forest deposition velocities are not presented.

Difference plots show that the introduction of the Local Plan, as represented by Scenario 2 and Scenario 3, leads to an increase in deposition rate of no more than 0.1 N ha^{-1} yr^{-1} over much of Thames Basin Heaths SPA. There are larger increases at areas of the SPA close to the modelled roads, but the highest values fall within an area of shelterbelt, where it is understood that habitats are less sensitive.

2 Introduction

Elmbridge Borough Council (the Council) is preparing a Local Plan to guide development in the Borough until 2037.

The main source of air pollution in Elmbridge is road transport from major roads; implementation of a Local Plan can lead to changes in the magnitude and location of these emissions. CERC was commissioned to carry out air dispersion modelling to identify the current baseline air quality profile across the area and to assess three future (2037) scenarios, with and without proposed developments in the Elmbridge Local Plan in place, represented by:

- Scenario 1: 2037 Baseline;
- Scenario 2: Urban Growth Strategy scenario; and
- Scenario 3: Urban Growth Strategy scenario with mitigation.

The first part of the air quality assessment, provided in a separate report *Air quality modelling to support the Elmbridge Local Plan – current baseline (2017),* determined the current baseline (2017) levels of NO_2, PM_{10} and $PM_{2.5}$ across the area.

This is the second part of the assessment, in which levels of NO_2, PM_{10} and $PM_{2.5}$ in the scheme area have been assessed for the three future (2037) scenarios. Scenario 1 will be used as the 'do nothing' scenario against which Scenario 2 and Scenario 3 will be assessed.

High resolution air quality maps of concentrations of NO_2, PM_{10} and $PM_{2.5}$ across Elmbridge were generated for the future scenarios, for comparison against relevant air quality standards. Local mortality burdens were carried out by coupling population data with the modelled annual mean concentrations of NO_2 and $PM_{2.5}$.

The modelling also considers the impacts on sensitive habitat sites: the annual average NO_x concentrations and Nitrogen deposition rates were considered for each of the SPAs within Elmbridge.

In this report, Section 3 presents the criteria used to carry out the impact magnitude assessment of the 2037 modelling. With the exception of changes to the model set up and traffic emissions data outlined in Section 4 and 5 of this report, the model set-up is the same as that used in the 2017 assessment.

The results of the modelling of the future (2037) scenarios are then presented: the human health impacts in Section 6, which includes concentration maps, difference maps, health receptor concentrations, and mortality burden calculations. Sensitive habitat impacts are presented in Section 7. A discussion of the results is presented in Section 8.

A summary of the commercial and domestic developments expected as part of the Local Plan are included in Appendix A. Finally, a summary of the ADMS-Urban model is included as Appendix B.

3 Significance Criteria

The significance of the air quality impacts as a result of the Local Plan was assessed using The Environmental Protection UK (EPUK) and Institute of Air Quality Management (IAQM) guidance for Land-Use Planning & Development Control[1].

The impact magnitude criteria presented in the EPUK and IAQM guidance can be applied to any Air Quality Assessment Level (AQAL), such as the air quality objectives considered in this assessment.

Table 3.1 (reproduced from Table 6.3 of the document) sets out the impact descriptors for annual average NO_2 and particulate concentrations. A concentration decrease of 0.5% or more from the baseline is considered a *Beneficial* impact and an increase of 0.5% or more is considered an *Adverse* impact.

Table 3.1: Impact descriptors

Long term average concentration at receptor in assessment year	**% change in concentration relative to Air Quality Assessment level (AQAL)**			
	1	2-5	6-10	>10
75% or less of AQAL	Negligible	Negligible	Slight	Moderate
76-94% of AQAL	Negligible	Slight	Moderate	Moderate
95-102% of AQAL	Slight	Moderate	Moderate	Substantial
103-109% of AQAL	Moderate	Moderate	Substantial	Substantial
110% or more of AQAL	Moderate	Substantial	Substantial	Substantial

Note percentages used in defining these descriptors are rounded to the nearest whole number

[1] Land-Use Planning & Development Control: Planning for Air Quality (January 2017) http://www.iaqm.co.uk/text/guidance/air-quality-planning-guidance.pdf

4 Model set-up

This section outlines the changes to the current baseline (2017) model set-up to represent the future (2037) scenarios. Unless otherwise stated, the model set-up is the same as outlined in Section 5 of the current baseline (2017) report. The following sections are not included as the inputs have remained the same:

- Surface roughness;
- Monin-Obukhov length;
- Meteorological data; and
- Chemistry.

Section 5 outlines the changes to the emissions data to represent the future (2037) scenarios.

4.1 Modelling software

All modelling was carried out using ADMS-Urban[2] version 5.0.0.1, developed by CERC.

4.2 Background data

Projections of background concentrations for 2037 were based on Local Air Quality Management background air pollution maps, published by Defra[3]. The maps provide annual average background concentrations on a 1 km by 1 km grid square basis, with projections up to the year 2030. The 2030 background maps were used to project the 2017 background concentrations to the year 2037 at each of the monitoring sites. This is likely to be a conservative approach, as background concentrations are expected to decrease slightly each year due to expected reduction in pollutant emissions, for example through newer vehicle technologies into the road transport fleet mix.

Table 4.1 summarises the annual statistics for background data used for the modelling of the current baseline (2017) and future (2037) scenarios, calculated using wind data from Heathrow Airport.

Table 4.1: Summary of 2017 and 2037 background data used in the modelling ($\mu g/m^3$)

Year	Statistic	NO_x	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2
2017	Annual average	17.5	12.0	51.3	14.8	8.8	0.9
	99.79th percentile of hourly average	392.4	80.0	111.8	-	-	-
	90.41st percentile of 24-hour average	-	-	-	26.0	19.0	1.4
2037	Annual average	11.2	8.2	55.3	13.6	7.8	0.9
	99.79th percentile of hourly average	233.7	51.9	114.1	-	-	-
	90.41st percentile of 24-hour average	-	-	-	24.5	16.9	1.4

[2] http://cerc.co.uk/environmental-software/ADMS-Urban-model.html

[3] https://uk-air.defra.gov.uk/data/laqm-background-home

4.3 Street canyons

The advanced street canyon module option in ADMS-Urban was used to modify the dispersion of pollutants from a road source according to the presence and properties of canyon walls on one or both sides of the road. Street canyon parameters, calculated from Ordnance Survey Mastermap topographic data in the current baseline (2017) modelling, were used as input to the ADMS Advanced Canyon option for the future (2037) scenarios modelling, supplemented with advanced canyon inputs calculated for the additional roads.

5 Emissions

Emission inventories were compiled for each of the scenarios modelled, using CERC's EMIT[4] emissions inventory tool, version 3.7. This section outlines the changes to the current baseline (2017) emissions inventory to represent the future (2037) scenarios. Unless otherwise stated, the emissions data are the same as outlined in Section 6 of the current baseline (2017) report. The following sections are not included as the inputs have remained the same:

- Time varying emissions; and
- Point sources.

5.1 Road transport

Emissions from road transport were calculated using an activity data approach, whereby Annual Average Daily Traffic flows (AADTs) for each road link were combined with emission factors and speed data to calculate emissions for each road link on a vehicle-by-vehicle basis. This methodology is described below.

5.1.1 Emission factors

Traffic emissions of NO_x, NO_2, PM_{10} and $PM_{2.5}$ were calculated from traffic flows using EFT v10.1 emission factors based on Euro vehicle emissions categories. This dataset includes speed-emissions data that are based COPERT 5[5] emission factors. EFT v10.1 include exhaust, brake, tyre and road wear for PM_{10} and $PM_{2.5}$.

Note that projected vehicle fleet data is only available up to the year 2030; vehicle emissions data were therefore calculated using traffic flows for 2037 and vehicle fleet compositions for 2030. This is likely to be a conservative approach as vehicle emissions are predicted to decrease slightly each year with the uptake of newer, cleaner vehicles.

Traffic emissions of NH_3 were calculated from traffic flows using Air Quality Consultants' ammonia emissions factor tool CREAM V1A[6]. The vehicle fleet projections in CREAM are provided up to 2035; vehicle emissions data were therefore calculated using traffic flows for 2037 and vehicle fleet compositions for 2035.

5.1.2 Activity data

Traffic activity data were provided by Elmbridge Borough Council for the future scenarios, in the same format as the Surrey Traffic Model. The data comprised AM peak and PM peak traffic flows split by vehicle type and a derived AADT, calculated using factors provided by Surrey County Council. For each scenario, updated traffic emissions were calculated based on the traffic data provided.

[4] http://cerc.co.uk/environmental-software/EMIT-tool.html
[5] http://www.emisia.com/copert/General.html
[6] https://www.aqconsultants.co.uk/resources/calculator-for-road-emissions-of-ammonia

As with the current baseline (2017) modelling, the future scenario (2037) speeds were derived by calculating a weighted average speed on each road, based on the flow of each vehicle throughout the day.

Emissions from traffic flows across Surrey, used as input into the current baseline (2017) modelling, were modelled as part of the aggregated grid source described in Section 5.2. The traffic flows were projected to 2037, based on the change in vehicle kilometres between 2017 and Scenario 1 data for Elmbridge roads.

5.2 Other emissions

Spatially-diffuse emissions from sources other than those explicitly modelled, such as emissions from domestic combustion, were represented by a set of 1-km square grid sources with a depth of 10 m. Gridded emissions data for 2015 from the NAEI[7] were used to represent these sources.

Local Air Quality Management background air pollution maps, published by Defra [8], provide annual average background concentrations on a 1 km by 1 km grid square basis, with projections up to the year 2030. The background data was used to project the 2015 NAEI gridded data to 2030 for each grid square and emissions sector.

5.2.1 Domestic emissions

Emissions from commercial and domestic developments expected as part of the Local Plan were included for Scenario 2 and 3. The domestic emissions were calculated based on the number of units and the commercial emissions were calculated based on the area of floor space assigned to each development. A summary of the developments is included in Appendix A.

Emission factors were obtained from the NAEI and a representative energy demand was obtained from the Department of Energy and Climate Change (DECC) Energy demand benchmarks. A value of 200 kWh per square metre per year was used for the calculation of commercial emissions and a value of 10,000 kWh per year was used for the calculation of domestic emissions, based on an average of the energy demand benchmarks for different types of houses, as shown in Table 5.1. The emissions were modelled as 1-km resolution grid sources, consistent with the modelling of current domestic and commercial emissions.

Table 5.1: DECC Energy demand benchmarks[9]

Type	Energy demand (kWh/year)
Flat	6218
Terrace	8371
Semi	10306
Detached	15459
Average	10089

[7] http://naei.defra.gov.uk/
[8] https://uk-air.defra.gov.uk/data/laqm-background-home
[9] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/379052/EED_regs_-_benchmark_heat_demand_paper_-_261114_.pdf

6 2037 scenarios: human health impacts

6.1 Concentration contours

This section comprises borough-wide air quality maps for the three 2037 scenarios, for comparison against air quality objectives for NO_2, PM_{10} and $PM_{2.5}$.

Pollutant concentrations were generated at a set of output points on a 100 m regular grid across the region, along with additional output points along modelled roads to capture the steep concentration gradients at roadside. These model-calculated concentrations were used to generate 10 m resolution air quality maps in GIS software, using the Natural Neighbour interpolation method.

In the air quality maps, exceedences of the air quality objective are shown in orange and red, and pollutant concentrations below the objective are shown in blue, green and yellow.

Figure 6.1 to Figure 6.15 present contour plots of the modelled annual and hourly mean NO_2 concentrations, the modelled annual and daily mean PM_{10} concentrations and the annual mean $PM_{2.5}$ concentrations across Elmbridge for the 2037 scenarios. There are no exceedences of the relevant air quality objectives in each case.

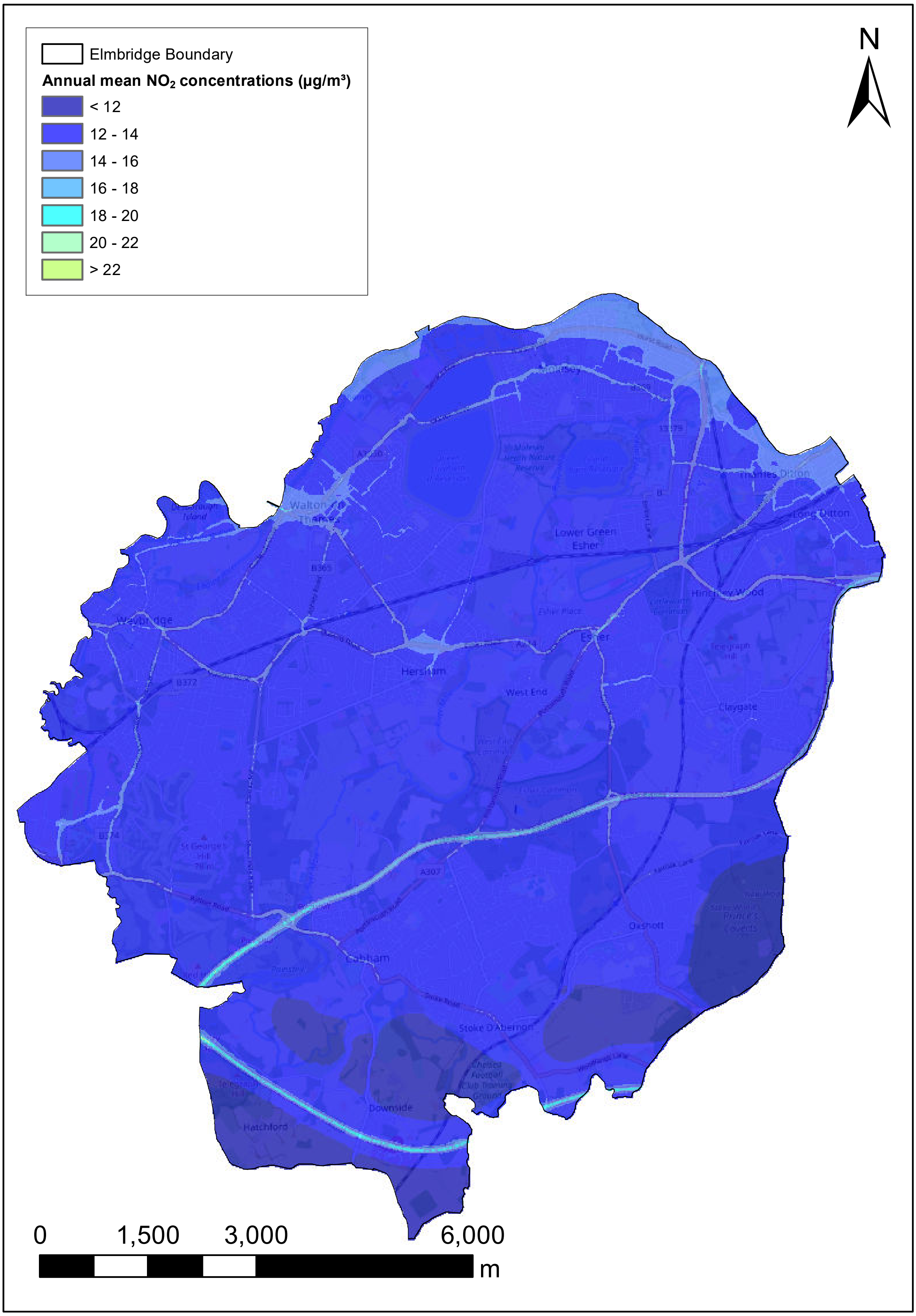

Figure 6.1: Annual mean NO_2 concentrations for Elmbridge, Scenario 1, 2037 (µg/m³)

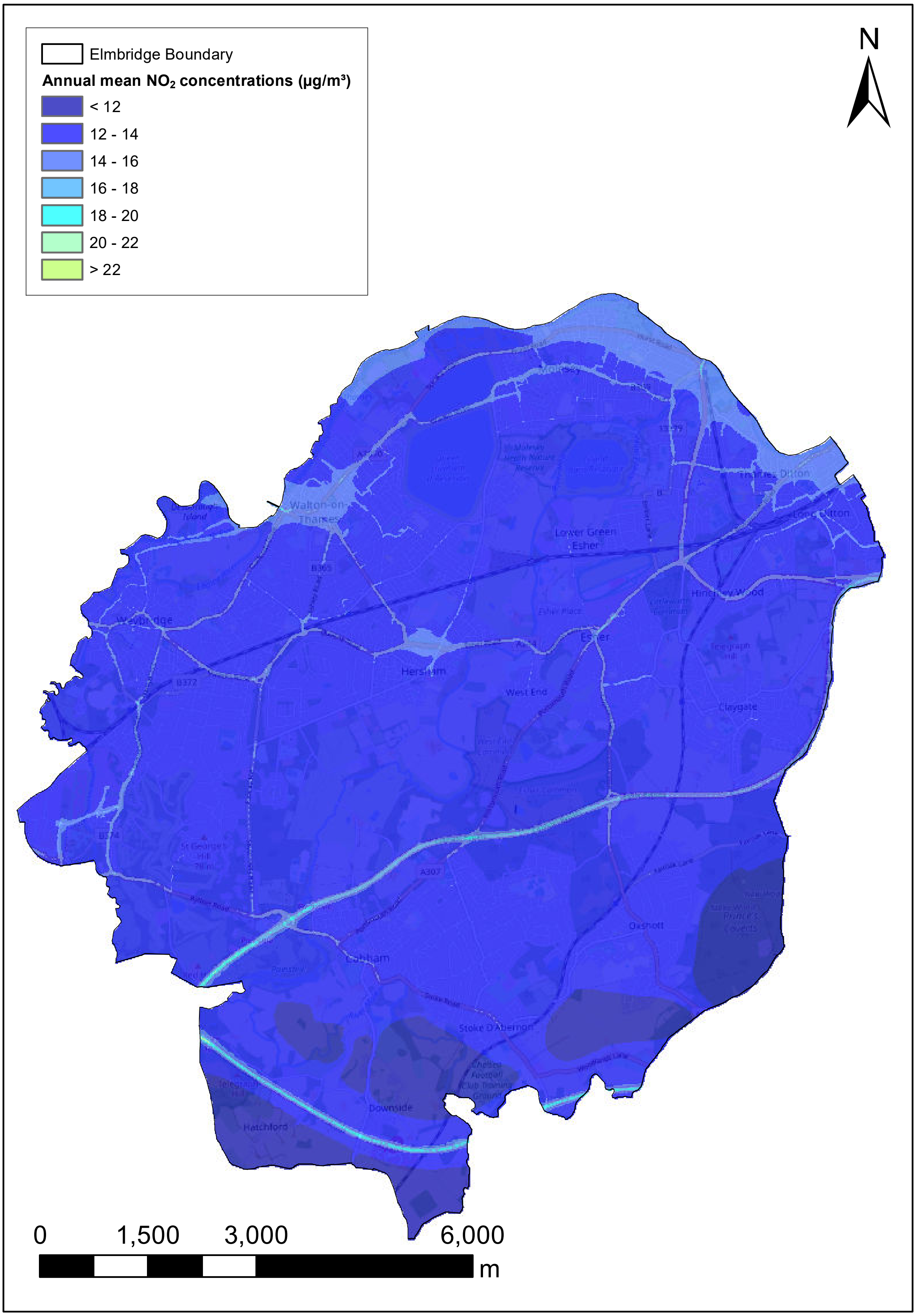

Figure 6.2: Annual mean NO_2 concentrations for Elmbridge, Scenario 2, 2037 (µg/m³)

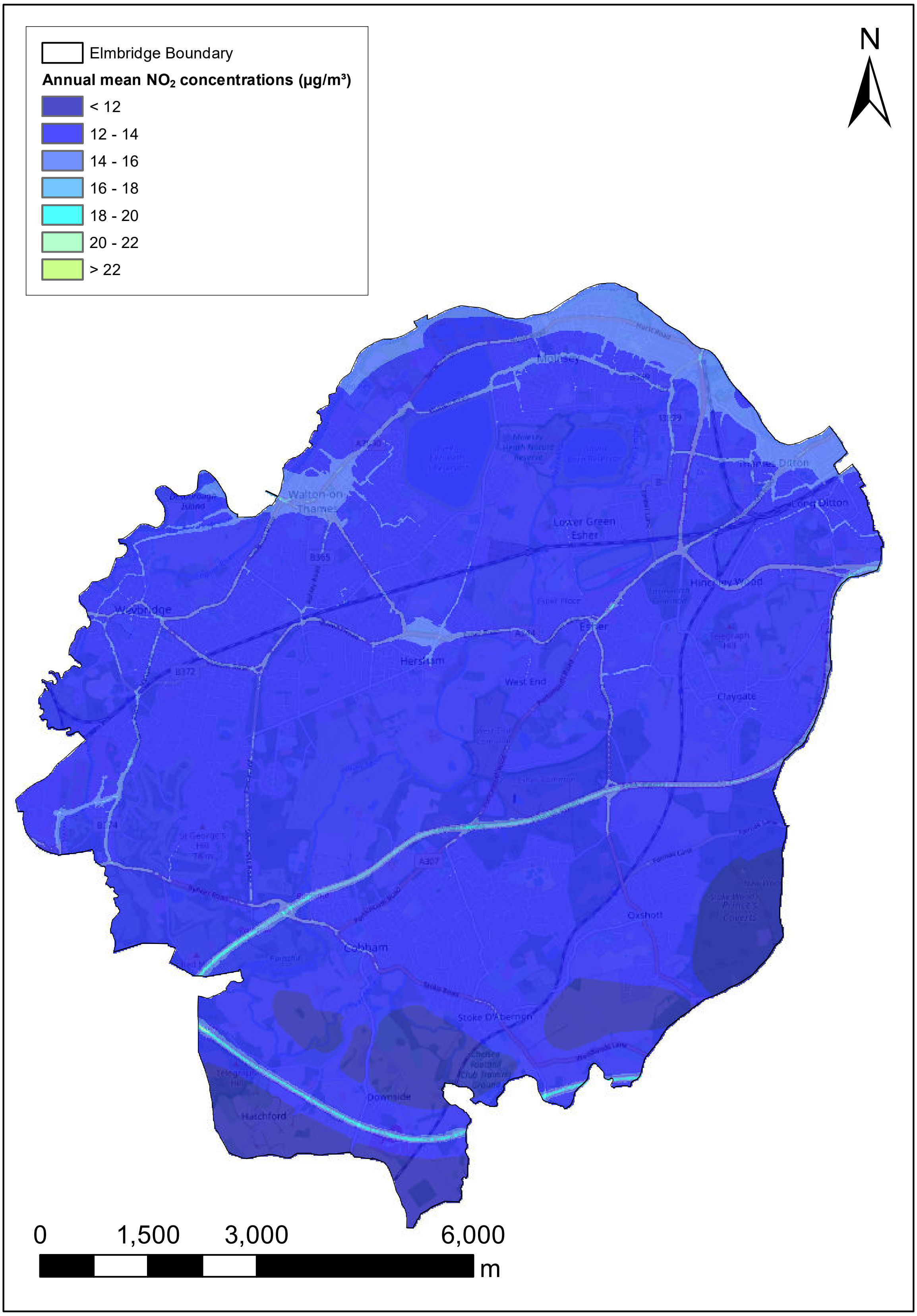

Figure 6.3: Annual mean NO_2 concentrations for Elmbridge, Scenario 3, 2037 (µg/m³)

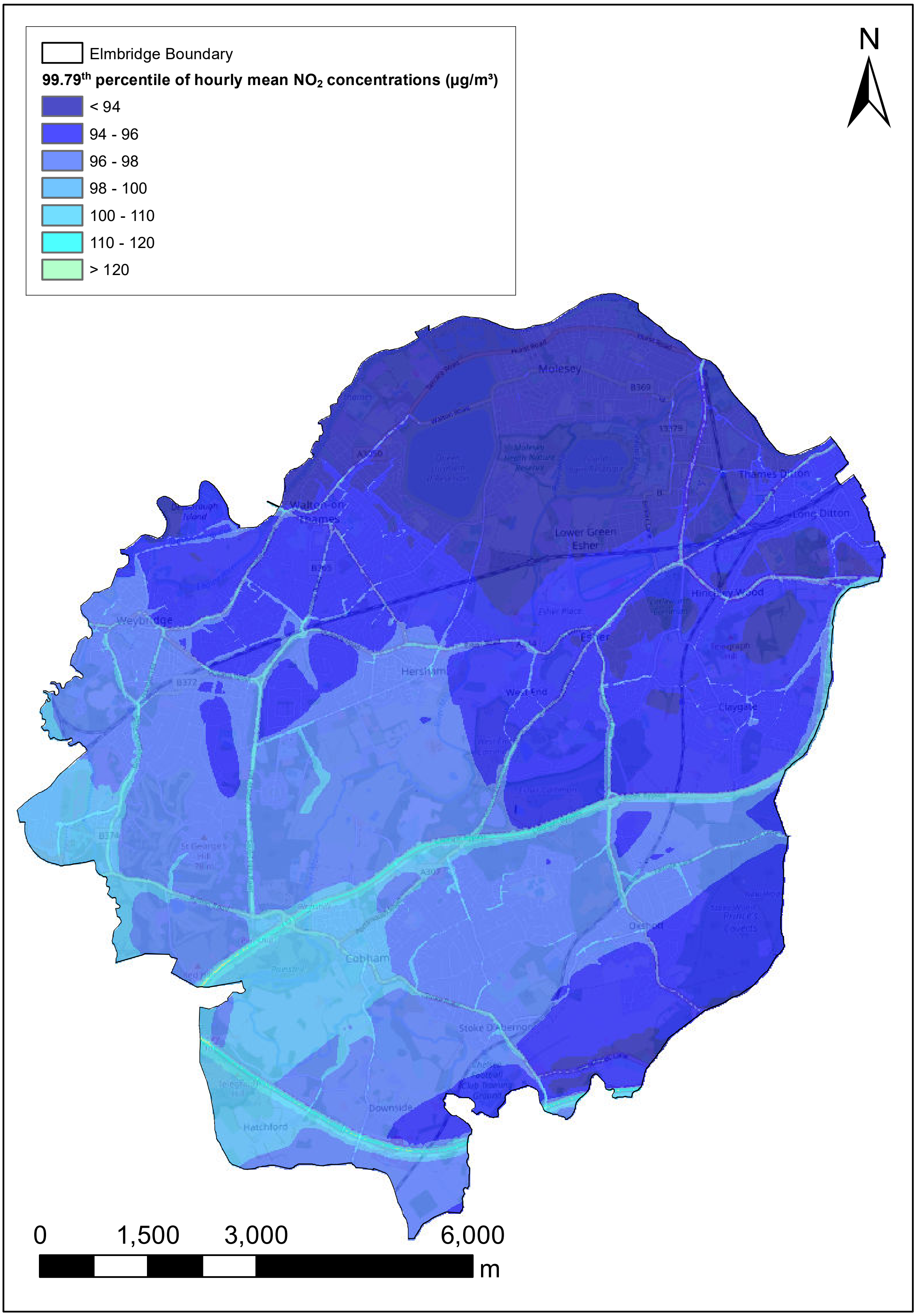

Figure 6.4: 99.79th percentile of hourly mean NO_2 concentrations for Elmbridge, Scenario 1, 2037 (µg/m³)

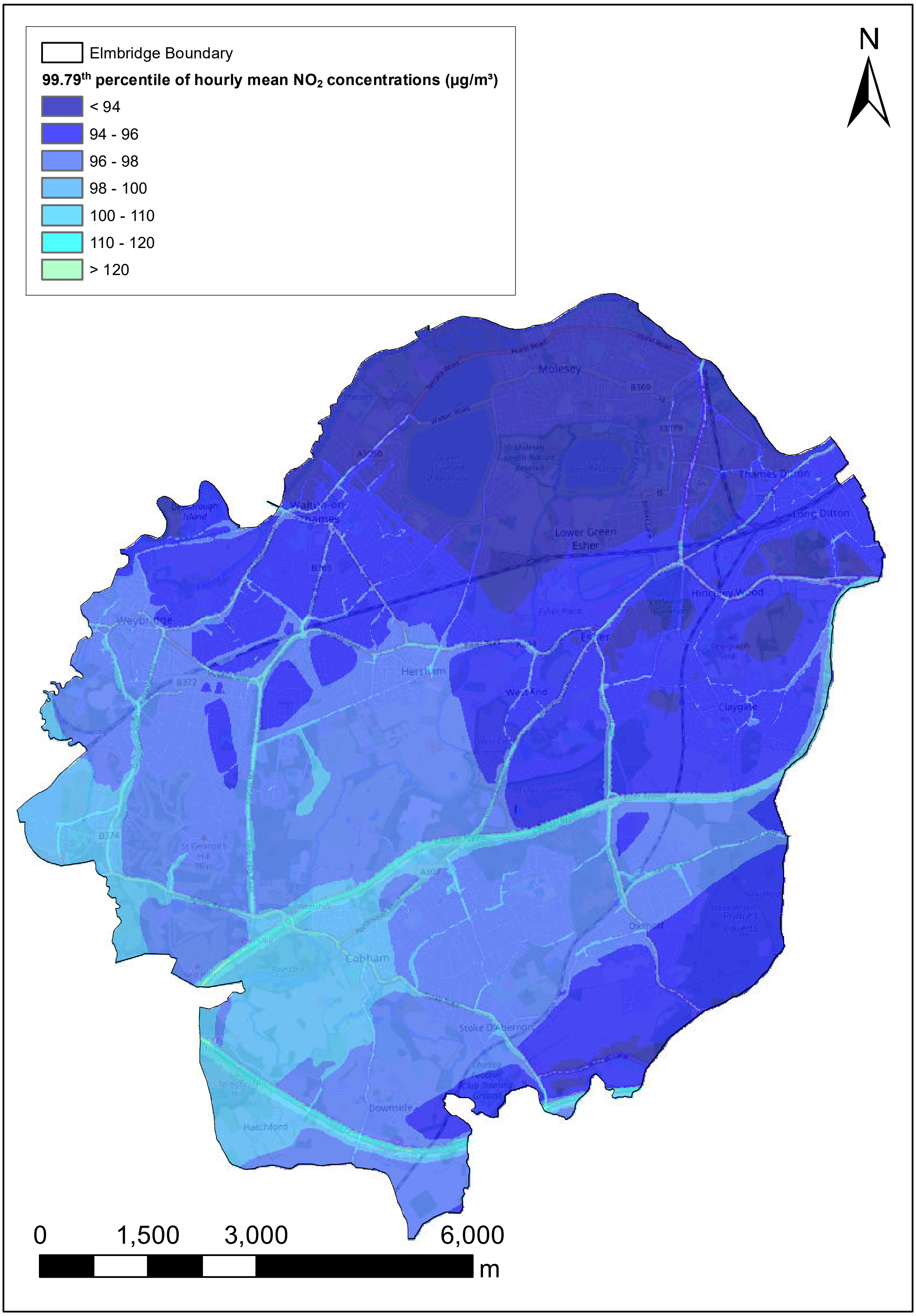

Figure 6.5: 99.79th percentile of hourly mean NO_2 concentrations for Elmbridge, Scenario 2, 2037 (µg/m³)

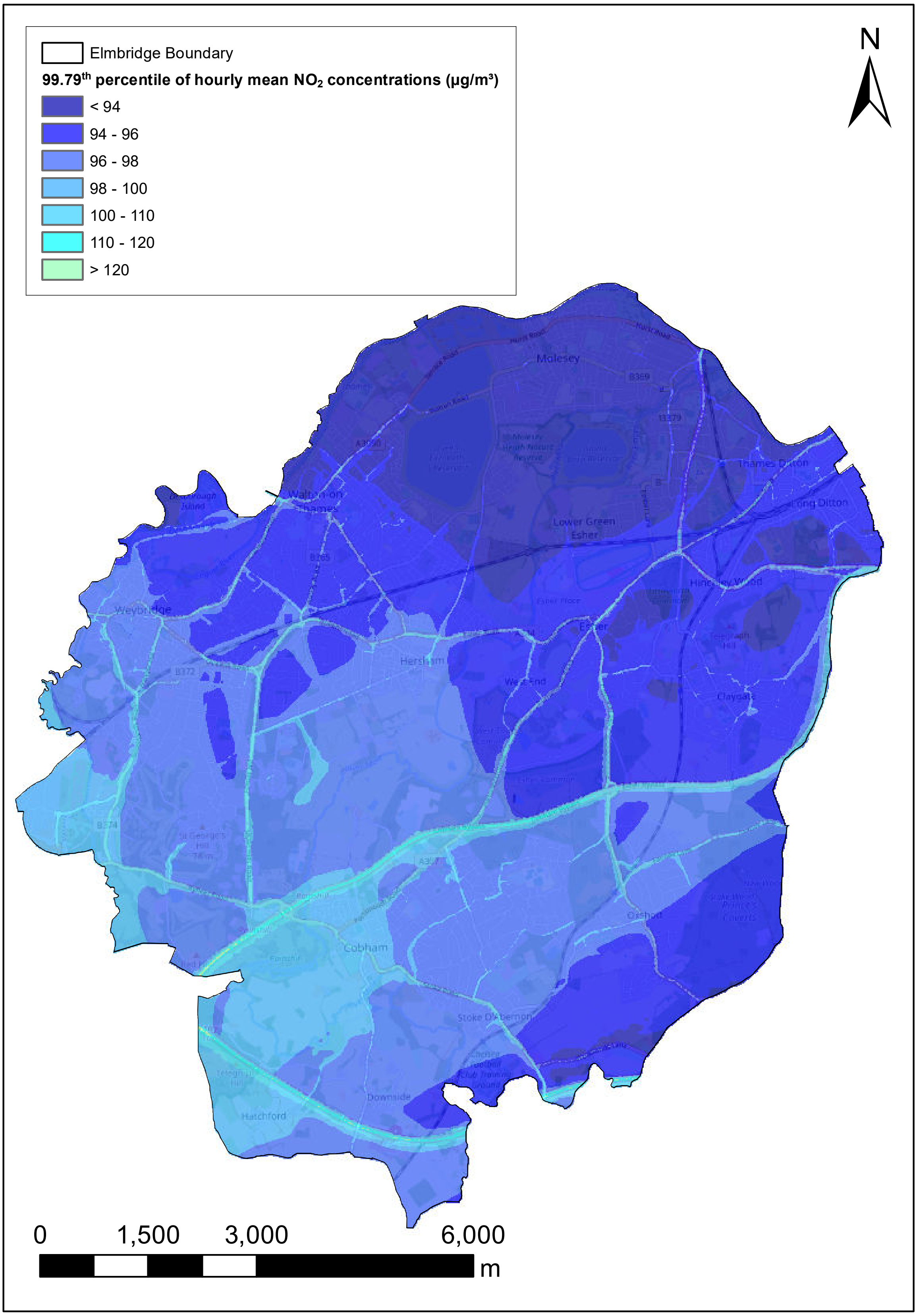

Figure 6.6: 99.79th percentile of hourly mean NO_2 concentrations for Elmbridge, Scenario 3, 2037 (µg/m³)

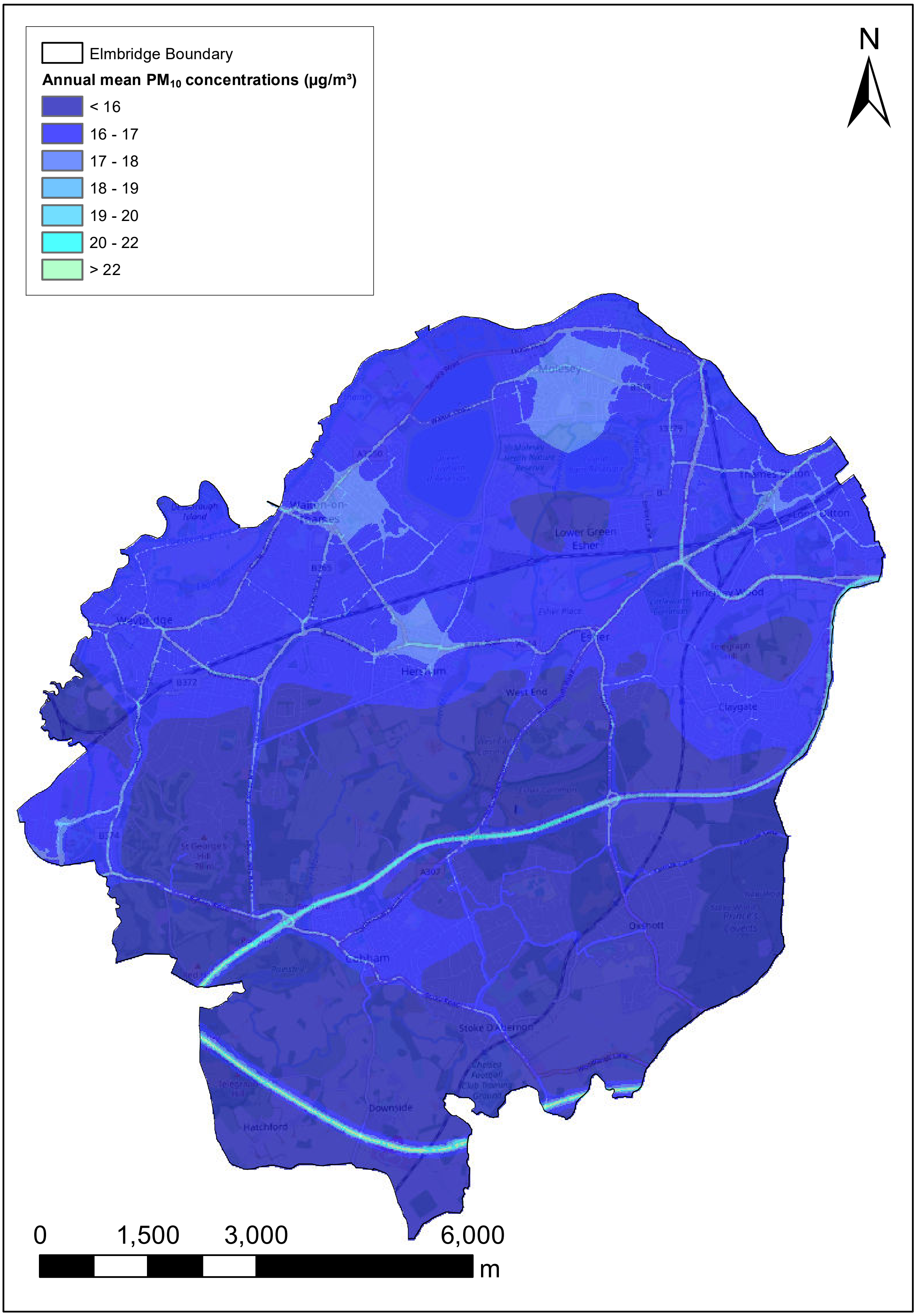

Figure 6.7: Annual mean PM_{10} concentrations for Elmbridge, Scenario 1, 2037 (µg/m³)

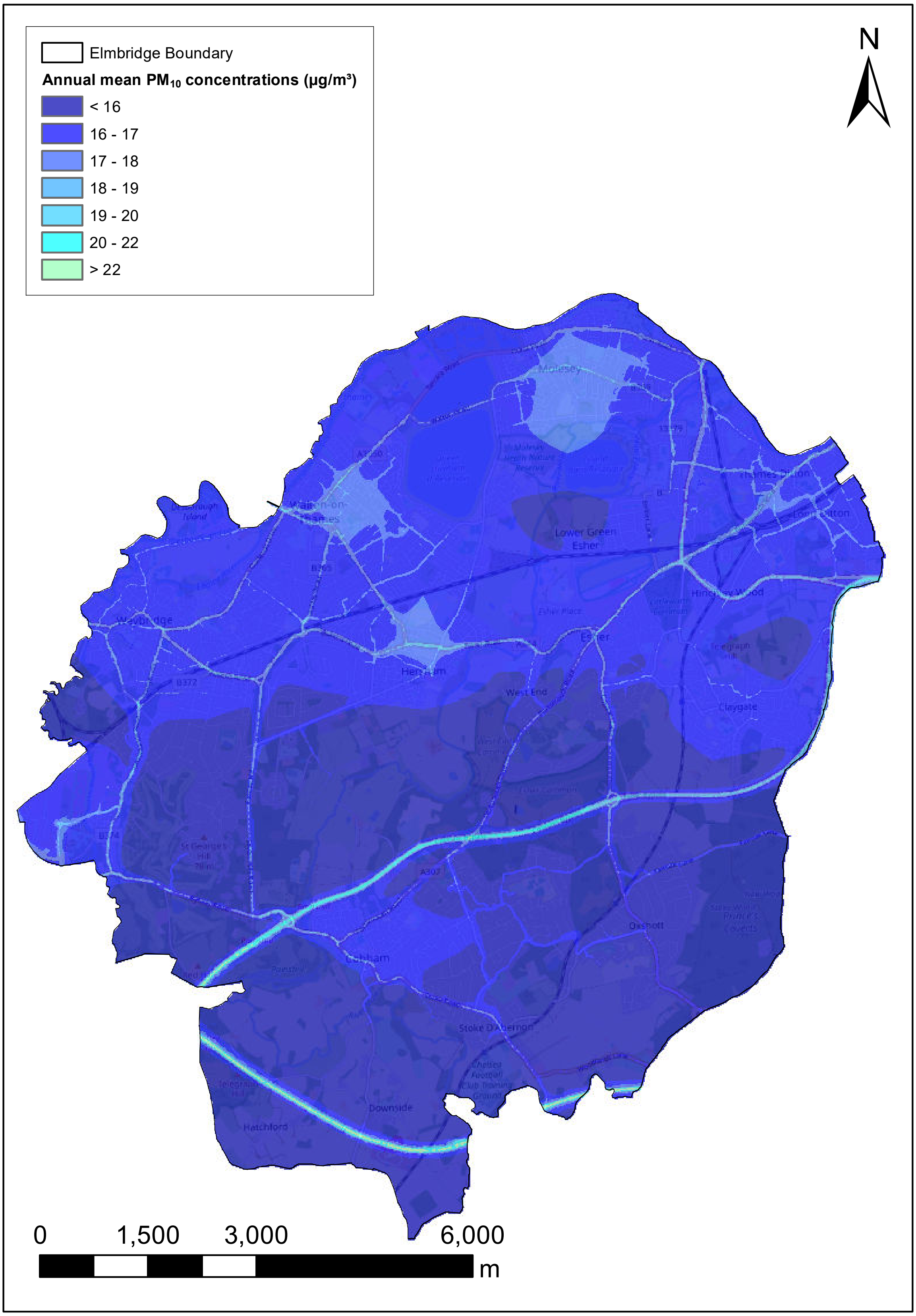

Figure 6.8: Annual mean PM_{10} concentrations for Elmbridge, Scenario 2, 2037 (µg/m³)

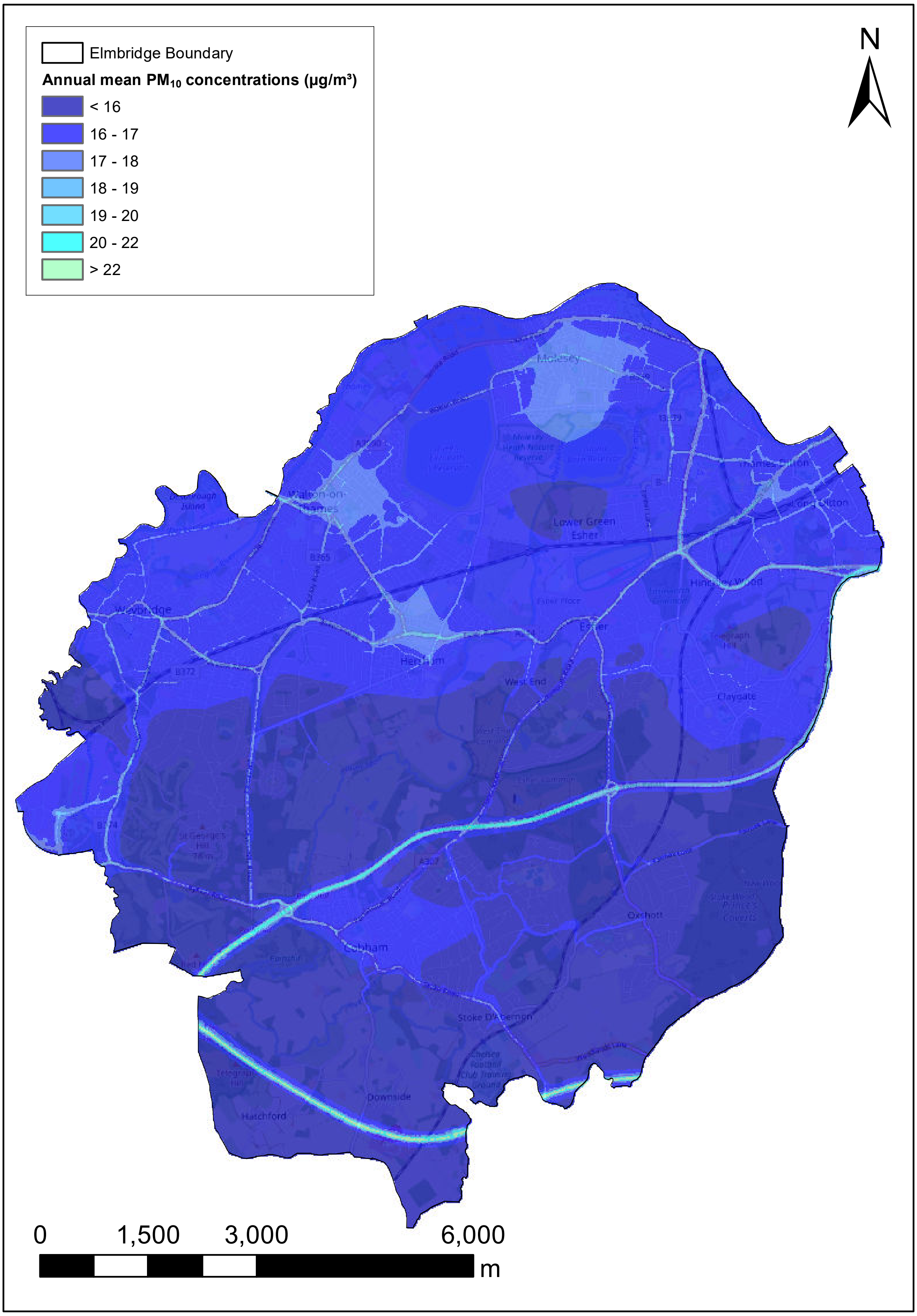

Figure 6.9: Annual mean PM_{10} concentrations for Elmbridge, Scenario 3, 2037 (µg/m³)

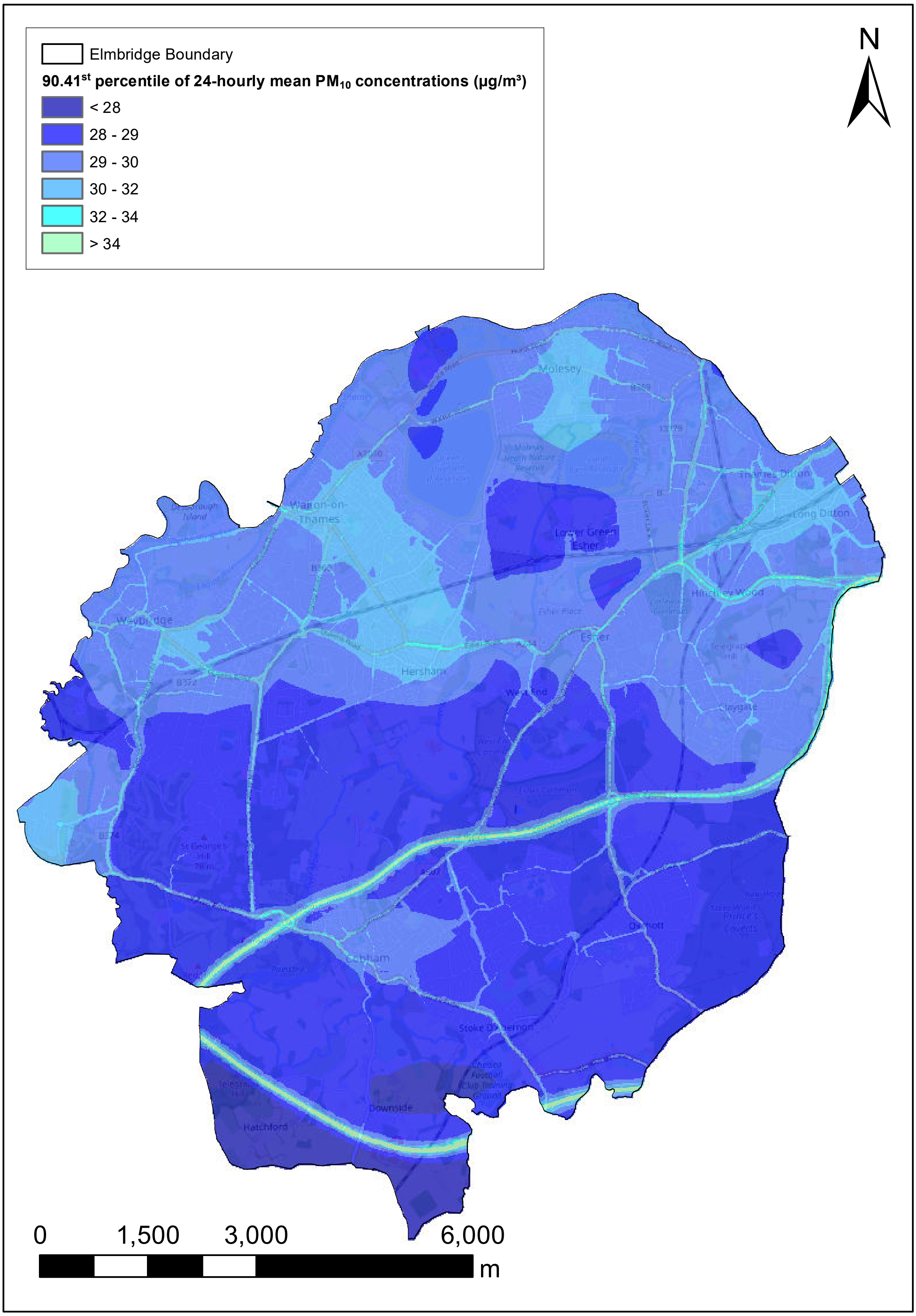

Figure 6.10: 90.41st percentile of 24-hourly mean PM_{10} concentrations for Elmbridge, Scenario 1, 2037 (µg/m³)

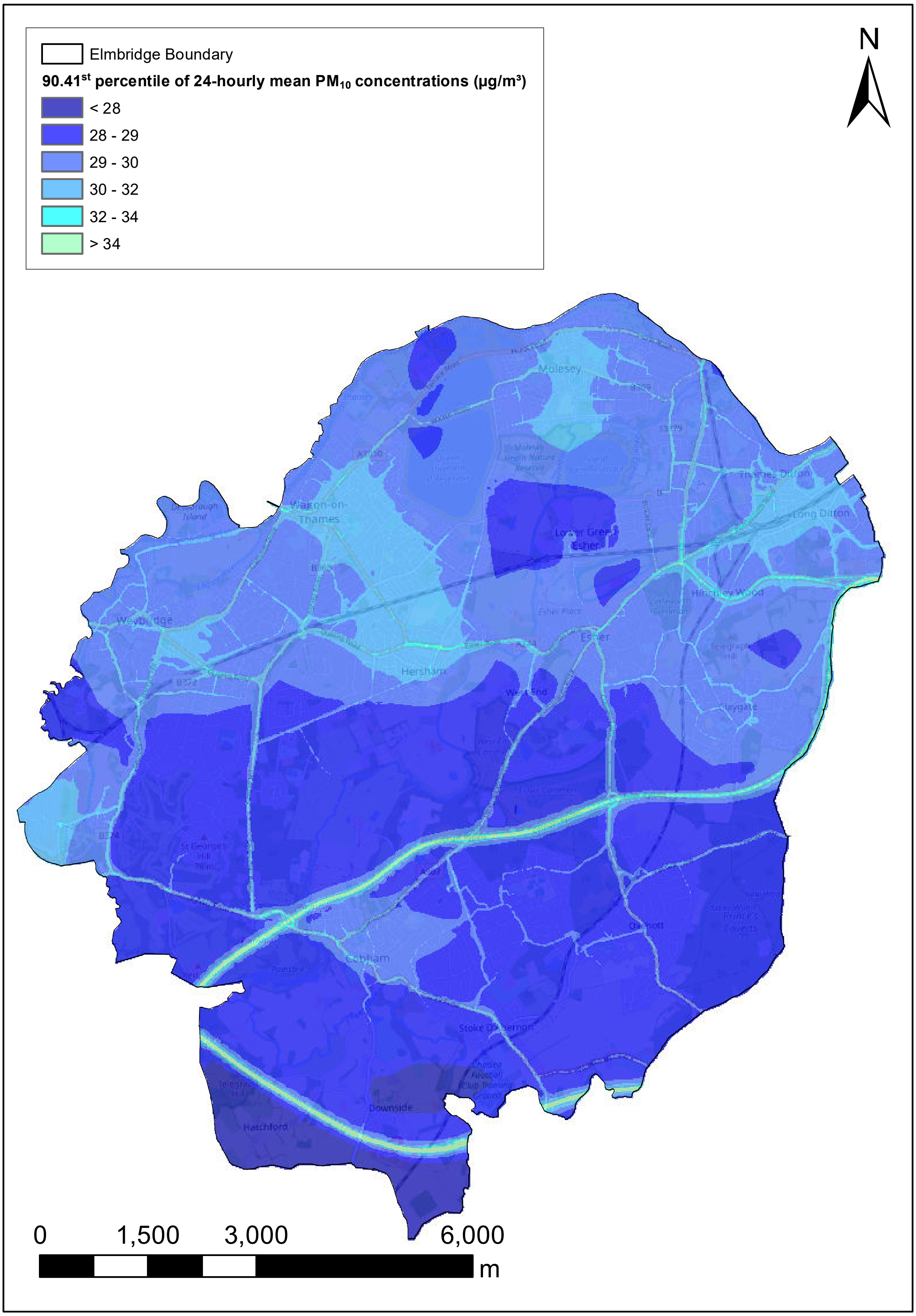

Figure 6.11: 90.41st percentile of 24-hourly mean PM_{10} concentrations for Elmbridge, Scenario 2, 2037 (µg/m³)

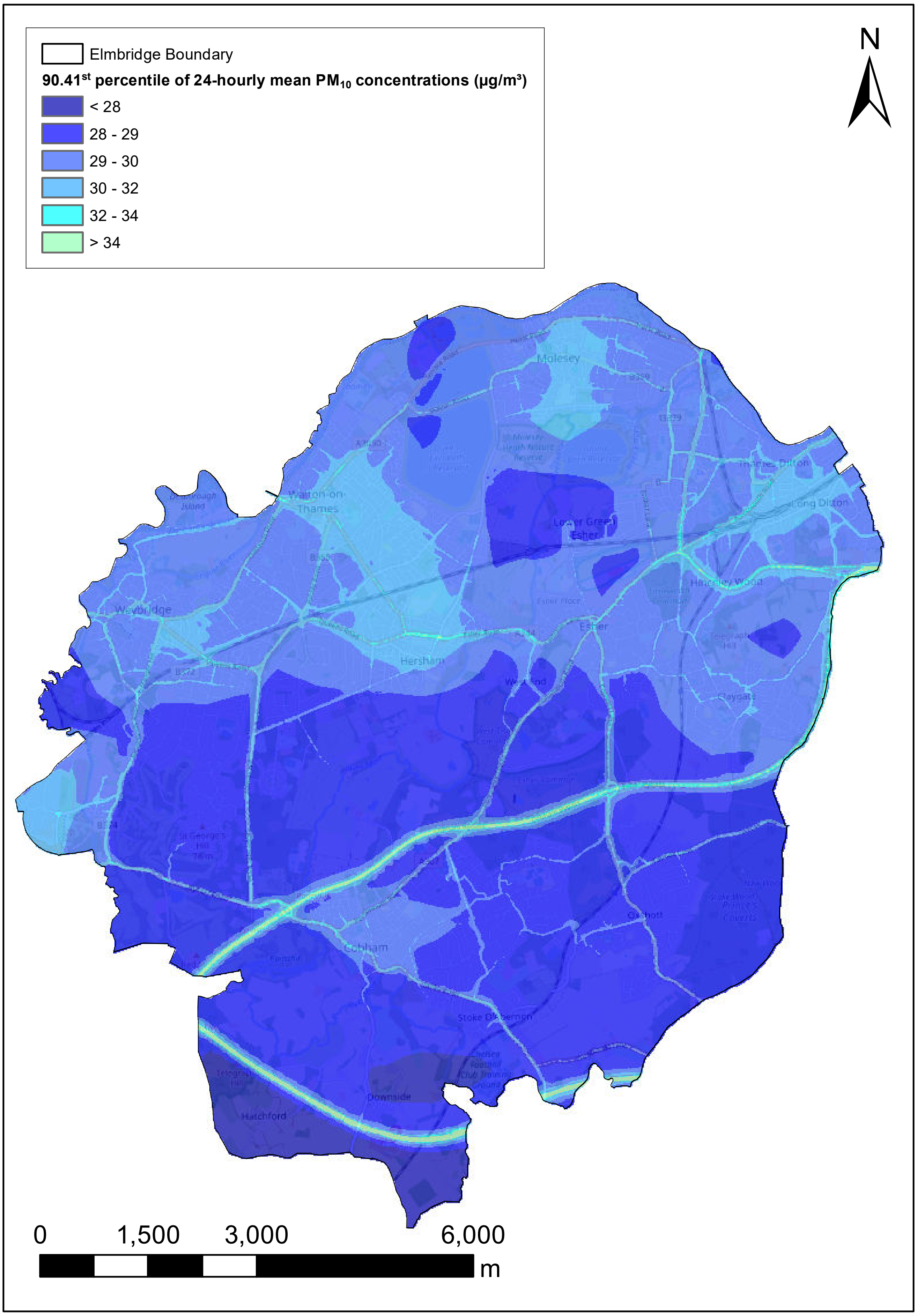

Figure 6.12: 90.41st percentile of 24-hourly mean PM_{10} concentrations for Elmbridge, Scenario 3, 2037 (µg/m³)

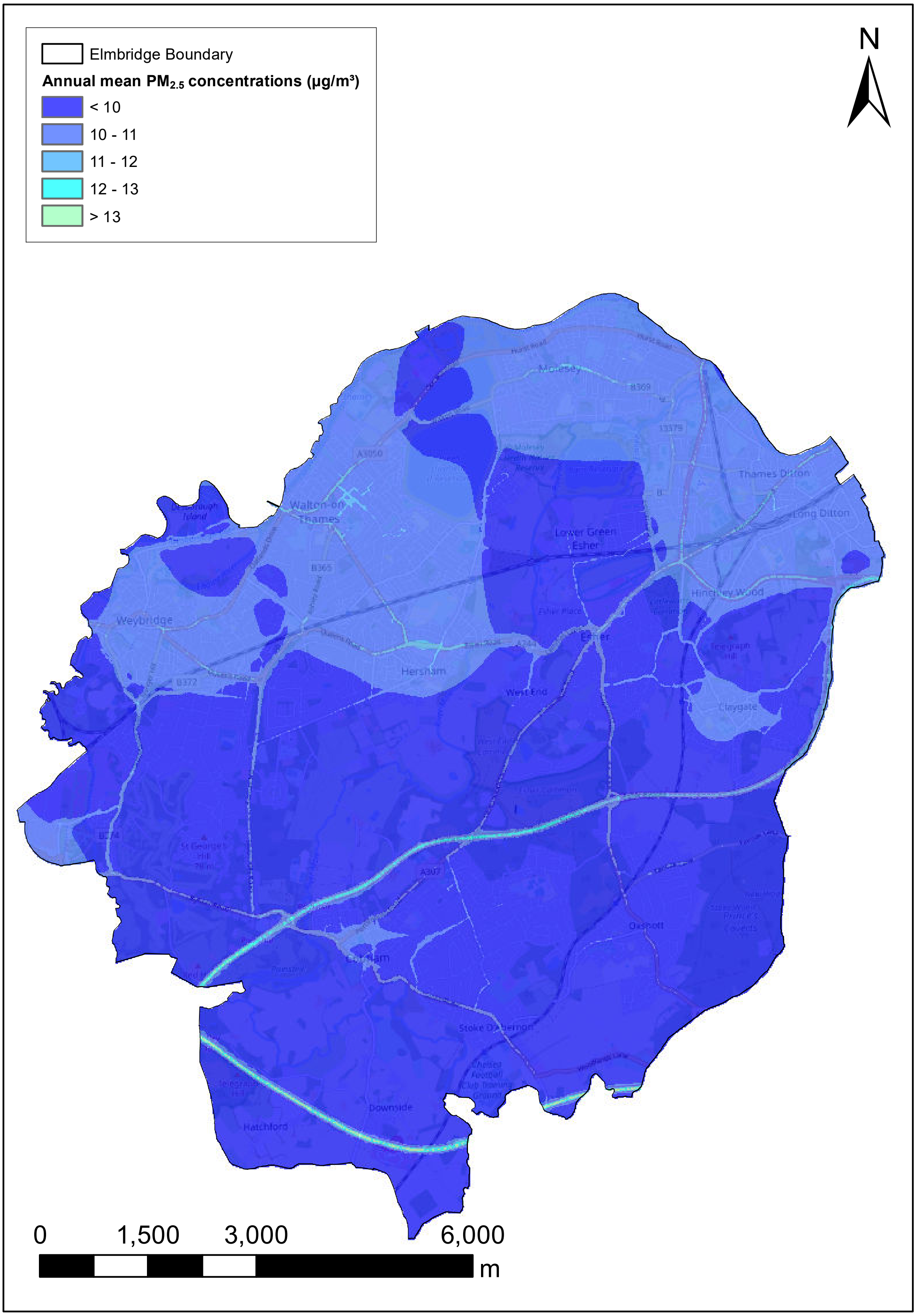

Figure 6.13: Annual mean $PM_{2.5}$ concentrations for Elmbridge, Scenario 1, 2037 (µg/m³)

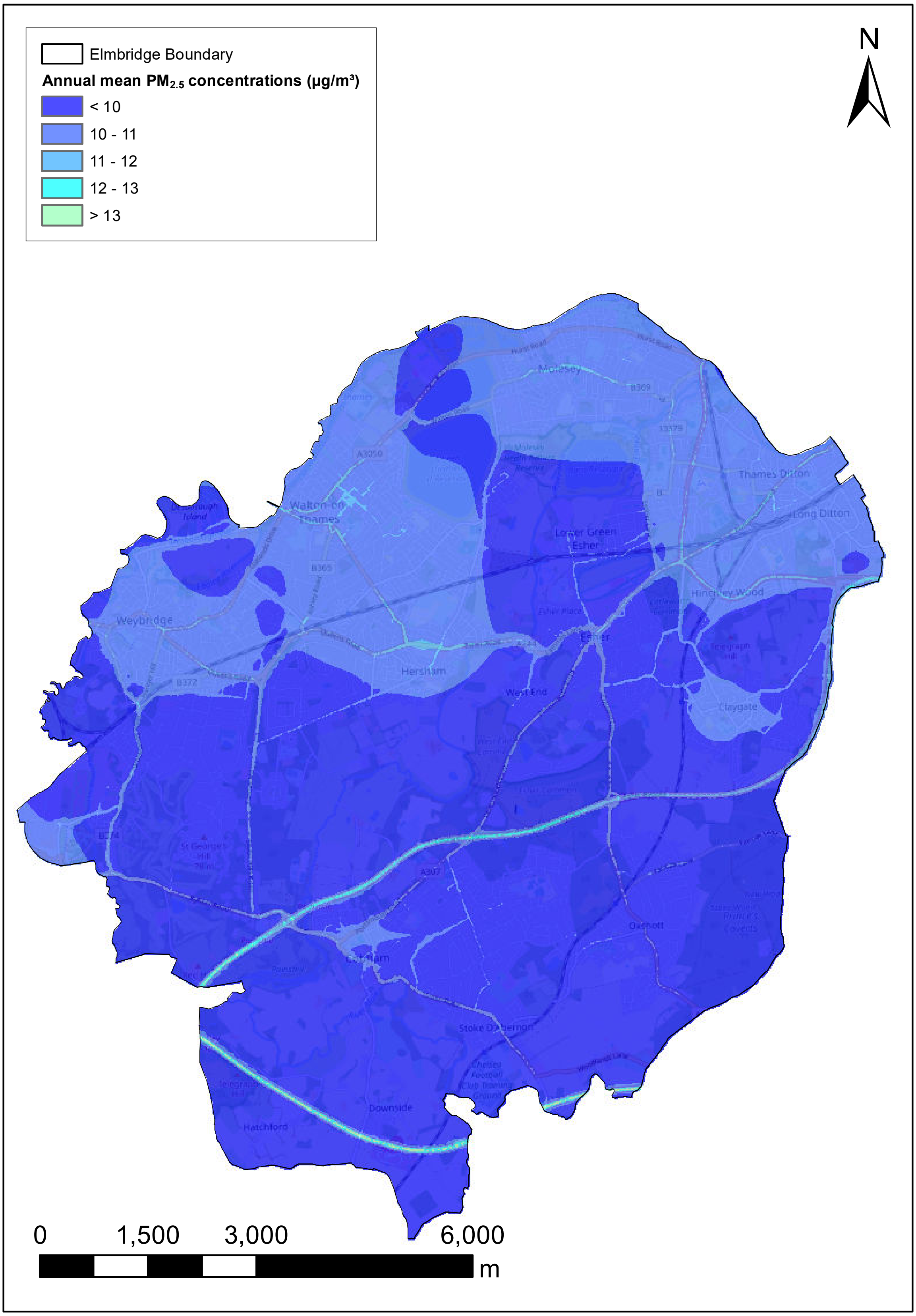

Figure 6.14: Annual mean $PM_{2.5}$ concentrations for Elmbridge, Scenario 2, 2037 (µg/m³)

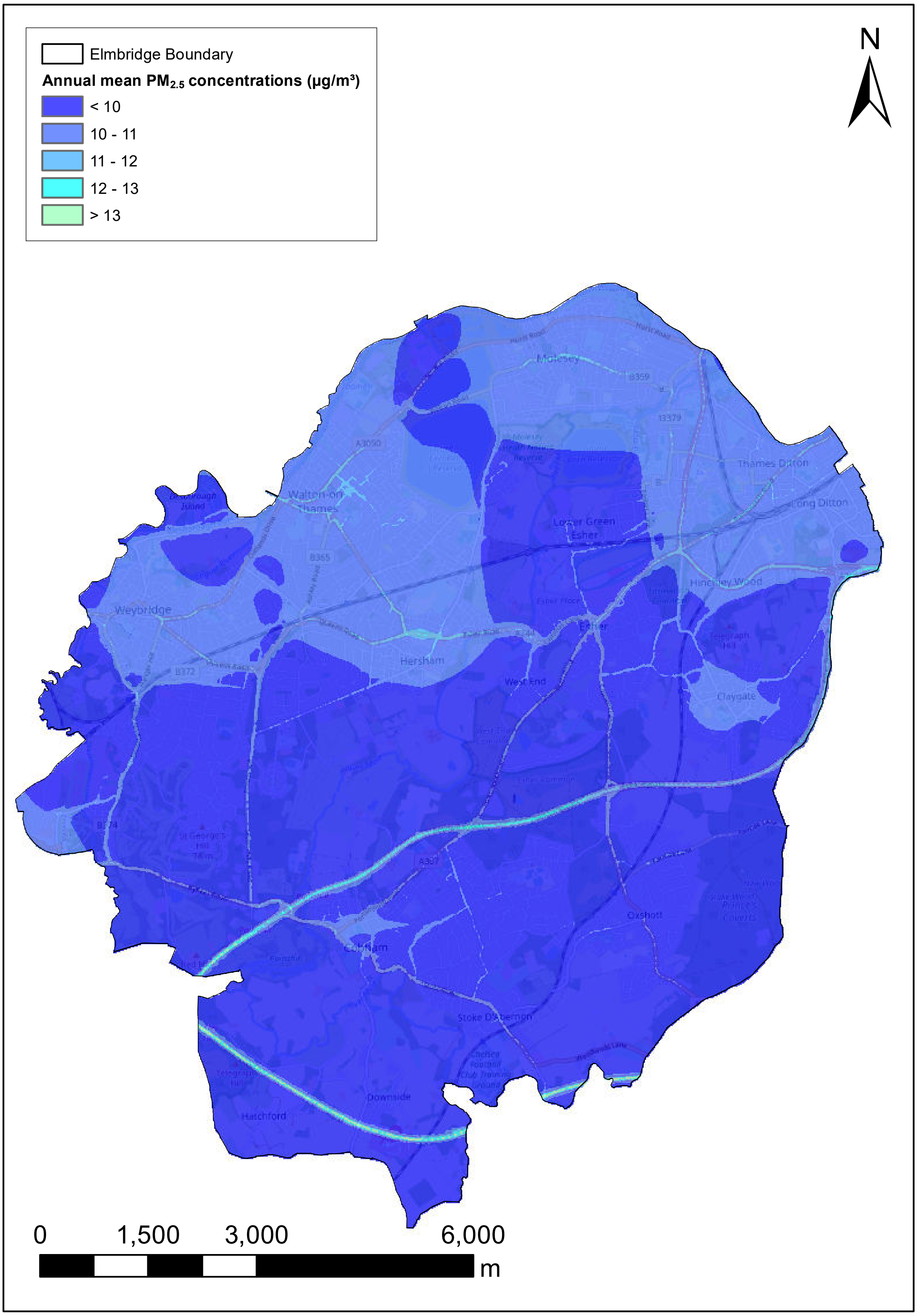

Figure 6.15: Annual mean $PM_{2.5}$ concentrations for Elmbridge, Scenario 3, 2037 (µg/m³)

6.2 Difference plots

Difference plots were calculated by subtracting the modelled annual average concentrations of Scenario 1, the future baseline, from Scenario 2, the Urban Growth Strategy scenario; or from Scenario 3, the Urban Growth Strategy scenario with mitigation. The resulting concentrations are shown as maps: areas coloured red show an increase in concentrations; areas coloured blue show a decrease in concentrations; and areas with no colour show no significant change in concentrations. The colour scale used in the difference plots reflects the percentage change criteria used for IAQM EPUK significance assessments; a change of less than 0.5% of the standard is generally considered to be negligible.

Figure 6.16 to Figure 6.21 show the modelled change in annual average NO_2, PM_{10} and $PM_{2.5}$ concentrations between Scenario 1 and Scenarios 2 and 3, with the Local Plan in place. In the majority of the modelled area, the concentrations change by less than 0.5% of the relevant limit values. Along some roads, the modelled changes in concentrations are greater, with the change less than 1% at the majority of locations with relevant exposure.

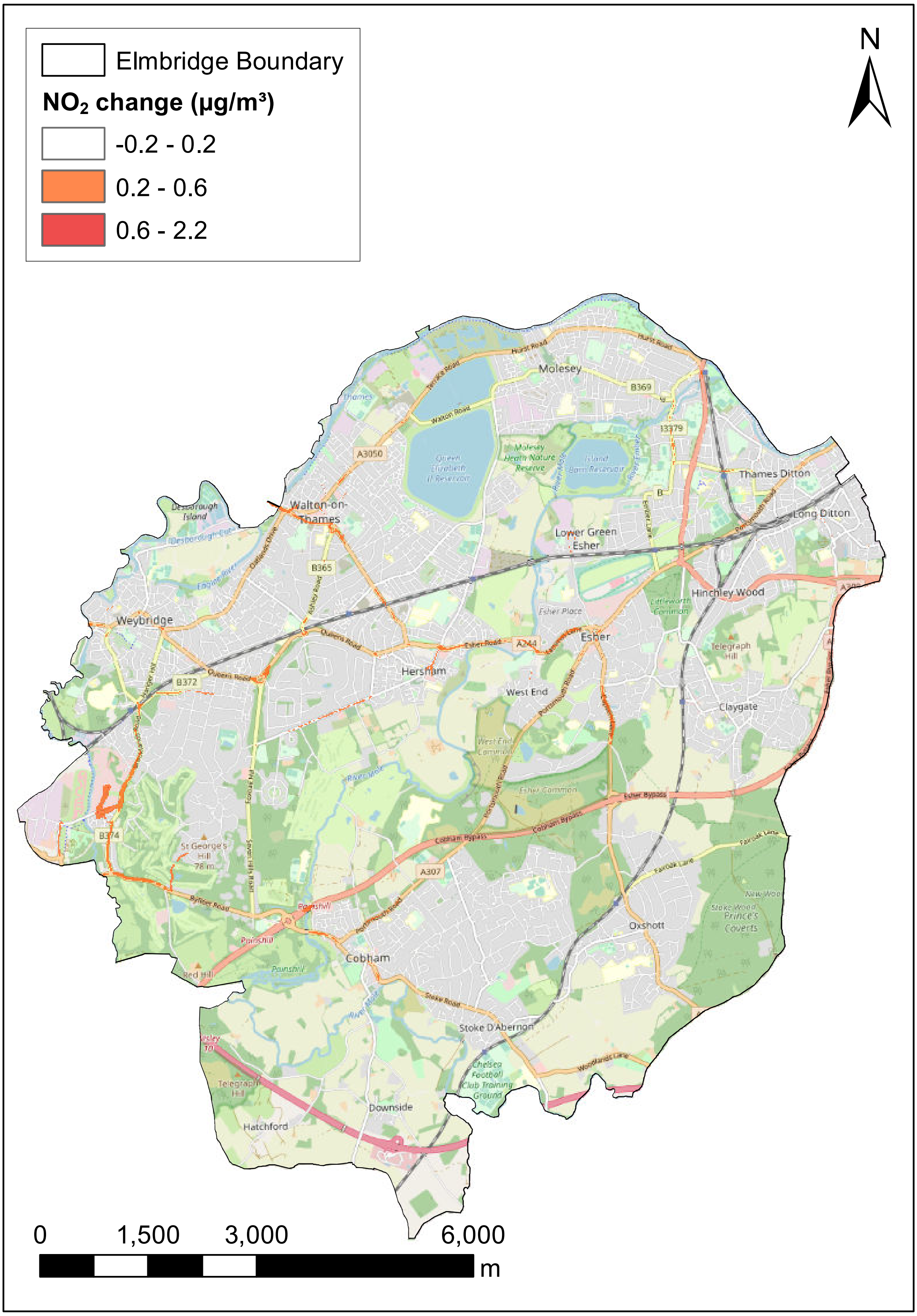

Figure 6.16: Modelled change in annual average NO_2 concentration between Scenario 2 and Scenario 1 (µg/m³)

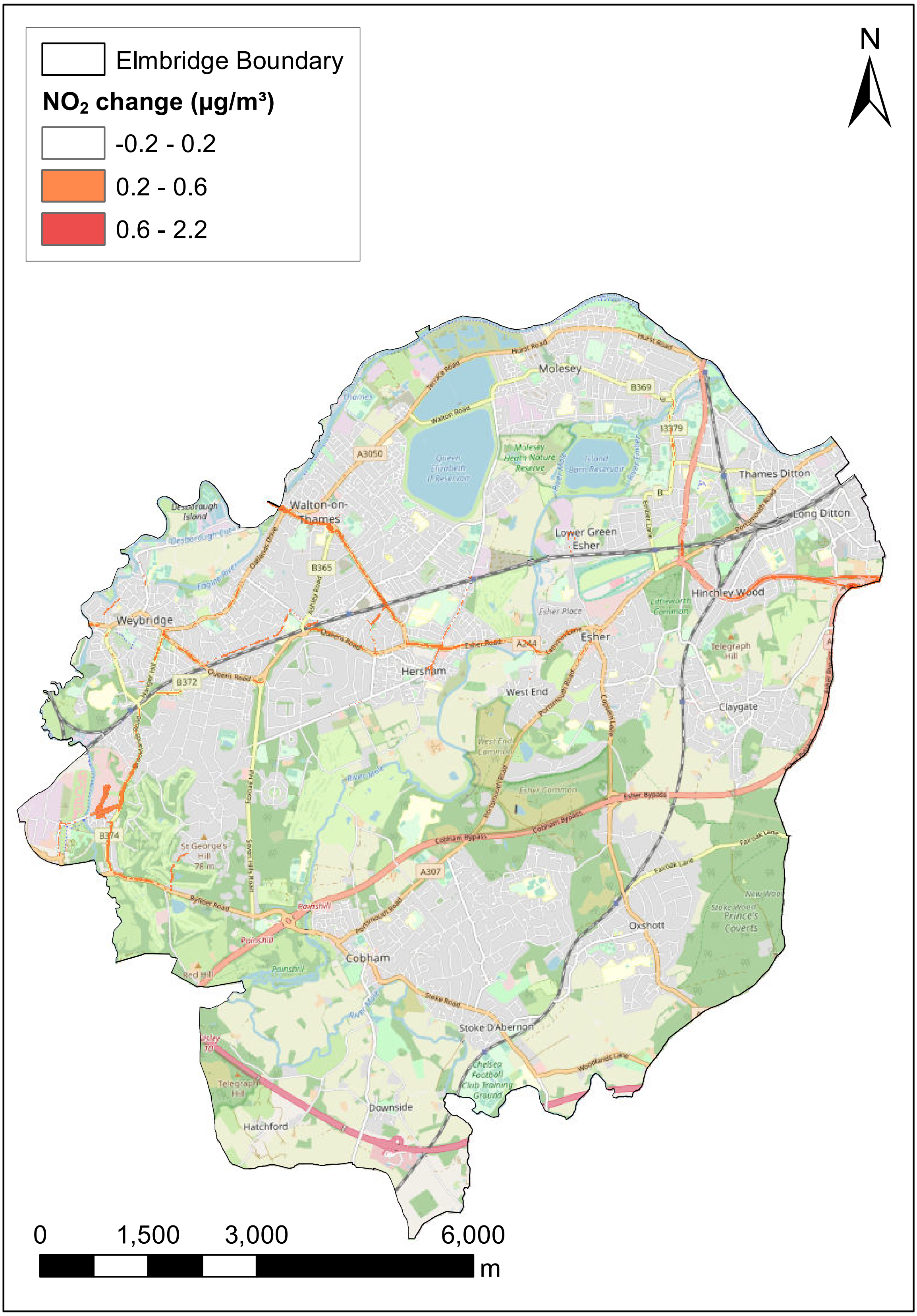

Figure 6.17: Modelled change in annual average NO_2 concentration between Scenario 3 and Scenario 1 (µg/m³)

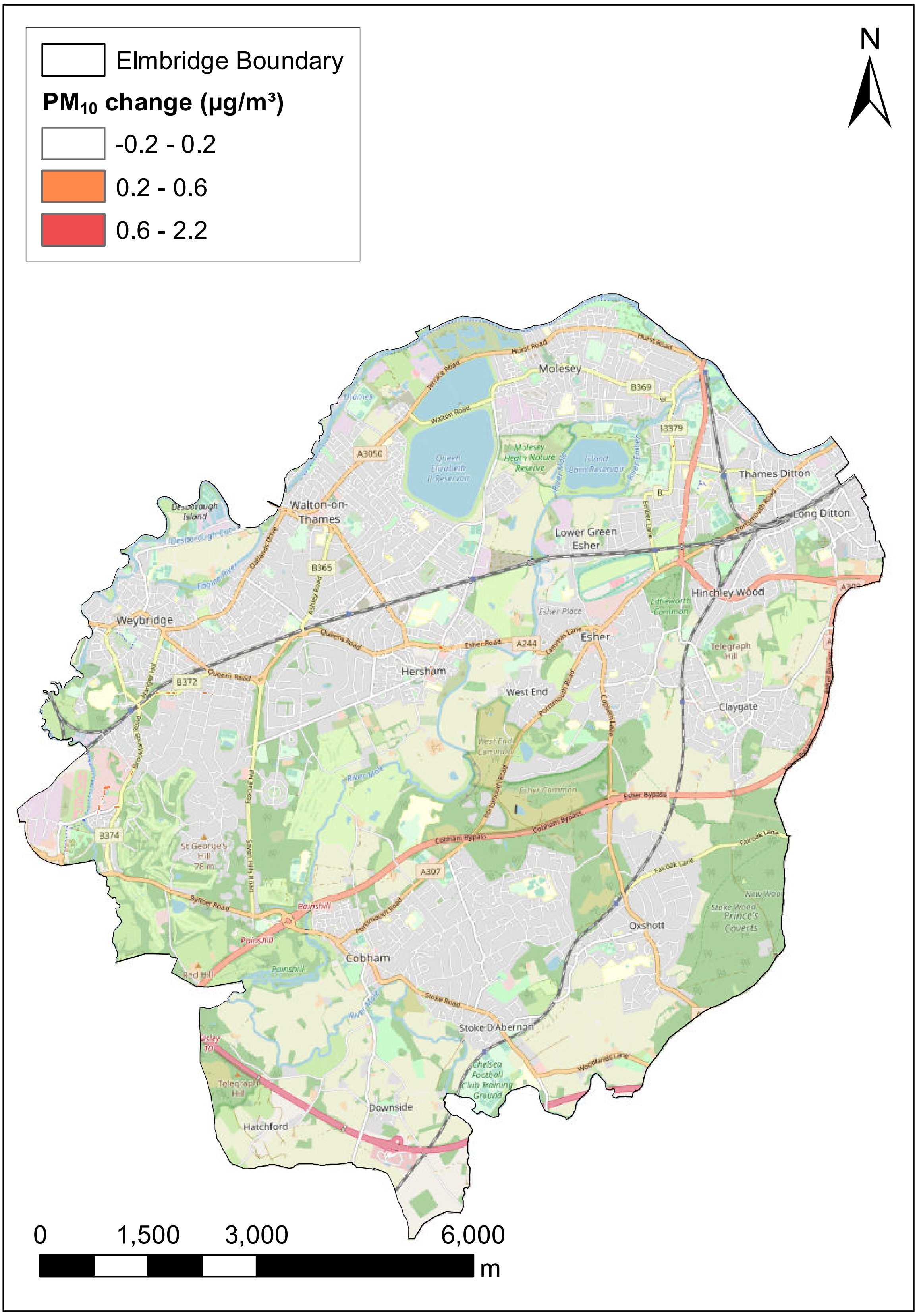

Figure 6.18: Modelled change in annual average PM_{10} concentration between Scenario 2 and Scenario 1 (µg/m³)

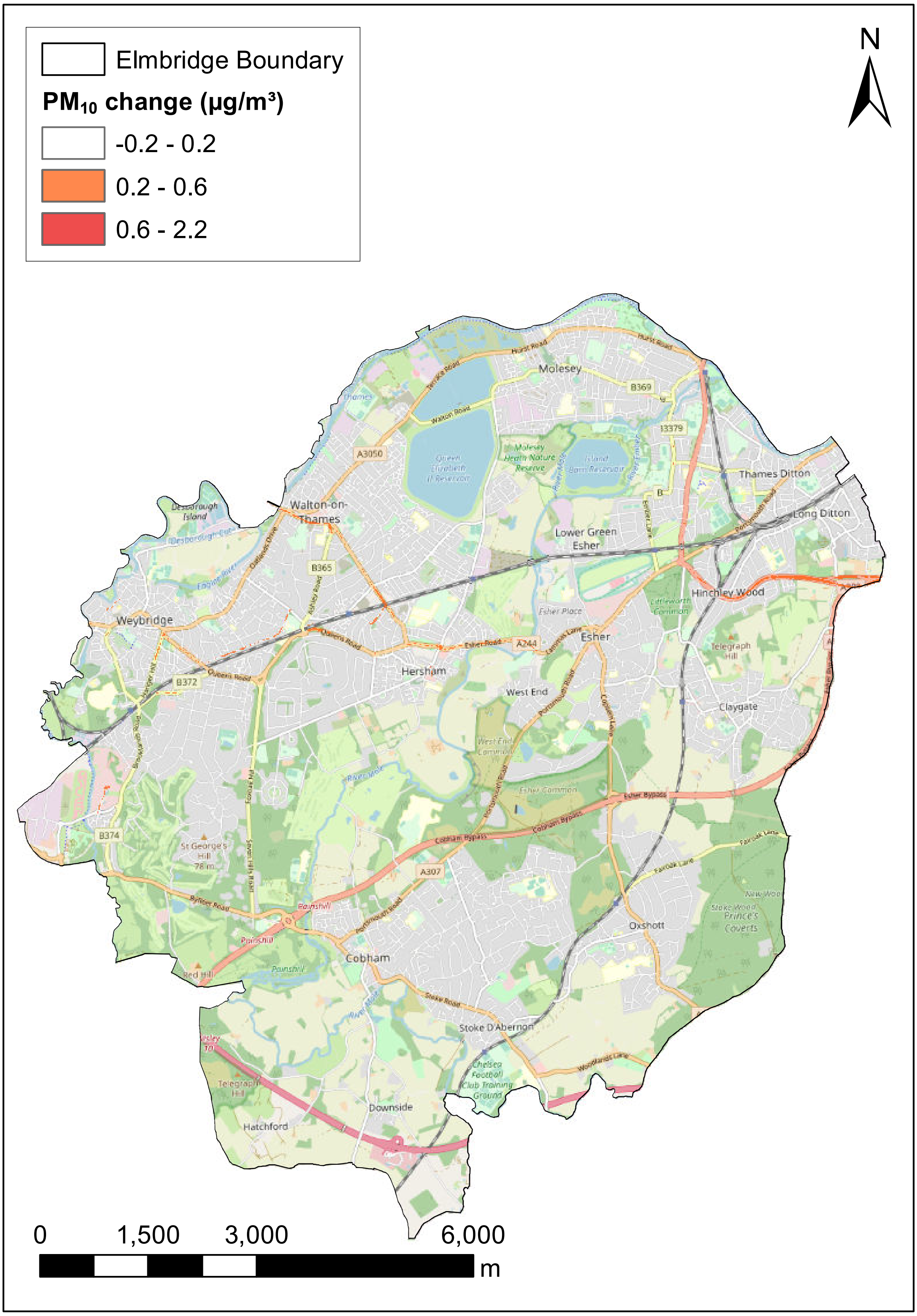

Figure 6.19: Modelled change in annual average PM_{10} concentration between Scenario 3 and Scenario 1 ($\mu g/m^3$)

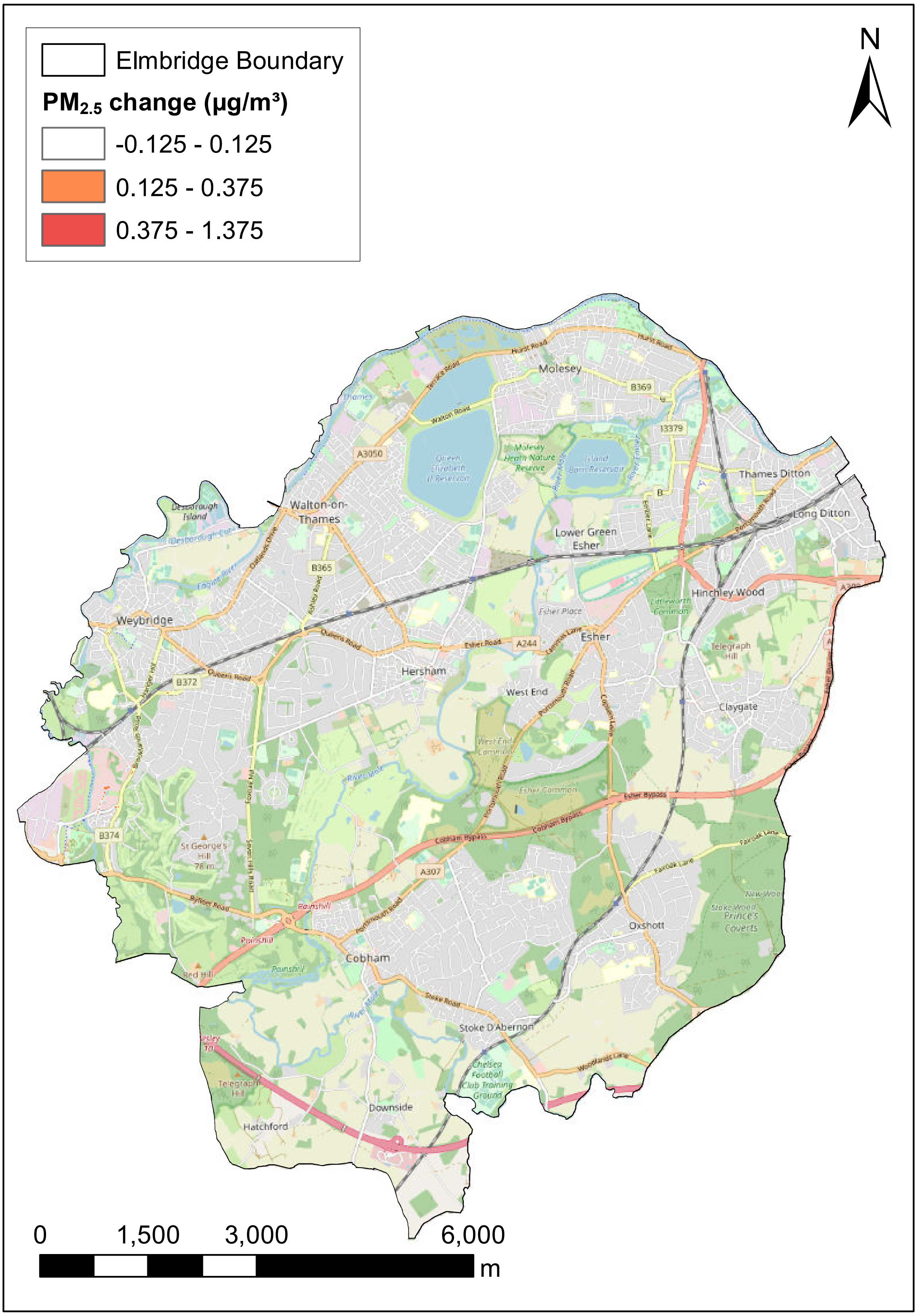

Figure 6.20: Modelled change in annual average $PM_{2.5}$ concentration between Scenario 2 and Scenario 1 (µg/m³)

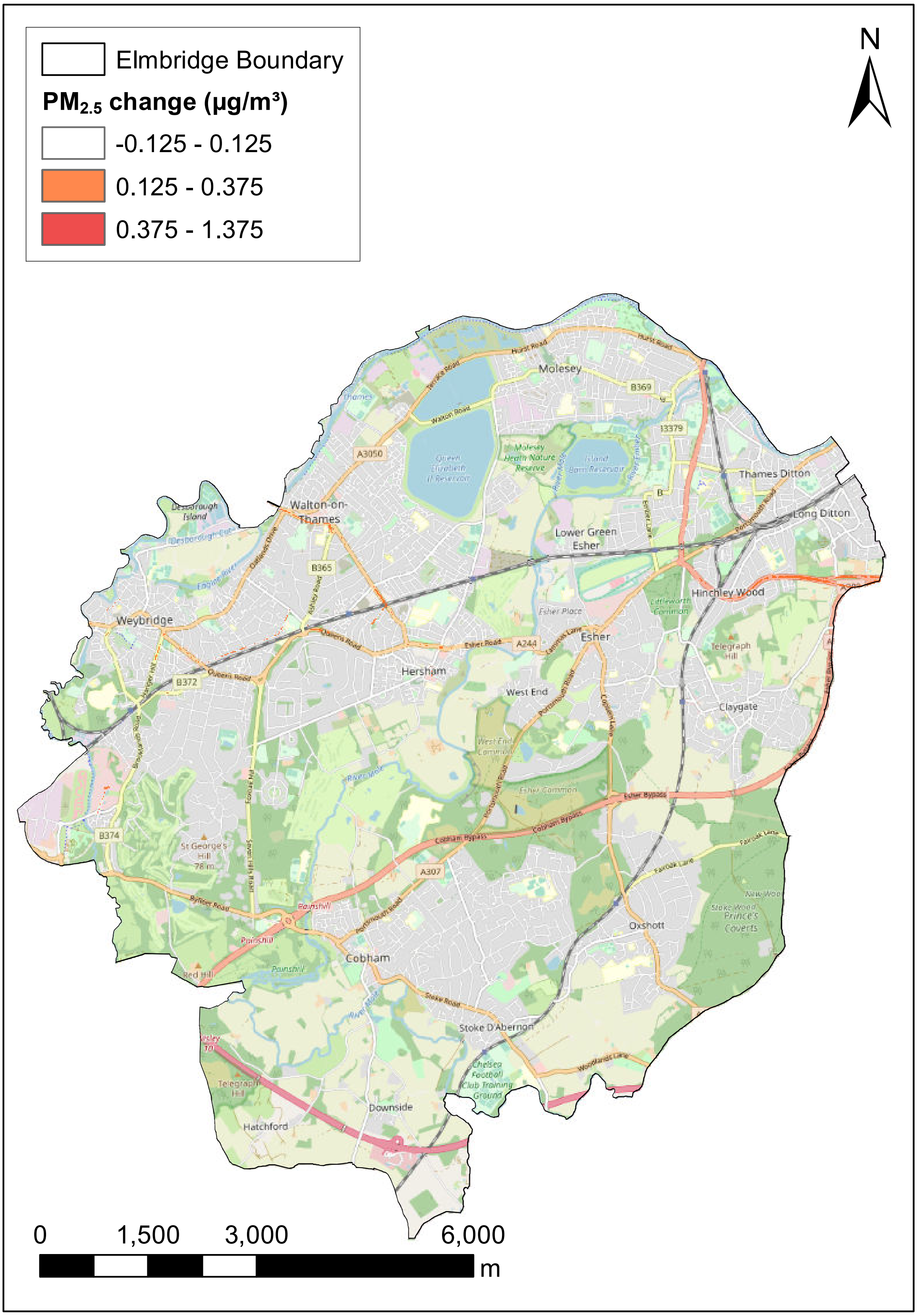

Figure 6.21: Modelled change in annual average $PM_{2.5}$ concentration between Scenario 3 and Scenario 1 (µg/m³)

6.3 Health receptors

The following tables present the modelled concentrations for Scenario 1, 2 and 3 of NO_2, PM_{10} and $PM_{2.5}$:

- Table 6.1 at health centres throughout Elmbridge
- Table 6.2 at private surgeries throughout Elmbridge
- Table 6.3 at dental surgeries throughout Elmbridge
- Table 6.4 at hospitals throughout Elmbridge
- Table 6.5 at state schools throughout Elmbridge

Table 6.1: Modelled annual average NO_2, PM_{10} and $PM_{2.5}$ concentrations at health centres throughout Elmbridge, 2037 scenarios (µg/m³)

Receptor name	Location x,y	Road name	Postcode	Practice name	Scenario 1 (2037)			Scenario 2 (2037)			Scenario 3 (2037)		
					NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$
Health_1	513541, 165342	Esher Green Drive	KT10 8BX	Esher Green Surgery	13.4	16.1	9.8	13.4	16.1	9.8	13.4	16.1	9.8
Health_2	511039, 165832	Rodney Road	KT12 3LB	The Health Centre	13.4	16.8	10.5	13.4	16.8	10.5	13.4	16.8	10.5
Health_3	511497, 163998	Pleasant Place	KT12 4HT	Hersham Surgery	13.3	16.5	10.3	13.3	16.6	10.3	13.3	16.6	10.3
Health_4	510582, 165620	Hersham Road	KT12 1UX	The Fort House Surgery	13.3	16.7	10.4	13.4	16.7	10.4	13.4	16.7	10.4
Health_5	510512, 165817	Crutchfield Lane	KT12 2QY	Ashley Medical Centre	13.6	17.0	10.6	13.7	17.0	10.6	13.7	17.0	10.6
Health_6	516522, 166412	Thorkhill Road	KT7 0UW	Thorkhill Surgery	13.7	17.0	10.6	13.7	17.0	10.6	13.7	17.0	10.6
Health_7	514391, 160725	Holtwood Road	KT22 0QL	N/A	12.3	15.8	9.6	12.3	15.8	9.6	12.3	15.8	9.6
Health_8	515719, 165276	Station Approach	KT10 0SP	N/A	13.2	16.5	10.2	13.3	16.5	10.2	13.3	16.6	10.2
Health_9	515740, 163804	Elm Road	KT10 0EH	Capelfield Surgery	12.6	16.3	10.0	12.7	16.3	10.0	12.7	16.3	10.0
Health_10	513902, 164588	Esher Park Avenue	KT10 9NY	Littleton Surgery	13.8	16.7	10.2	13.9	16.8	10.2	13.9	16.8	10.2
Health_11	514363, 168435	Pemberton Road	KT8 9LJ	Vine Medical Centre	14.2	17.2	10.8	14.3	17.3	10.8	14.3	17.3	10.8
Health_12	514331, 167762	Molesey Park Road	KT8 0JX	Glenlyn Medical Centre	13.4	16.7	10.3	13.5	16.7	10.3	13.4	16.7	10.3
Health_13	515954, 166579	Raphael Drive	KT7 0EB	Giggs Hill Surgery	13.4	16.7	10.4	13.5	16.7	10.4	13.5	16.7	10.4

Table 6.2: Modelled annual average NO_2, PM_{10} and $PM_{2.5}$ concentrations at private surgeries throughout Elmbridge, 2037 scenarios (µg/m³)

Receptor name	Location x,y	Road name	Postcode	Practice name	Scenario 1 (2037)			Scenario 2 (2037)			Scenario 3 (2037)		
					NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$
Surgery_1	509543, 162710	North Avenue	KT12 4EJ	N/A	12.3	15.6	9.4	12.3	15.6	9.4	12.3	15.6	9.4
Surgery_2	515598, 165266	Station Approach	KT10 0SR	Hinchley Wood Practice	13.6	17.0	10.5	13.6	17.0	10.5	13.7	17.1	10.5
Surgery_3	515309, 163481	Foley Road	KT10 0NA	N/A	12.6	16.3	10.1	12.6	16.3	10.1	12.6	16.3	10.1
Surgery_4	514351, 164049	Milbourne Lane	KT10 9ED	N/A	14.1	16.5	10.0	14.2	16.5	10.0	14.1	16.5	10.0
Surgery_5	512114, 160877	Fairmile Lane	KT11 2DA	N/A	12.4	16.0	9.7	12.4	16.0	9.7	12.4	16.0	9.7

Table 6.3: Modelled annual average NO_2, PM_{10} and $PM_{2.5}$ concentrations at dental surgeries throughout Elmbridge, 2037 scenarios (µg/m³)

Receptor name	Location x,y	Road name	Postcode	Practice name	Scenario 1 (2037)			Scenario 2 (2037)			Scenario 3 (2037)		
					NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$
Dentist_1	508361, 164293	Queens Road	KT13 9UT	N/A	14.5	17.5	10.8	14.7	17.6	10.8	14.9	17.7	10.9
Dentist_2	508719, 164946	Oatlands Drive	KT13 9LB	Preventative Dental Practice	13.4	16.6	10.2	13.5	16.6	10.2	13.5	16.6	10.2
Dentist_3	507541, 165144	Dorchester Road	KT13 8PE	N/A	13.5	16.5	10.2	13.5	16.5	10.2	13.5	16.5	10.2
Dentist_4	507729, 164842	Monument Hill	KT13 8RN	Portmore Dental Practice	14.5	17.2	10.6	14.6	17.2	10.6	14.6	17.2	10.6
Dentist_5	511903, 164827	Molesey Road	KT12 4QY	N/A	13.9	17.0	10.6	14.0	17.0	10.6	14.0	17.0	10.6
Dentist_6	510739, 165460	Hersham Road	KT12 1LL	N/A	13.5	16.8	10.4	13.6	16.8	10.4	13.6	16.8	10.4
Dentist_7	511510, 164095	The green	KT12 4HW	N/A	13.5	16.7	10.4	13.6	16.8	10.4	13.6	16.8	10.4
Dentist_8	510184, 165926	Ashley Road	KT12 1JB	N/A	14.2	17.2	10.7	14.3	17.3	10.7	14.2	17.2	10.7
Dentist_9	510173, 165983	Ashley Road	KT12 1HS	N/A	13.6	16.8	10.5	13.7	16.8	10.5	13.7	16.8	10.5
Dentist_10	515890, 167090	Ashley Road	KT7 0NH	N/A	13.7	16.6	10.3	13.8	16.6	10.3	13.8	16.6	10.3
Dentist_11	513962, 160433	Steels Lane	KT22 0RD	N/A	12.9	16.3	9.9	13.0	16.4	10.0	13.0	16.4	10.0

Receptor name	Location x,y	Road name	Postcode	Practice name	Scenario 1 (2037)			Scenario 2 (2037)			Scenario 3 (2037)		
					NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$
Dentist_12	515293, 163737	Hare Lane	KT10 0QY	Hare Lane Dental Surgery	12.7	16.3	10.0	12.7	16.3	10.0	12.7	16.3	10.0
Dentist_13	515210, 163586	Albany Crescent	KT10 0PF	N/A	12.6	16.2	10.0	12.6	16.2	10.0	12.6	16.2	10.0
Dentist_14	514175, 164950	Portsmouth Road	KT10 9PJ	Fairoak Dental Surgery	14.3	16.8	10.2	14.2	16.8	10.2	14.4	16.8	10.2
Dentist_15	515747, 165300	Manor Road North	KT10 0AA	N/A	13.3	16.6	10.2	13.3	16.6	10.2	13.4	16.6	10.2
Dentist_16	510719, 160050	Hollyhedge Road	KT11 3DG	Lloyds Dental Surgery	12.7	16.2	9.9	12.7	16.2	9.9	12.7	16.2	9.9
Dentist_17	510811, 159844	Church Street	KT11 3EG	Beech House Dental Surgery	12.6	16.1	9.8	12.7	16.2	9.8	12.7	16.1	9.8
Dentist_18	510834, 160316	Anyards Road	KT11 2LA	N/A	12.7	16.3	10.0	12.8	16.3	10.0	12.7	16.3	10.0
Dentist_19	510850, 159935	High Street	KT11 3EB	N/A	14.1	17.0	10.3	14.3	17.2	10.4	14.2	17.1	10.3
Dentist_20	516558, 166178	Sugden Road	KT7 0AB	N/A	13.8	17.0	10.6	13.8	17.0	10.6	13.8	17.0	10.5
Dentist_21	510749, 165452	Hersham Road	KT12 1LL	N/A	13.4	16.7	10.4	13.4	16.8	10.4	13.4	16.8	10.4
Dentist_22	510926, 165463	Sidney Road	KT12 3SD	N/A	13.4	16.8	10.4	13.5	16.8	10.5	13.5	16.8	10.5
Dentist_23	507453, 164909	High Street	KT13 8AB	N/A	13.5	16.6	10.2	13.6	16.6	10.2	13.6	16.6	10.2
Dentist_24	511650, 165752	Walton Park	KT12 3ET	N/A	13.5	16.9	10.5	13.5	16.9	10.5	13.5	16.9	10.5
Dentist_25	515978, 166955	Station Road	KT7 0NR	N/A	14.1	16.8	10.4	14.2	16.9	10.5	14.1	16.9	10.5
Dentist_26	514522, 168057	Spencer Road	KT8 0SP	N/A	13.7	16.8	10.4	13.8	16.8	10.4	13.8	16.8	10.4
Dentist_27	514224, 168083	Seymour Road	KT8 0PF	N/A	13.7	17.0	10.5	13.8	17.0	10.5	13.8	17.0	10.5

Table 6.4: Modelled annual average NO_2, PM_{10} and $PM_{2.5}$ concentrations at hospitals throughout Elmbridge, 2037 scenarios (µg/m³)

Receptor name	Location x,y	Road name	Postcode	Practice name	Scenario 1 (2037)			Scenario 2 (2037)			Scenario 3 (2037)		
					NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$
Hospital_1	511011, 165743	Rodney Road	KT12 3LD	Walton Community Hospital	13.3	16.8	10.5	13.4	16.8	10.5	13.4	16.8	10.5
Hospital_2	507232, 164935	Church Street	KT13 8DY	Weybridge Community Hospital	13.4	16.4	10.1	13.4	16.4	10.1	13.4	16.4	10.1
Hospital_3	513311, 167756	High Street	KT8 2LU	Molesey Hospital	13.5	17.3	10.4	13.6	17.3	10.4	13.6	17.3	10.4
Hospital_4	510986, 160712	Portsmouth Road	KT11	Cobham Community Hospital	12.7	16.2	9.9	12.7	16.2	9.9	12.7	16.2	9.9

Table 6.5: Modelled annual average NO_2, PM_{10} and $PM_{2.5}$ concentrations at state schools throughout Elmbridge, 2037 scenarios (µg/m³)

Receptor name	Location x,y	Road name	Post-code	School name	Scenario 1 (2037)			Scenario 2 (2037)			Scenario 3 (2037)		
					NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$
School_1	511934, 164835	174 Molesey Road, Walton-On-Thames	KT12 4QY	North East Surrey Short Stay School	13.6	16.8	10.5	13.6	16.8	10.5	13.6	16.8	10.5
School_2	514840, 167995	Bridge Road, East Molesey	KT8 9HT	The Orchard School	13.8	16.6	10.3	13.9	16.7	10.3	13.9	16.7	10.3
School_3	514375, 160345	Oakshade Road, Oxshott	KT22 0LE	The Royal Kent C of E Primary School	12.2	15.8	9.6	12.2	15.8	9.6	12.2	15.8	9.6
School_4	510160, 166139	Ashley Road, Walton-on-Thames	KT12 1HX	Ashley C Of E (A) Primary School	13.8	16.9	10.5	13.8	16.9	10.6	13.8	16.9	10.6
School_5	511415, 164878	Hersham Road, Walton-on-Thames	KT12 5NB	Bell Farm Junior School	13.8	17.1	10.8	13.8	17.1	10.8	13.8	17.1	10.8
School_6	511925, 165162	Arch Road, Walton-on-Thames	KT12 4QT	Cardinal Newman Catholic Primary School	13.4	16.6	10.4	13.4	16.6	10.4	13.4	16.6	10.4
School_7	513490, 167952	High Street, West Molesey	KT8 2LX	Chandlers Field Primary School	13.6	17.4	10.6	13.6	17.5	10.6	13.6	17.5	10.6
School_8	515457, 163406	Foley Road, Claygate	KT10 0NB	Claygate Primary School	12.6	16.3	10.1	12.6	16.4	10.1	12.6	16.3	10.1

Receptor name	Location x,y	Road name	Post-code	School name	Scenario 1 (2037)			Scenario 2 (2037)			Scenario 3 (2037)		
					NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$
School_9	509608, 164782	Oatlands Avenue, Weybridge	KT13 9TS	Cleves School	13.1	16.3	10.0	13.1	16.3	10.0	13.1	16.3	10.0
School_10	513882, 165899	The Drive, Esher	KT10 8DJ	Cranmere Primary School	13.2	16.0	9.8	13.2	16.0	9.8	13.2	16.0	9.8
School_11	514158, 164110	Milbourne Lane, Esher	KT10 9DU	Esher C Of E (Aided) Primary School	12.9	16.0	9.7	13.0	16.0	9.7	13.0	16.0	9.7
School_12	516298, 165666	Claygate Lane, Esher	KT10 0AQ	Hinchley Wood Primary School	13.2	16.5	10.2	13.2	16.5	10.2	13.2	16.5	10.2
School_13	512787, 168582	Hurst Road, West Molesey	KT8 1QW	Hurst Park Primary School	13.9	16.7	10.4	14.0	16.7	10.4	14.0	16.7	10.4
School_14	516905, 166356	Sugden Road, Thames Ditton	KT7 0AD	Long Ditton St Mary's C Of E (Aided) Junior School	13.7	16.9	10.5	13.8	16.9	10.5	13.7	16.9	10.5
School_15	514045, 167836	Beauchamp Road, West Molesey	KT8 2PG	St Albans Catholic Primary School	13.5	17.0	10.4	13.5	17.0	10.4	13.5	17.0	10.4
School_16	511329, 160719	Lockhart Road, Cobham	KT11 2AX	St Andrews C of E Primary School	12.4	16.1	9.9	12.5	16.1	9.9	12.5	16.1	9.9
School_17	507290, 165046	Portmore Way, Weybridge	KT13 8JD	St Charles Borromeo Catholic Primary School	13.4	16.4	10.1	13.5	16.4	10.1	13.5	16.4	10.1
School_18	508081, 165139	Grotto Road, Weybridge	KT13 8PL	St James C Of E Primary School	13.3	16.4	10.1	13.3	16.4	10.1	13.3	16.4	10.1
School_19	514495, 168475	Church Road, East Molesey	KT8 9DR	St Lawrence C Of E (A) Junior School	14.0	17.0	10.6	14.0	17.0	10.6	14.0	17.0	10.6
School_20	515140, 166919	Hampton Court Way, Thames Ditton	KT7 0LP	St Paul's Catholic Primary School	13.4	16.6	10.2	13.4	16.6	10.2	13.4	16.6	10.2
School_21	515881, 166666	Mercer Close, Thames Ditton	KT7 0BS	Thames Ditton Junior School	13.4	16.7	10.4	13.5	16.7	10.4	13.5	16.7	10.4
School_22	510765, 158070	Downside, Cobham	KT11 3NA	St Mathews Ce (A) Infant School	12.2	15.5	9.2	12.2	15.5	9.2	12.2	15.5	9.2
School_23	517193, 166283	Ditton Hill Road, Surbiton	KT6 5JB	Long Ditton Infant And Nursery School	13.6	16.7	10.3	13.7	16.7	10.4	13.6	16.7	10.3
School_24	508028, 164494	Princes Road, Weybridge	KT13 9DA	Manby Lodge Infant School	13.3	16.7	10.3	13.4	16.7	10.3	13.4	16.7	10.3

Receptor name	Location x,y	Road name	Post-code	School name	Scenario 1 (2037)			Scenario 2 (2037)			Scenario 3 (2037)		
					NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$	NO_2	PM_{10}	$PM_{2.5}$
School_25	508831, 164766	St. Marys Road, Weybridge	KT13 9PZ	Oatlands Infant School	13.4	16.6	10.2	13.4	16.6	10.2	13.4	16.5	10.2
School_26	511610, 163975	Pleasant Place, Walton-on-Thames	KT12 4HR	Burhill Community Infant School	13.2	16.4	10.2	13.2	16.5	10.2	13.2	16.5	10.2
School_27	511474, 166140	Ambleside Avenue, Walton-on-Thames	KT12 3LN	Walton Oak School	13.3	16.8	10.5	13.3	16.8	10.5	13.3	16.8	10.5
School_28	510952, 167344	Terrace Road, Walton-on-Thames	KT12 2EB	Grovelands School	13.9	16.7	10.3	14.0	16.8	10.3	14.0	16.7	10.3
School_29	515793, 167143	Speer Road, Thames Ditton	KT7 0NW	Thames Ditton Infant School	13.7	16.6	10.3	13.7	16.6	10.3	13.7	16.6	10.3
School_30	513465, 165247	More Lane, Esher	KT10 8AP	Esher Church Of England High School	13.3	16.1	9.8	13.4	16.1	9.8	13.4	16.1	9.8
School_31	506924, 164011	Brooklands Lane, Weybridge	KT13 8UZ	Heathside School	12.8	16.0	9.7	12.8	16.0	9.7	12.8	16.0	9.7
School_32	511443, 165018	Hersham Road, Hersham, Walton-on-Thames	KT12 5PY	Rydens School	13.7	17.0	10.7	13.7	17.0	10.7	13.7	17.0	10.7
School_33	516218, 165773	Claygate Lane, Esher	KT10 0AQ	Hinchley Wood School & Sixth Form Centre	13.2	16.6	10.3	13.3	16.6	10.3	13.3	16.6	10.3
School_34	509534, 164546	Queens Road, Walton-on-Thames	KT12 5AB	Walton Leigh School	13.1	16.2	9.9	13.2	16.3	10.0	13.1	16.3	10.0
School_35	510526, 160549	89-95 Portsmouth Road, Cobham	KT11 1JJ	Cobham Free School	13.1	16.6	10.2	13.3	16.6	10.2	13.2	16.6	10.2

6.4 Mortality burden

This section summarises local mortality burden of air pollution calculations. It includes the calculation of the number of deaths attributable to air pollution, the associated life-years lost and economic cost.

The mortality burden was assessed using the approach set out in Section 8.3 of the current baseline (2017) report.

The Office for National Statistics (ONS) population[10] and death[11] data split by age for each LSOA was updated to the latest available data, for the year 2019.

The economic cost of £42,780 for chronic mortality at 2017 prices in the Defra guidance[12] was projected to £62,569 for 2037, using a 2% per annum uplift. This approach is based on the methodology used for the activity and damage costs in the Defra guidance.

Table 6.6 to Table 6.8 present a mortality burden associated with NO_2 and $PM_{2.5}$ concentrations by ward, across Elmbridge, for Scenarios 1, 2 and 3.

[10] https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/lowersuperoutputareamidyearpopulationestimates

[11] https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/adhocs/12668deathregistrationsbylowerlayersuperoutputarealsoaenglandandwales2019

[12] https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-impact-pathways-approach

Table 6.6: Summary of attributable deaths, life years lost and economic cost resulting from NO_2 and $PM_{2.5}$ concentrations by Elmbridge wards Scenario 1

Ward		NO_2			$PM_{2.5}$			Total life years lost	Total economic cost (£ Million)
Code	Name	Attributable Deaths	Life years lost	Economic cost (£ Million)	Attributable Deaths	Life years lost	Economic cost (£ Million)		
E05011074	Claygate	1-2	18-32	1.12-2.01	1-4	19-51	1.21-3.26	51-69	3.22-4.38
E05011075	Cobham and Downside	1-1	12-21	0.75-1.35	1-2	13-35	0.81-2.2	34-46	2.16-2.95
E05011076	Esher	1-1	11-21	0.73-1.32	1-2	13-35	0.81-2.2	33-46	2.13-2.93
E05011077	Hersham Village	1-1	12-22	0.79-1.41	1-2	14-37	0.87-2.34	36-49	2.28-3.13
E05011078	Hinchley Wood and Weston Green	1-1	13-24	0.85-1.52	1-2	15-40	0.93-2.51	39-53	2.45-3.36
E05011079	Long Ditton	1-2	14-26	0.91-1.64	1-3	16-42	0.99-2.68	41-56	2.63-3.59
E05011080	Molesey East	0-1	6-11	0.39-0.71	0-1	7-18	0.43-1.16	18-24	1.13-1.55
E05011081	Molesey West	1-1	13-23	0.81-1.47	1-2	14-38	0.89-2.42	37-51	2.36-3.23
E05011082	Oatlands and Burwood Park	1-2	17-31	1.09-1.95	1-3	19-50	1.19-3.21	49-68	3.14-4.29
E05011083	Oxshott and Stoke D'Abernon	1-1	12-22	0.77-1.39	1-2	13-35	0.83-2.25	35-48	2.22-3.03
E05011084	Thames Ditton	1-1	8-15	0.52-0.93	1-2	9-24	0.56-1.52	23-32	1.49-2.04
E05011085	Walton Central	0-1	8-14	0.50-0.90	0-1	9-23	0.55-1.48	23-31	1.45-1.98
E05011086	Walton North	1-1	9-17	0.60-1.09	1-2	11-29	0.67-1.83	28-38	1.76-2.43
E05011087	Walton South	1-1	14-26	0.92-1.65	1-2	16-42	0.99-2.68	42-57	2.64-3.60
E05011088	Weybridge Riverside	1-1	14-24	0.86-1.55	1-2	15-40	0.95-2.57	39-54	2.50-3.43
E05011089	Weybridge St George's Hill	0-1	6-11	0.40-0.72	0-1	7-19	0.45-1.21	18-25	1.17-1.61

Table 6.7: Summary of attributable deaths, life years lost and economic cost resulting from NO_2 and $PM_{2.5}$ concentrations by Elmbridge wards Scenario 2

Ward		NO_2			$PM_{2.5}$			Total life years lost	Total economic cost (£ Million)
Code	**Name**	**Attributable Deaths**	**Life years lost**	**Economic cost (£ Million)**	**Attributable Deaths**	**Life years lost**	**Economic cost (£ Million)**		
E05011074	Claygate	1-2	18-32	1.12-2.02	1-4	19-51	1.21-3.27	51-69	3.23-4.39
E05011075	Cobham and Downside	1-1	12-21	0.75-1.36	1-2	13-35	0.81-2.20	34-47	2.17-2.96
E05011076	Esher	1-1	12-21	0.73-1.32	1-2	13-35	0.81-2.20	34-46	2.14-2.94
E05011077	Hersham Village	1-1	12-22	0.79-1.42	1-2	14-37	0.87-2.34	36-49	2.29-3.13
E05011078	Hinchley Wood and Weston Green	1-1	13-24	0.85-1.53	1-2	15-40	0.93-2.52	39-53	2.46-3.37
E05011079	Long Ditton	1-2	14-26	0.91-1.64	1-3	16-42	0.99-2.68	41-57	2.63-3.6
E05011080	Molesey East	0-1	6-11	0.39-0.71	0-1	7-18	0.43-1.16	18-24	1.14-1.55
E05011081	Molesey West	1-1	13-23	0.82-1.47	1-2	14-38	0.89-2.42	37-51	2.37-3.24
E05011082	Oatlands and Burwood Park	1-2	17-31	1.09-1.96	1-3	19-51	1.19-3.21	49-68	3.15-4.30
E05011083	Oxshott and Stoke D'Abernon	1-1	12-22	0.78-1.39	1-2	13-36	0.83-2.26	35-48	2.23-3.03
E05011084	Thames Ditton	1-1	8-15	0.52-0.93	1-2	9-24	0.56-1.52	24-32	1.50-2.04
E05011085	Walton Central	0-1	8-14	0.50-0.90	0-1	9-23	0.55-1.48	23-31	1.45-1.98
E05011086	Walton North	1-1	10-17	0.61-1.09	1-2	11-29	0.68-1.83	28-38	1.77-2.43
E05011087	Walton South	1-1	15-26	0.92-1.66	1-2	16-42	0.99-2.69	42-57	2.65-3.61
E05011088	Weybridge Riverside	1-1	14-25	0.87-1.56	1-2	15-40	0.95-2.57	39-54	2.51-3.44
E05011089	Weybridge St George's Hill	0-1	6-11	0.40-0.73	0-1	7-19	0.45-1.21	18-25	1.17-1.62

Table 6.8: Summary of attributable deaths, life years lost and economic cost resulting from NO_2 and $PM_{2.5}$ concentrations by Elmbridge wards Scenario 3

Ward		NO_2			$PM_{2.5}$			Total life years lost	Total economic cost (£ Million)
Code	Name	Attributable Deaths	Life years lost	Economic cost (£ Million)	Attributable Deaths	Life years lost	Economic cost (£ Million)		
E05011074	Claygate	1-2	18-32	1.12-2.02	1-4	19-51	1.21-3.27	51-69	3.23-4.39
E05011075	Cobham and Downside	1-1	12-21	0.75-1.36	1-2	13-35	0.81-2.21	34-47	2.17-2.96
E05011076	Esher	1-1	12-21	0.73-1.32	1-2	13-35	0.81-2.2	34-46	2.14-2.94
E05011077	Hersham Village	1-1	12-22	0.79-1.42	1-2	14-37	0.87-2.34	36-49	2.29-3.13
E05011078	Hinchley Wood and Weston Green	1-1	13-24	0.85-1.53	1-2	15-40	0.93-2.52	39-53	2.46-3.37
E05011079	Long Ditton	1-2	14-26	0.91-1.64	1-3	16-42	0.99-2.68	41-57	2.63-3.59
E05011080	Molesey East	0-1	6-11	0.39-0.71	0-1	7-18	0.43-1.16	18-24	1.14-1.55
E05011081	Molesey West	1-1	13-23	0.82-1.47	1-2	14-38	0.89-2.42	37-51	2.37-3.24
E05011082	Oatlands and Burwood Park	1-2	17-31	1.09-1.96	1-3	19-51	1.19-3.21	49-68	3.15-4.30
E05011083	Oxshott and Stoke D'Abernon	1-1	12-22	0.78-1.39	1-2	13-36	0.83-2.26	35-48	2.23-3.03
E05011084	Thames Ditton	1-1	8-15	0.52-0.93	1-2	9-24	0.56-1.52	24-32	1.49-2.04
E05011085	Walton Central	0-1	8-14	0.50-0.90	0-1	9-23	0.55-1.48	23-31	1.45-1.98
E05011086	Walton North	1-1	10-17	0.61-1.09	1-2	11-29	0.68-1.83	28-38	1.77-2.44
E05011087	Walton South	1-1	15-26	0.92-1.66	1-2	16-42	0.99-2.69	42-57	2.65-3.61
E05011088	Weybridge Riverside	1-1	14-25	0.87-1.56	1-2	15-40	0.95-2.57	39-54	2.51-3.43
E05011089	Weybridge St George's Hill	0-1	6-11	0.40-0.73	0-1	7-19	0.45-1.21	18-25	1.17-1.62

7 2037 scenarios: sensitive habitat impacts

7.1 Critical levels

Contour plots of annual average NO_x concentration were generated for the future (2037) scenarios using model output on a 100 m regular grid across each SPA within Elmbridge, along with additional output points along modelled roads to capture the steep concentration gradients at roadsides. These model-calculated concentrations were interpolated to generate 10 m resolution air quality maps.

In the air quality maps, exceedences of the NO_x critical level are shown in yellow, orange and red and pollutant concentrations below the critical level are shown in green.

Figure 7.1 to Figure 7.3 present contour plots of the modelled annual average NO_x concentration across the South West London Waterbodies SPA for the 2037 scenarios. Modelled concentrations show no exceedences of the 30 µg/m³ NO_x critical level across the SPA.

Figure 7.4 to Figure 7.6 present contour plots of the modelled annual average NO_x concentrations across the Thames Basin Heaths SPA for the 2037 scenarios. Modelled concentrations show no exceedences of the 30 µg/m³ NO_x critical level across the SPA.

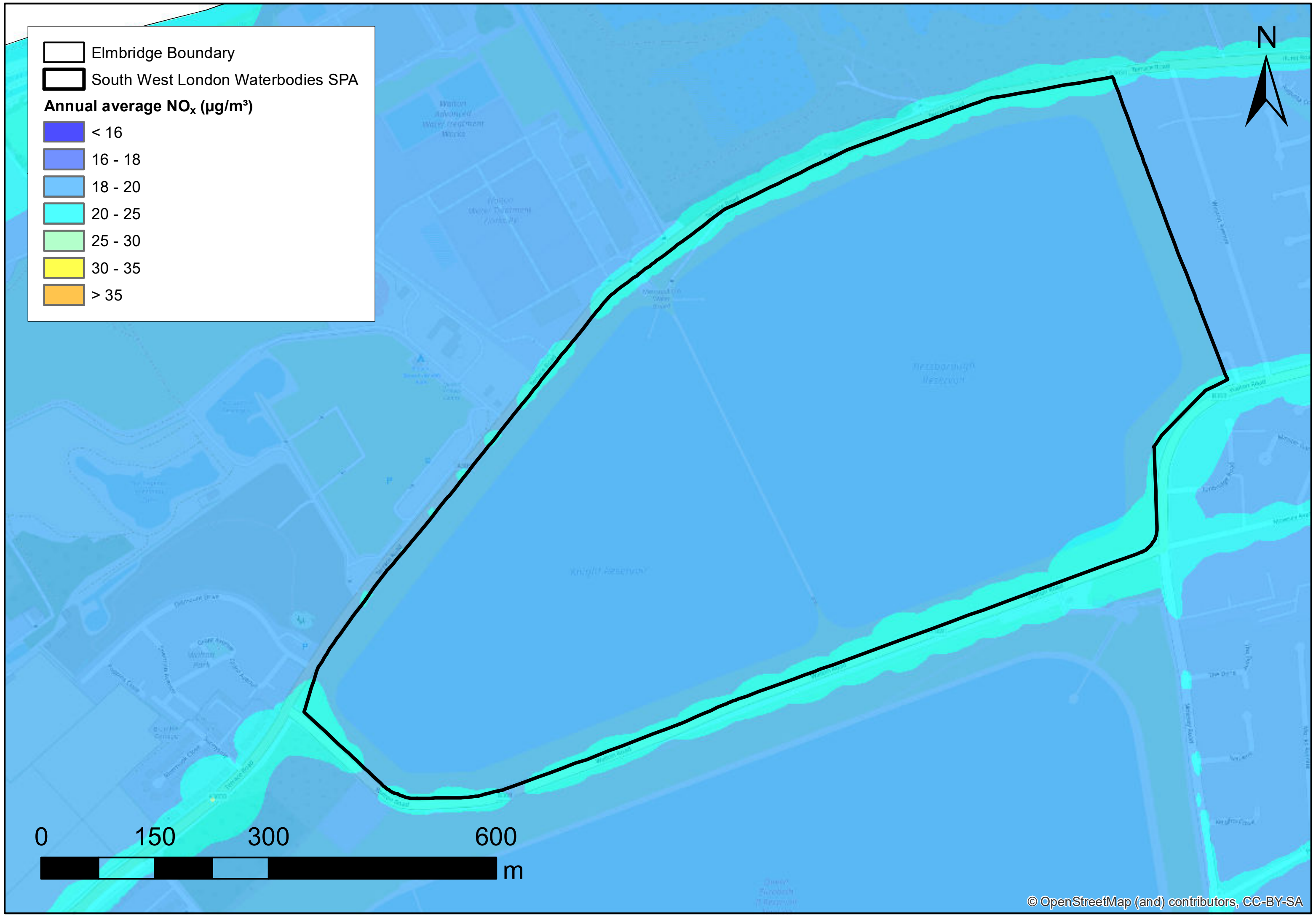

Figure 7.1: Annual average NO_x concentration across the South West London Waterbodies SPA within Elmbridge, Scenario 1, 2037 (µg/m³)

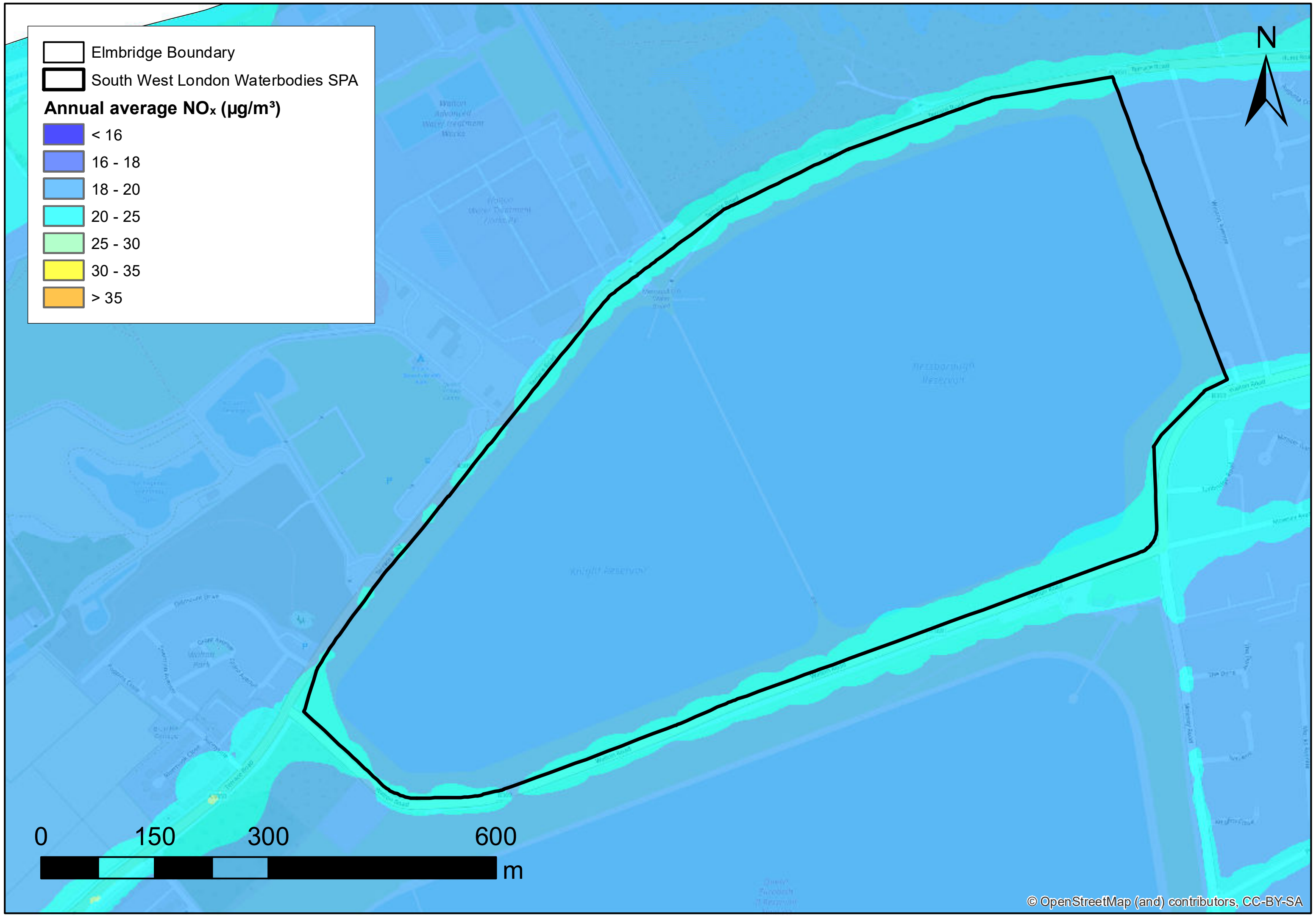

Figure 7.2: Annual average NO_x concentration across the South West London Waterbodies SPA within Elmbridge, Scenario 2, 2037 (µg/m³)

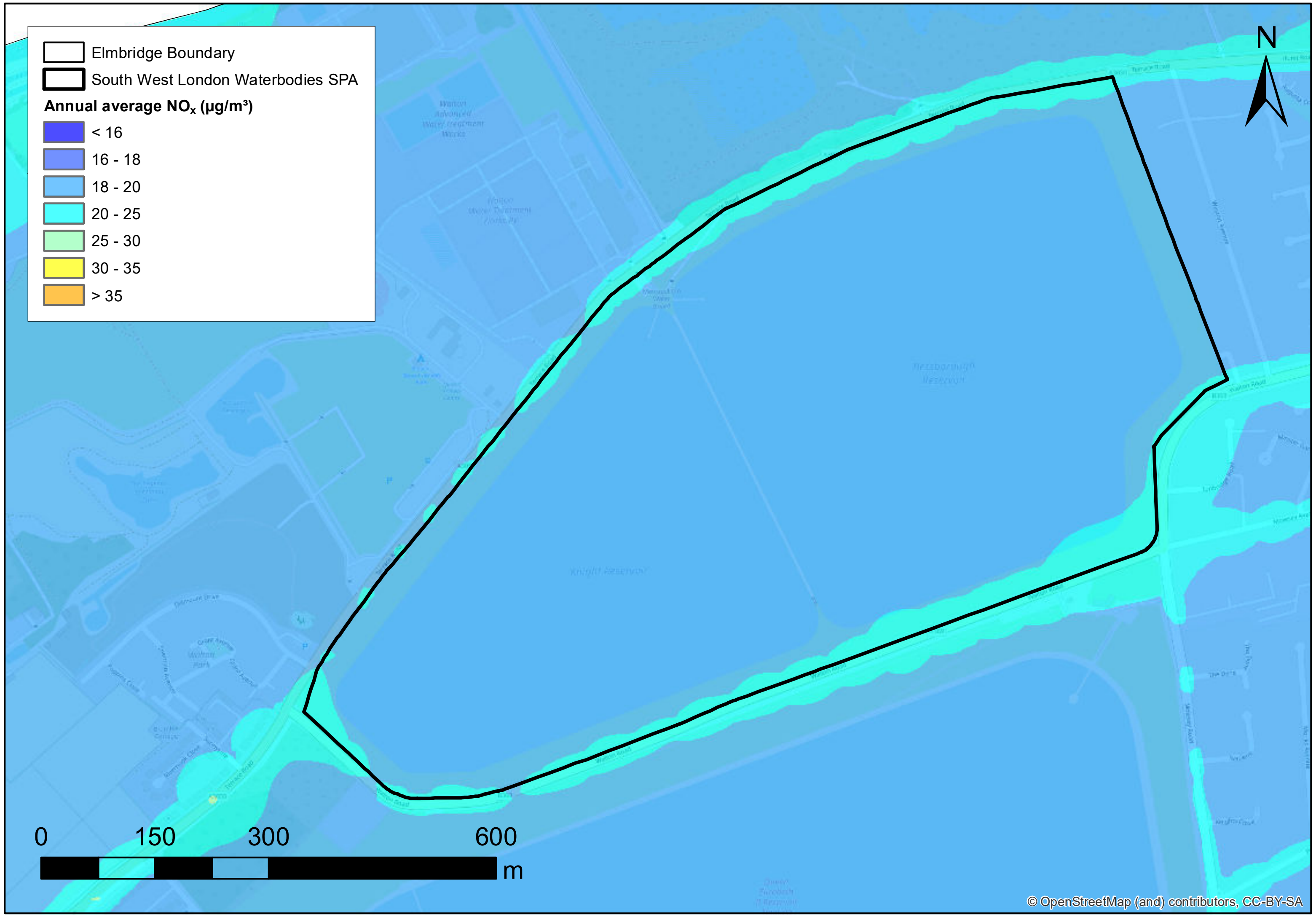

Figure 7.3: Annual average NO_x concentration across the South West London Waterbodies SPA within Elmbridge, Scenario 3, 2037 (µg/m³)

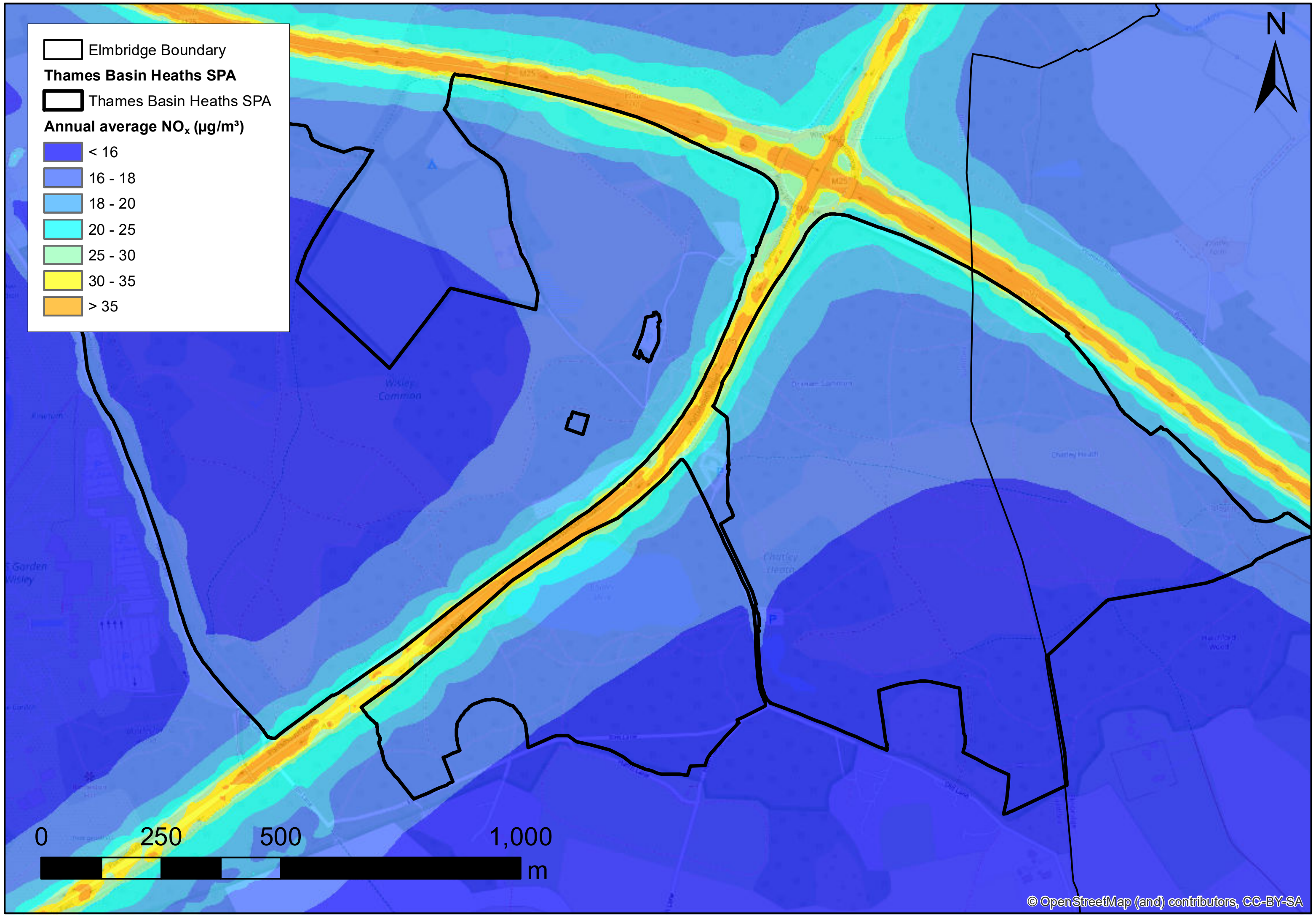

Figure 7.4: Annual average NO_x concentration across the Thames Basin Heaths SPA within Elmbridge, Scenario 1, 2037 (µg/m³)

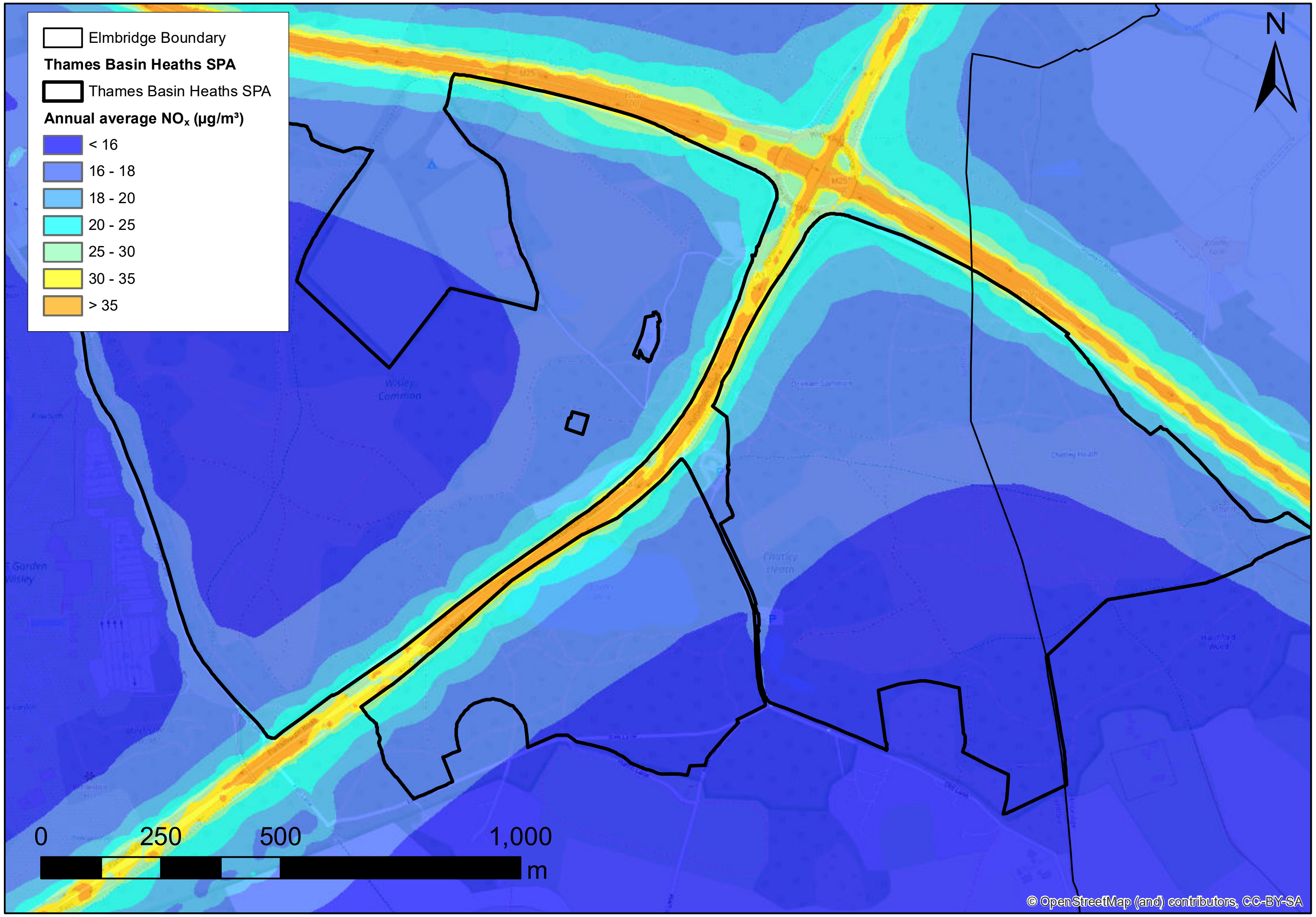

Figure 7.5: Annual average NO_x concentrations across the Thames Basin Heaths SPA within Elmbridge, Scenario 2, 2037 (µg/m³)

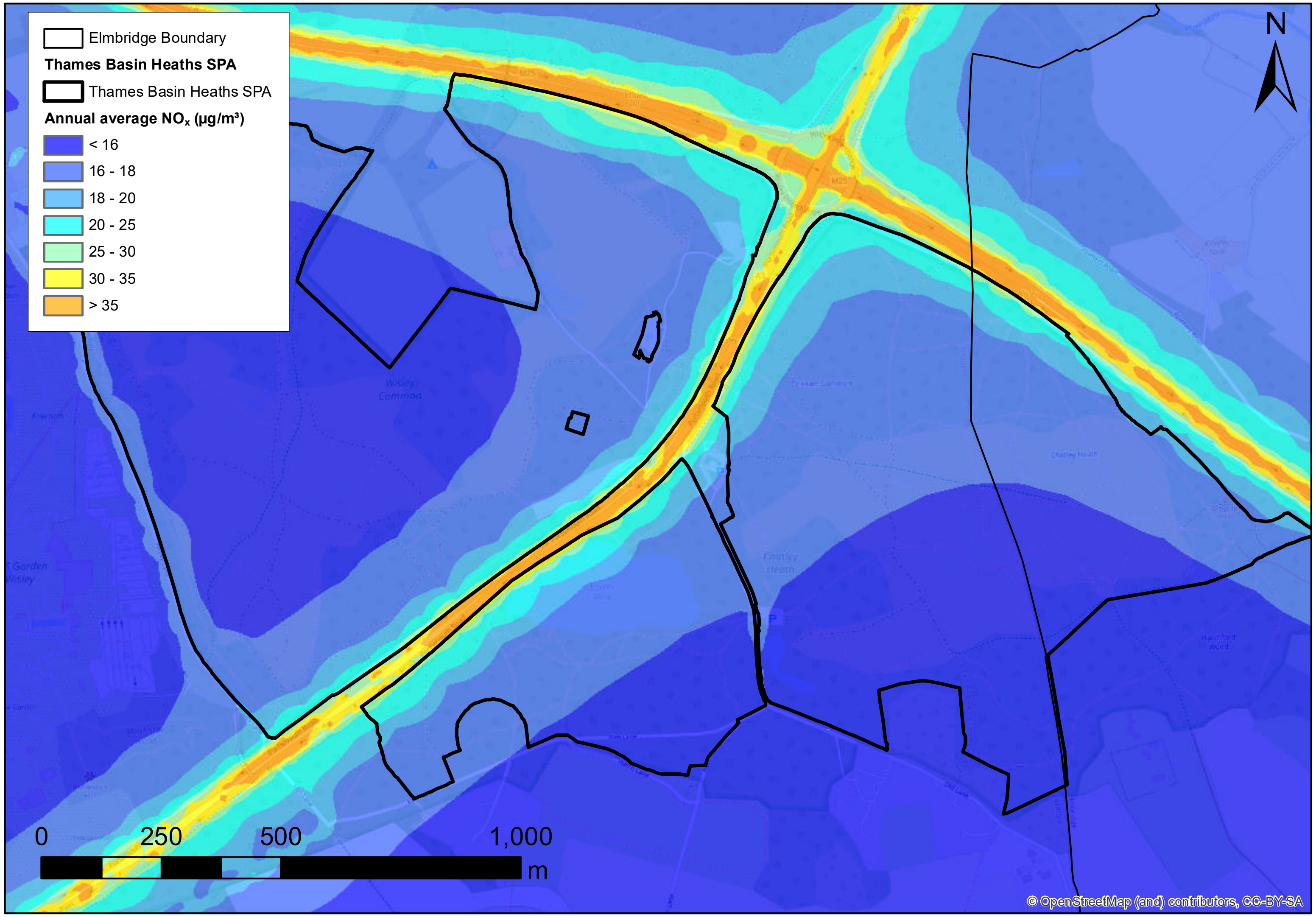

Figure 7.6: Annual average NO_x concentrations across the Thames Basin Heaths SPA within Elmbridge, Scenario 3, 2037 (µg/m³)

7.2 Critical loads

Material emitted into the atmosphere can be lost to the ground, at the surface of the ground (dry deposition), and through wash out with precipitation (wet deposition). Deposition of pollutants may lead to detrimental effects at sensitive habitats due to acidification and nitrogen eutrophication. In this assessment, modelling was carried out to predict the nitrogen deposition rate across the two SPAs.

As described in Section 9.2 of the current baseline (2017) report, for each SPA, model-output annual average ground level NO_2 concentrations were multiplied by an appropriate deposition velocity to calculate the NO_2 contribution to nitrogen deposition.

Since the modelling for the current baseline was carried out, in 2018, ammonia traffic emission factors have become available[6]. These were used to model annual average ammonia (NH_3) concentrations for road traffic impacts, as described in Section 5.1.1. The NH_3 concentrations were multiplied by an appropriate deposition velocity to calculate the NH_3 contribution to nitrogen deposition.

The contribution to nitrogen deposition from non-traffic NH_3 and ammonium (NH_4) was represented by adding the reduced nitrogen contribution to nitrogen deposition for each SPA, taken from the APIS (Air Pollution Information System) web site. A value of 8.2 kg N ha^{-1} yr^{-1} is provided for Thames Basin Heaths SPA and a value of 4.6 kg N ha^{-1} yr^{-1} is provided for South West London Waterbodies SPA[13][14].

Finally, the impact from nitrate (NO_3) and nitric acid (HNO_3) was calculated in the same way as described in the current baseline (2017) report, using concentrations of these species measured at the Rothamsted non-automatic monitoring site. A concentration of 0.27 µg/m³ was used for HNO_3 and a concentration of 3.4 µg/m³ was used for NO_3, calculated from the latest available monitoring data, for the year 2019.

7.2.1 Nitrogen deposition maps

Contour plots of annual nitrogen deposition were generated for the future (2037) scenarios using model output NO_2 on a 100 m regular grid across each SPA, along with additional output points along modelled roads to capture the steep concentration gradients at the roadside. These model-calculated concentrations were interpolated to generate a 10 m resolution deposition map. The contributions from NH_3, NH_4, NO_3 and HNO_3 were then added, as described above.

In the deposition maps, values that fall within or exceed the nitrogen deposition critical load range are shown in yellow, orange and red and values below the critical level range are shown in blue and green.

[13]http://www.apis.ac.uk/srcl/source-attribution?submit=Source+Attribution&sitetype=SPA&sitecode=UK9012141&sitename=Thames+Basin+Heaths

[14]http://www.apis.ac.uk/srcl/source-attribution?submit=Source+Attribution&sitetype=SPA&sitecode=UK9012171&sitename=South+West+London+Waterbodies

Figure 7.7 to Figure 7.9 present contour plots of the modelled annual nitrogen deposition over grassland across the South West London Waterbodies SPA for the 2037 scenarios. Modelled deposition shows no exceedences of the 20 – 30 kg N ha^{-1} yr^{-1} critical load range. As there are no modelled exceedences of the critical load range, difference maps are not provided for this SPA.

Figure 7.10 to Figure 7.12 present contour plots of the modelled annual nitrogen deposition across the Thames Basin Heaths SPA for the 2037 scenarios. For all three 2037 scenarios, the calculated nitrogen deposition exceeds the critical load range of 10 – 20 kg N ha^{-1} yr^{-1} for the short vegetation habitats at Thames Basin Heaths SPA, calculated using grassland deposition velocities.

As tall vegetation habitats are not an interest feature of the SPA, deposition results calculated using forest deposition velocities are not presented.

Figure 7.13 and Figure 7.14 show the modelled change in annual nitrogen deposition over short vegetation across the Thames Basin Heaths SPA between Scenario 1 and Scenarios 2 and 3, with the Local Plan in place. Difference plots show that the introduction of the Local Plan, as represented by Scenario 2 and Scenario 3, leads to an increase in deposition rate of no more than 0.1 N ha^{-1} yr^{-1} over much of Thames Basin Heaths SPA. There are larger increases at areas of the SPA close to the modelled roads, but the highest values fall within an area of shelterbelt, where it is understood that habitats are less sensitive.

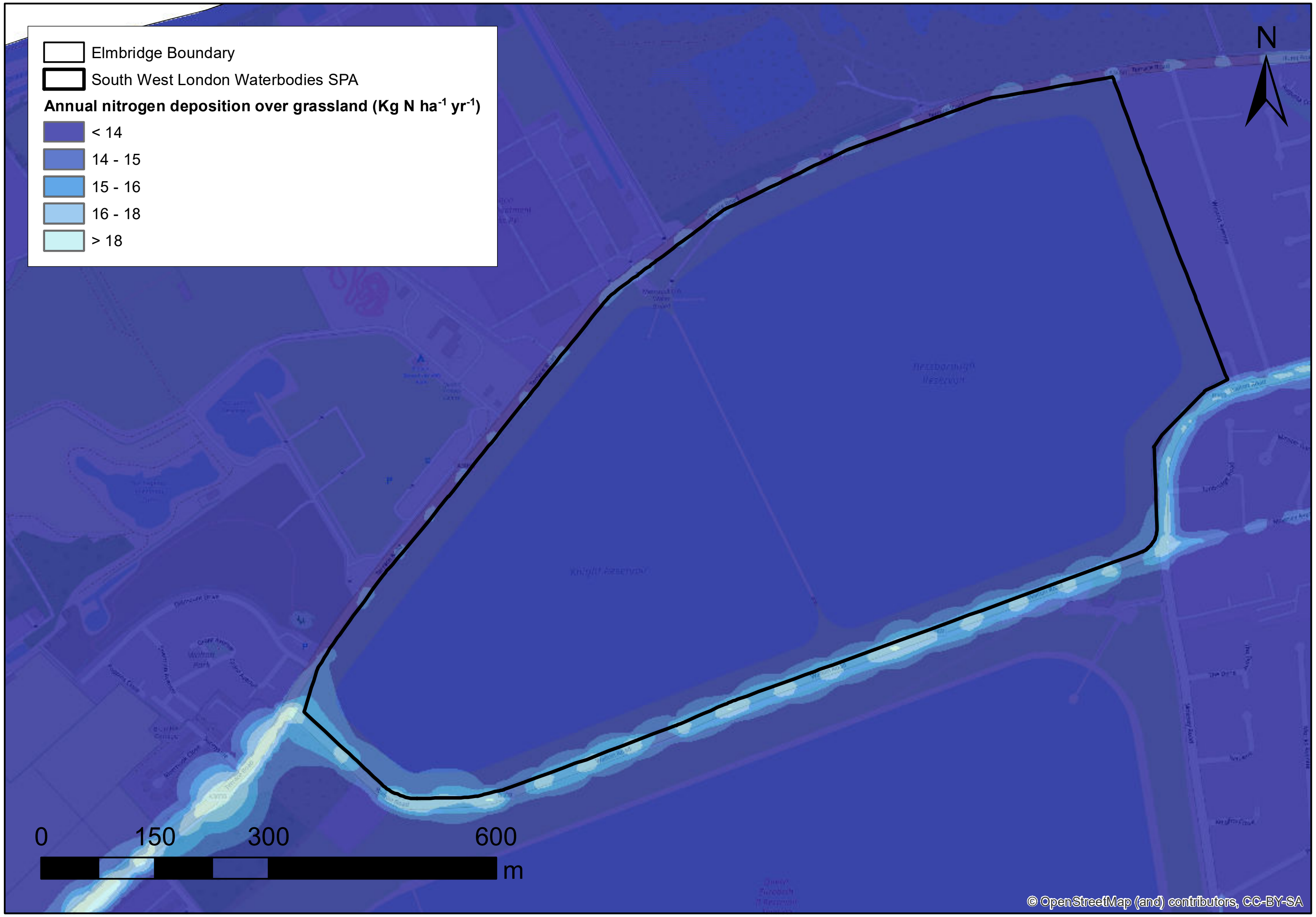

Figure 7.7: Annual nitrogen deposition (grassland) across the South West London Waterbodies SPA within Elmbridge, Scenario 1, 2037

Figure 7.8: Annual nitrogen deposition (grassland) across the South West London Waterbodies SPA within Elmbridge, Scenario 2, 2037

Figure 7.9: Annual nitrogen deposition (grassland) across the South West London Waterbodies SPA within Elmbridge, Scenario 3, 2037

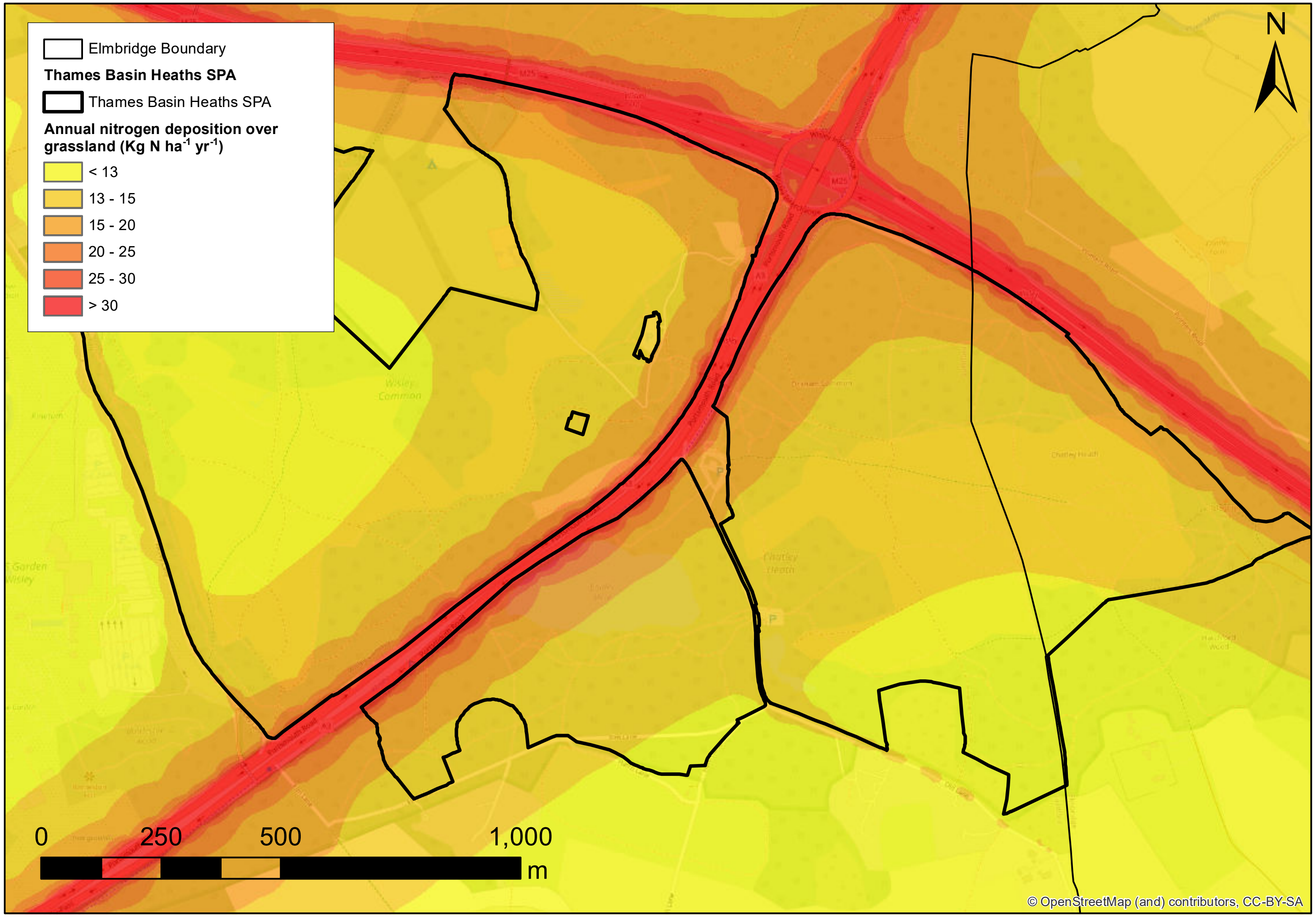

Figure 7.10: Annual nitrogen deposition (grassland) across the Thames Basin Heaths SPA within Elmbridge, Scenario 1, 2037

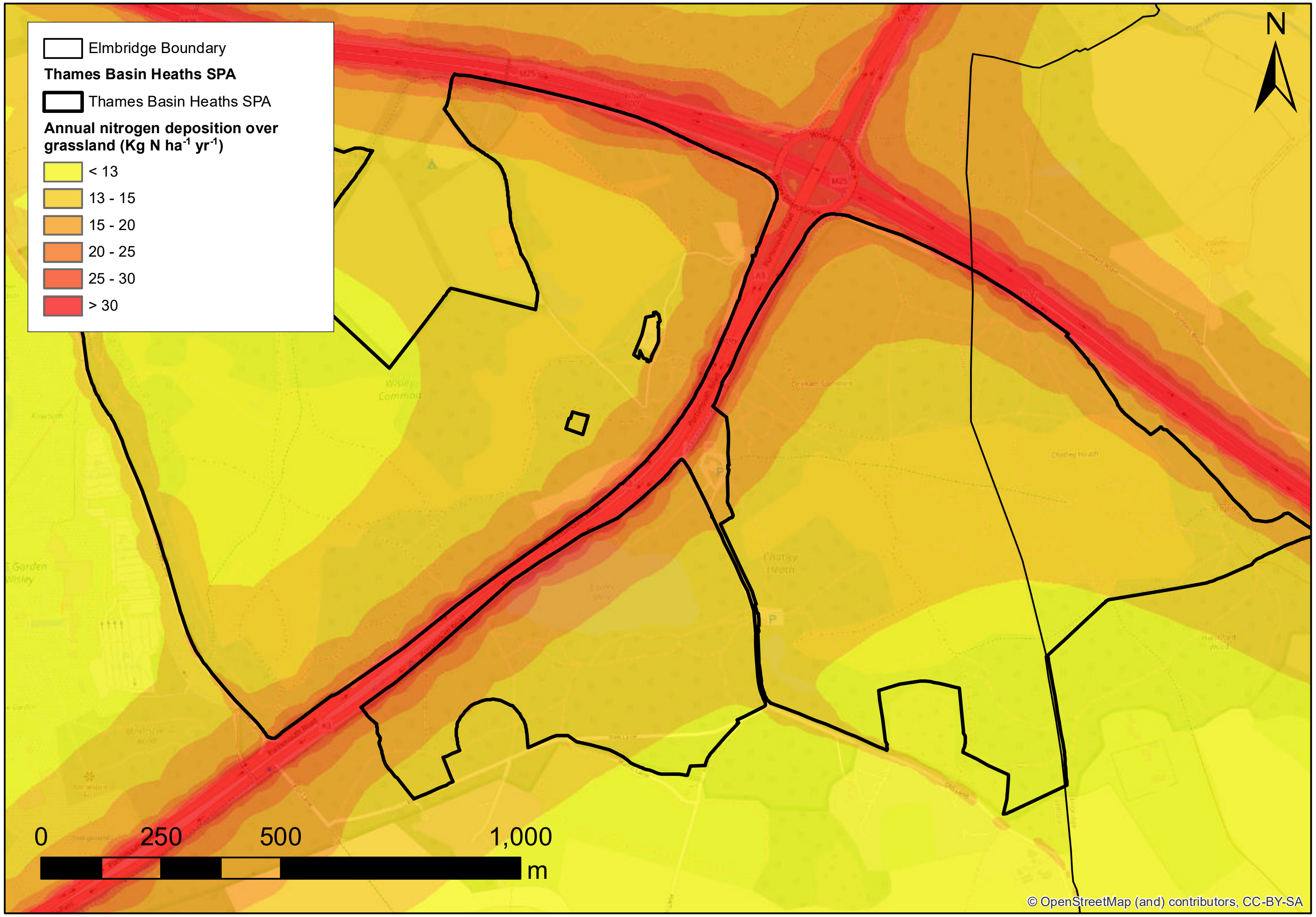

Figure 7.11: Annual nitrogen deposition (grassland) across the Thames Basin Heaths SPA within Elmbridge, Scenario 2, 2037

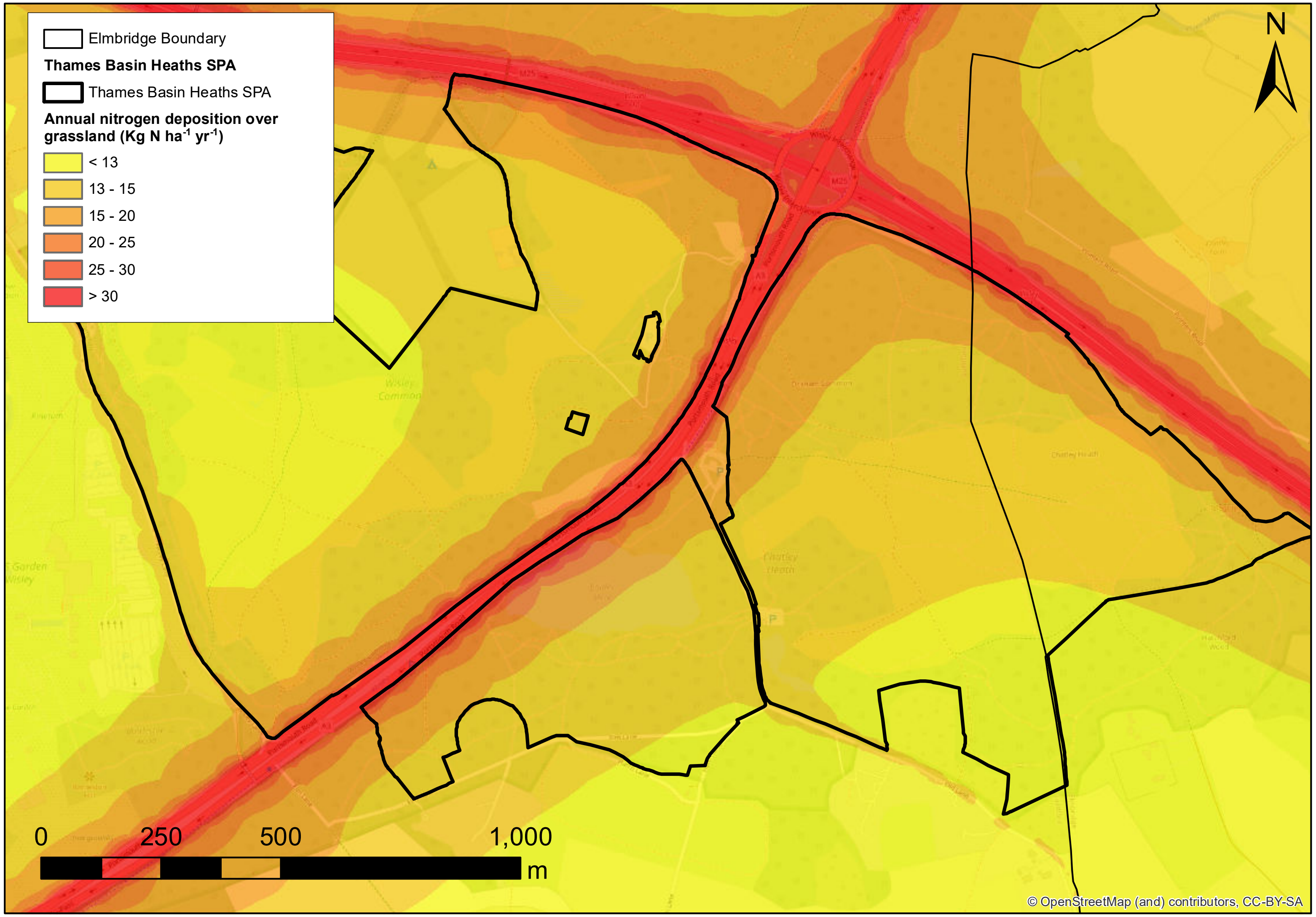

Figure 7.12: Annual nitrogen deposition (grassland) across the Thames Basin Heaths SPA within Elmbridge, Scenario 3, 2037

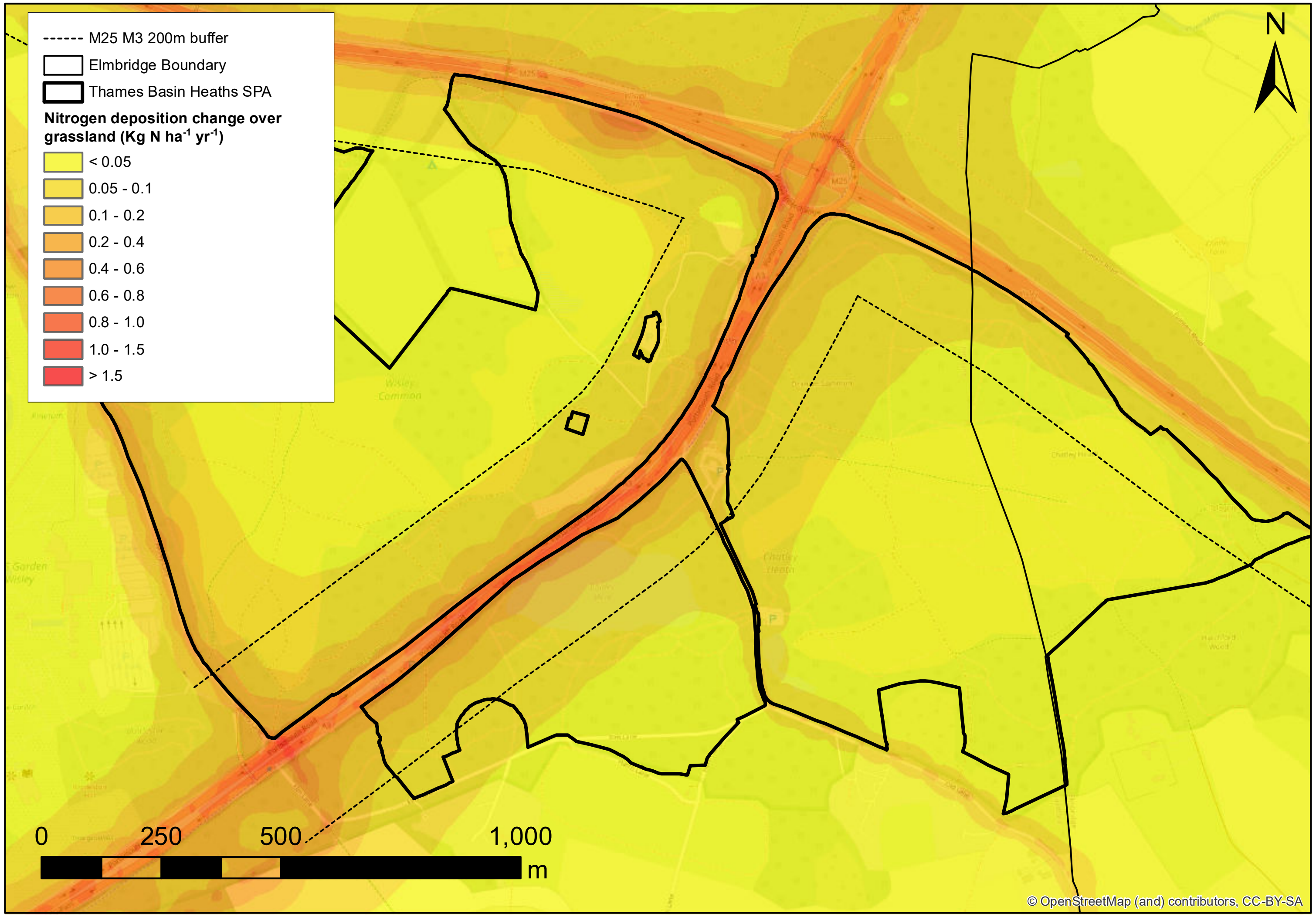

Figure 7.13: Modelled change in annual nitrogen deposition (grassland) between Scenario 2 and Scenario 1 across the Thames Basin Heaths SPA within Elmbridge

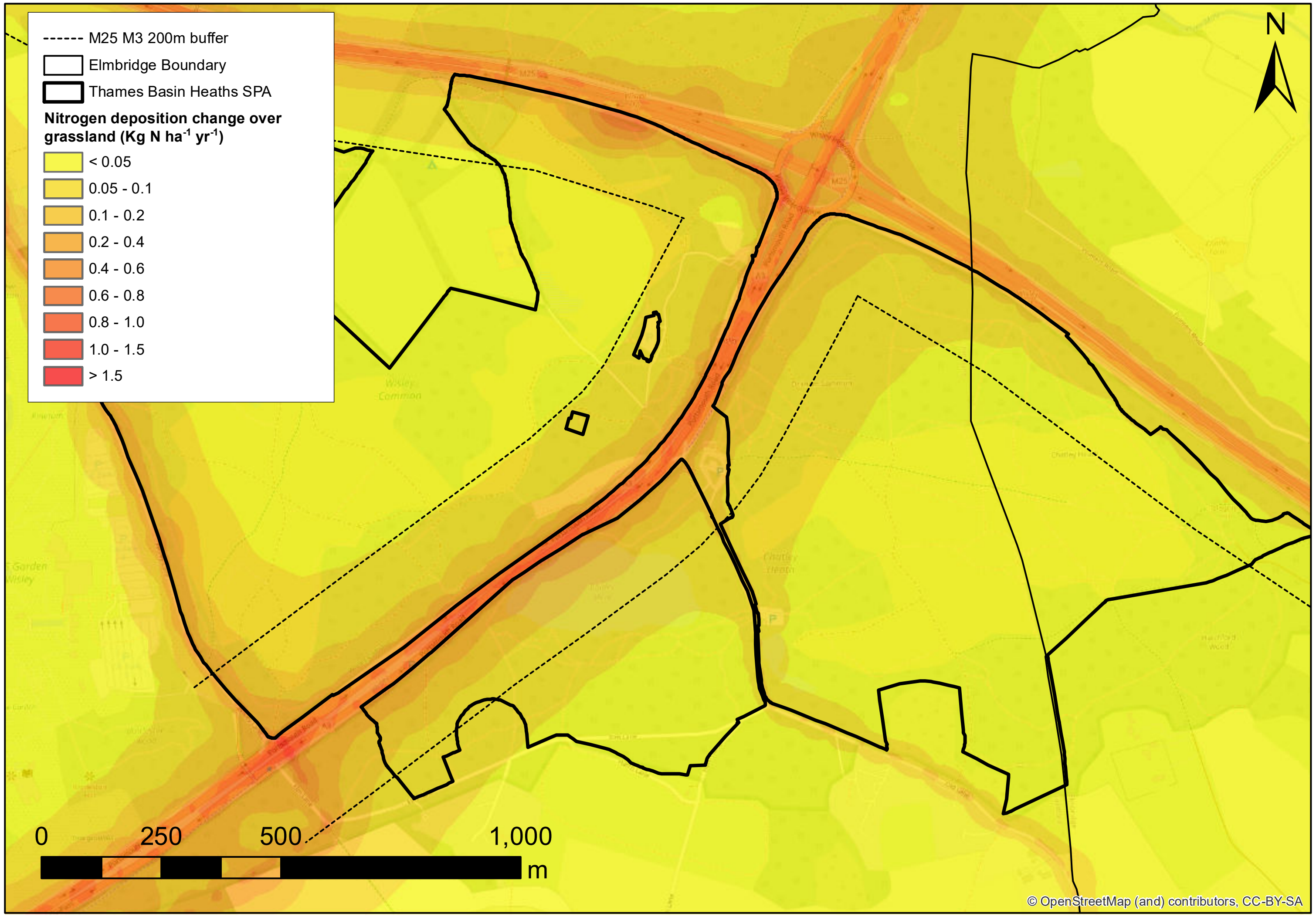

Figure 7.14: Modelled change in annual nitrogen deposition (grassland) between Scenario 3 and Scenario 1 across the Thames Basin Heaths SPA within Elmbridge

8 Discussion

Air quality modelling was carried out for NO_2, PM_{10} and $PM_{2.5}$ using ADMS-Urban (version 5.0.0.1) to assess air quality throughout Elmbridge for the future (2037) scenarios, Scenario 1, Scenario 2 and Scenario 3.

8.1 Human health impacts

For the assessment of human health impacts, the model was run to produce contour plots of annual mean NO_2, 99.79th percentile of hourly mean NO_2, annual mean PM_{10}, 90.41st percentile of 24-hourly mean PM_{10} and annual mean $PM_{2.5}$ concentrations.

For all three 2037 scenarios, modelled concentrations of NO_2, PM_{10} and $PM_{2.5}$ are all below the relevant limit values. Difference plots show that the introduction of the Local Plan, as represented by Scenario 2 and Scenario 3, is likely to have a small impact on annual average pollutant concentrations along some roads in the borough.

Local mortality burden calculations were carried out by coupling population data, by Lower Layer Super Output Areas (LSOA), with the modelled annual mean concentrations of NO_2 and $PM_{2.5}$. This includes deaths attributable to air pollution, the associated life-years lost and economic cost.

The combined health impacts of NO_2 and $PM_{2.5}$ for Elmbridge were calculated to be:

- in the range of 547 and 748 life-years lost for Scenario 1;
- in the range of 548 and 749 life-years lost for Scenario 2; and
- in the range of 548 and 749 life-years lost for Scenario 3.

For each of the three 2037 scenarios, the life years lost equate to an economic cost for chronic mortality between £35 million and £48 million.

8.2 Sensitive habitats impacts

For the assessment of impacts on sensitive habitats:

- annual average NO_x concentrations were calculated at the area of each SPA within Elmbridge for comparison with the critical level of 30 µg/m^3; and
- annual Nitrogen deposition rates were calculated at the area of each SPA within Elmbridge for comparison with site-specific critical loads.

For all three 2037 scenarios, the model-predicted annual average NO_x concentrations across the South West London Waterbodies SPA and Thames Basin Heaths SPA are below the NO_x critical level of 30 µg/m^3.

For South West London Waterbodies SPA, for all three 2037 scenarios, the nitrogen deposition falls below the critical load range of 20 – 30 kg N ha^{-1} yr^{-1}.

For all three 2037 scenarios, the calculated nitrogen deposition exceeds the critical load range of 10 – 20 kg N ha^{-1} yr^{-1} for the short vegetation habitats at Thames Basin Heaths SPA, calculated using grassland deposition velocities.

As tall vegetation habitats are not an interest feature of the SPA, deposition results calculated using forest deposition velocities are not presented.

Difference plots show that the introduction of the Local Plan, as represented by Scenario 2 and Scenario 3, leads to an increase in deposition rate of no more than 0.1 N ha^{-1} yr^{-1} over much of Thames Basin Heaths SPA. There are larger increases at areas of the SPA close to the modelled roads, but the highest values fall within an area of shelterbelt, where it is understood that habitats are less sensitive.

APPENDIX A: Summary of Local Plan developments

Table A.1: Local Plan development areas

Site Ref	Site Address	Units	Floor space (m^2)
US155	Garages to the rear of Holroyd Road Claygate	3	0
US156	Garages to the rear of Foxwarren Claygate	5	0
US6	Crown House Church Road Claygate	12	0
US2	Hare Lane Car Park Hare Lane Claygate	7	0
US3	Torrington Lodge Car Park Hare Lane Claygate	8	0
US169	Claygate Station Car park The Parade Claygate	15	0
US174	Claygate Village Youth Club Elm Road Claygate	6	0
US175	Claygate Centre Elm Road Claygate	14	0
US177	Claygate Lawn Tennis Club Torrington Close Claygate	24	0
US159	Garages to the rear of 6-24 Lockhart Road Cobham	4	0
US160	Garages at Bennett Close Cobham	3	0
US162	Site B Garages at Wyndham Avenue Cobham	4	0
US163	Site C Garages at Wyndham Avenue Cobham	3	0
US164	Cobham Health Centre and Garages off Tartar Road Cobham	11	0
US92	Glaxo SmithKline St George's Avenue Weybridge	100	0
US7	20 Stoke Road Cobham	9	0
US84	Elm Grove, 1 Hersham Road Walton-on-Thames	70	0
US183	BMW Cobham 18-22 Portsmouth Road Cobham	27	0
US187	87 Portsmouth Road Cobham	10	0
US188	97 Portsmouth Road Cobham	21	0
US189	101 Portsmouth Road Cobham	7	0
US190	270 Portsmouth Road Cobham	10	0
US191	73 Between Streets Cobham	40	0
US194	Protech House Copse Road Cobham	28	0
US83	Homebase New Zealand Avenue Walton-on-Thames	200	0
US201	Tiltwood Care Home Hogshill Lane Cobham	88	0
US214	Waitrose 16-18 Between Streets Cobham	20	0
US215	38 Copse Road Cobham	7	0
US217	68 Between Streets and 7-11 White Lion Gate Cobham	11	0
US218	Coveham House, Downside Bridge Road and The Royal British Legion Hollyhedge Road Cobham	14	0
US221	Garages and parking to the rear of Cobham Gate Cobham	8	0

Site Ref	Site Address	Units	Floor space (m^2)
US72	Courtlands & 1-5 Terrace Road Walton-on-Thames	78	0
US50	Royal Cambridge Home, 82-84 Hurst Road East Molesey	62	0
US134	Hanover Cottage, 6 Claremont Lane Esher	13	0
US146	35 New Road Esher	6	0
US157	Garages at Farm Road Esher	3	0
US481	6 Bracondale and 43 Claremont Lane Esher	18	0
US475	Willow House, Mairfair House and Amberhurst 4B Claremont Lane Esher	60	0
US47	Hampton Court Station & Jolly Boatman Hampton Court Way East Molesey	97	0
US462	Sundial House The Molesey Venture Orchard Lane East Molesey	77	0
US27	81 High Street Esher	8	0
US32	Windsor House 34-40 (inc. car park) High Street Esher	8	0
US435	Car Park next to Waterloo Court Mayfield Road Walton-on-Thames	62	0
US274	Two Furlongs and Wren House Portsmouth Road Esher	10	0
US282	42 New Road Esher	7	0
US286	Highwaymans Cottage Car Park Portsmouth Road Esher	9	0
US407	Foxholes estate Foxholes Weybridge	150	0
US288	Hawkshill Place Portsmouth Road Esher	15	0
US395	Weybridge Hospital and car park 22 Church Street Weybridge	60	0
US40	Hersham Day Centre & Village Hall 7 Queens Road Hersham	15	0
US43	Hersham Place Technology Park Molesey Road Hersham	0	4350
US45	Car park to the south of Mayfield Road Hersham	9	0
US374	Hersham Library Molesey Road Hersham	13	0
US375	Volkswagen Ltd Esher Road Hersham	27	0
US39	Units A & B Sandown Industrial Estate Mill Road Esher	40	0
US378	All Saints Catholic Church hall Queens Road Hersham	8	0
US379	Waitrose car park New Berry Lane Hersham	30	0
US380	EBC car park New Berry Lane Hersham	7	0
US389	Hersham sports and social club 128 Hersham Road Hersham	8	0
US390	The Royal George 130-132 Hersham Road Hersham	15	0
US44	Claremont House 34-38 Molesey Road Hersham	6	0
US441	63 Queens Road Hersham Walton-on-Thames	5	0
US186	78 Portsmouth Road Cobham	30	0
US158	Garages to the rear of Blair Avenue Esher	3	0
US38	Units C & D Sandown Industrial Estate Mill Road Esher	60	0
US226	Sandpiper Newlands Avenue Thames Ditton	30	0

Site Ref	Site Address	Units	Floor space (m^2)
US265	5A-6A Station Road Esher	5	0
US443	47 Portsmouth Road Thames Ditton	25	0
US18	British Legion Betts Way Long Ditton	9	0
US230	Car Park south of Southbank Thorkill Road Thames Ditton	7	0
US232	Nuffield Health Sports Club Simpson Way Thames Ditton	16	0
US233	Nuffield Health Car Park Simpson Way Thames Ditton	10	0
US245	Brook House and Thames Honda Portsmouth Road Thames Ditton	30	0
US260	46 St Marys Road Long Ditton	6	0
US376	Trinity Hall and 63-67 Molesey Road Hersham	48	0
US370	The Health Centre Rodney Road Walton-on-Thames	36	0
US498	7 Seymour Close and Land to rear of 103-113 Seymour Close East Molesey	6	0
US356	Station Avenue Car Park Station Avenue Walton-on-Thames	50	0
US296	5 Matham Road East Molesey	24	0
US299	East Molesey Car Park Walton Road East Molesey	23	0
US302	43 Palace Road East Molesey	19	0
US306	Molesey Clinic and Library Walton Road East Molesey	10	0
US315	Parking / garages at Grove Court Walton Road East Molesey	7	0
US317	Tesco Metro parking south of store Walton Road East Molesey	11	0
US318	Vine Medical Centre 69 Pemberton Road East Molesey	7	0
US319	Pavilion Sports Club car park Hurst Lane East Molesey	9	0
US456	Molesey Community Hospital High Street Molesey	70	0
US355	Walton Audi, 1 Station Avenue Walton-on-Thames	100	0
US151	Garages to the rear of Belvedere Gardens West Molesey	4	0
US152	Garages to the rear of Island Farm Road West Molesey	4	0
US153	11 to 27 Down Street West Molesey	16	0
US56	Joseph Palmer Centre, 319a Walton Road West Molesey	60	0
US308	Former Hurst Park Primary School, 357 Hurst Road West Molesey	77	0
US309	Water Works south of Hurst Road West Molesey	14	0
US312	Henrietta Parker Centre Ray Road West Molesey	13	0
US117	9 and rear of 11 and 13 Hall Place Drive Weybridge	8	0
US406	179 Queens Road Weybridge	10	0
US350	Leylands House Molesey Road Walton-on-Thames	56	0
US348	Cornerstone Church 38 Station Avenue Walton-on-Thames	30	0
US410	Oatlands car park Oatlands Drive Weybridge	8	0
US429	Garages at Brockley Combe Weybridge	7	0

Site Ref	Site Address	Units	Floor space (m^2)
US460	1, 3 and 5 Goldrings Road Oxshott Leatherhead	35	0
US467	Ambleside 3 The Spinney Queens Drive Oxshott	9	0
US474	Greenways and Bluebell Lodge 46 Copsem Lane Esher	22	0
US121	Oxshott Medical Practice and Village Centre Hall Holtwood Road Oxshott	10	1395
US124	St Andrew's Church Oakshade Road Oxshott	0	127
US165	Garages at Waverley Road Oxshott	6	0
US33	River Mole Business Park Mill Road Esher	200	0
US327	Bridge Motor Works New Zealand Avenue and Playhouse Hurst Grove Walton-on-Thames	55	0
US326	13-19a High Street Walton-on-Thames	25	0
US324	Manor Road Car Park Manor Road Walton-on-Thames	31	0
US287	15 Clare Hill Esher	56	0
US283	1 to 5 Millbourne Lane Esher	28	0
US339	Walton Park Car Park Walton Park Walton-on-Thames	17	0
US237	Ashley Road Car Park Ashley Road Thames Ditton	14	0
US248	School Bungalow Mercer Close Thames Ditton	10	0
US250	Community centres at the junction of Mercer Close and Watts Road Thames Ditton	29	0
US280	St Andrews and Hillbrow House Portsmouth Road Esher	30	0
US271	118-120 Bridge Road East Molesey	6	0
US272	Industrial units at 67 Summer Road East Molesey	12	0
US77	Annetts Yard 1-3 Annett Road Walton-on-Thames	10	0
US279	Esher Place 30 Esher Place Avenue Esher	25	0
US276	Café Rouge Portsmouth Road Esher	20	711
US269	Units 1-2 Hampton Court Summer Road Thames Ditton	60	318
US357	Rylton House Hersham Road Walton-on-Thames	26	0
US66	7-9 Ashley Road Walton-on-Thames	14	0
US79	Regnolruf Court Church Street Walton-on-Thames	33	0
US464	63-69 High Street Walton-on-Thames	29	366
US254	4-6 Manor Road South and 4 Greenways Hinchely Wood	35	0
US251	Old Pauline Sports Ground Car Park St Nicholas Road Thames Ditton	35	0
US321	Case House 85-89 High Street Walton-on-Thames	28	0
US323	Bradshaw House Bishops Hill and Walton Centre for the Community Manor Road Walton-on-Thames	49	0
US24	Flats 9-41 and Garages on Longmead Road Thames Ditton	55	0
US325	Garages to the rear of 8 Sidney Road Walton-on-Thames	8	0
US328	Walton Lodge Bridge Street Walton-on-Thames	18	0
US386	145-149 and rear access of 151-157 Hersham Road Hersham	18	200

Site Ref	Site Address	Units	Floor space (m^2)
US112	20 Sandy Lane Walton-on-Thames	8	0
US195	Cobham Village Hall and Centre for the Community Lushington Drive Cobham	37	0
US168	Garages at Sunnyside Walton-on-Thames	4	0
US471	147 Sidney Road Walton-on-Thames	9	0
US331	Land to the rear of 60-70 Sandy Lane Walton-on-Thames	8	0
US360	Walton Comrades Club 7 Franklyn Road Walton-on-Thames	16	0
US361	Garages adjacent to 1 Tumbling Bay Walton-on-Thames	2	0
US363	Unit Rear of and 12-14 Sandy Lane Walton-on-Thames	11	0
US487	16-18 Sandy Lane Walton-on-Thames	9	0
US166	Garages to the rear of 17-27 Field Common Lane Walton-on-Thames	3	0
US354	P G S Court Halfway Green Walton-on-Thames	23	0
US193	Glenhelm and 160 Anyard Road Copse Road Cobham	35	0
US59	Halfway Car Park Hersham Road Hersham	8	0
US335	Garages at Home Farm Gardens Walton-on-Thames	6	0
US346	Garages at Collingwood Place Walton-on-Thames	9	0
US178	Sainsbury's car park Bridge Way Cobham	58	0
US351	Land north of Mellor Close Walton-on-Thames	5	0
US352	Fire/Ambulance station Hersham Road Walton-on-Thames	21	0
US353	Fernleigh Day Centre Fernleigh Close Walton-on-Thames	19	0
US135	12 to 16a High Street Walton-on-Thames	26	388
US366	Garages off Copenhagen Way Walton-on-Thames	7	0
US372	1 Cleveland Close Walton-on-Thames	8	0
US127	30 Copsem Lane Esher	22	0
US94	Locke King House 2 Balfour Road Weybridge	12	0
US470	Oak House 19 Queens Road Weybridge	10	0
US107	Weybridge Delivery Office / Retail unit Elmgrove Road Weybridge	5	0
US108	Weybridge Library Church Street Weybridge	30	0
US125	Baker Street car park Baker Street Weybridge	7	0
US391	Woodlawn Hanger Hill and 2 Churchfields Avenue Weybridge	13	0
US393	The Old Warehouse, 37A Church Street Weybridge	5	0
US394	NHS North West, 58 Church Street Weybridge	19	0
US396	Idis House Churchfield Road Weybridge	22	0
US397	Floors above Waitrose, 62 High Street Weybridge	9	0
US398	1 to 8 Dovecote Close Weybridge	15	0
US411	York Road car park York Road Weybridge	8	0

Site Ref	Site Address	Units	Floor space (m^2)
US416	Garages to the west of 17 Grenside Road Weybridge	5	0
US417	Garages to the rear of Broadwater House Grenside Road Weybridge	20	0
US419	35-47 Monument Hill Weybridge	25	0
US420	59-65 Baker Street Weybridge	14	0
US421	181 Oatlands Drive Weybridge	12	0
US424	Weybridge Bowling Club 19 Springfield Lane Weybridge	11	0
US116	Molesey Football and Social Club and 22-29 and 30-33 Grange Close and 412 Walton Road West Molesey	50	0
US469	Heath Lodge St Georges Avenue Weybridge	16	0
US110	The Heights Weybridge	0	9500
US402	1 Prince's Road Weybridge	19	0
US403	HFMC House, New Road and 51 Prince's Road Weybridge	6	0
US404	2 to 8 Prince's Road Weybridge	10	0
US431	Shell Petrol Filling Station 95 Brooklands Road Weybridge	5	0
US93	Horizon Business Park Brooklands Road Weybridge	0	6000
US482	24-26 Church Street Weybridge	15	0
US489	19 Old Esher Road Hersham	6	0
US492	Cedar House Mill Road Cobham	7	0
US493	Selden Cottage and Ronmar Leatherhead Road Oxshott	20	0
US495	Corner Cottage Portsmouth Road Thames Ditton	6	0
US496	Quadrant Court Yard Quadrant Way Weybridge	15	0
US497	Cedar Road Car Park Cedar Road Cobham	5	0
US503	89-90 Woodfield Road Thames Ditton	9	0
US504	9 Esher Road Hersham	5	0
US505	75 Oatlands Drive Weybridge	10	0
US506	Land to the rear of 5 Hinchley Way Esher	6	0
US507	133-135 Walton Road East Molesey	9	0
US509	2 Beauchamp Road East Molesey	10	0
US511	8 to 14 Oatlands Drive Walton-on-Thames	30	0
US516	Bransby Lodge St Leondards Road Thames Ditton	6	0
US517	Park House Pratts Lane Hersham	9	0
US518	Thames Ditton Centre for the Community Mercer Close Thames Ditton	18	0
US519	Esher Public Library and land adjoining Church Street Esher	15	0
US520	Weybridge Centre for the Community Churchfield Place Weybridge	8	0

APPENDIX B: Summary of ADMS-Urban

ADMS-Urban is a scientifically advanced but practical air pollution modelling tool, which has been developed to provide high resolution calculations of pollution concentrations for all sizes of study area relevant to the urban environment. The model can be used to look at concentrations near a single road junction or over a region extending across the whole of a major city. ADMS-Urban is used worldwide to assess air quality impact for a wide range of planning and policy studies, incorporating elements such as Low Emission Zones, traffic management, clean vehicle technologies and modal shift. In the UK, it is used extensively for air quality review and assessment carried out by local government.

The following is a summary of the capabilities and validation of ADMS-Urban. More details can be found on the CERC web site[15].

ADMS-Urban is a development of the Atmospheric Dispersion Modelling System (ADMS), which has been developed to investigate the impacts of emissions from industrial facilities. ADMS-Urban allows full characterisation of the wide variety of emissions in urban areas, including an extensively validated road traffic emissions model. It also includes a number of other features, which include consideration of:

- the effects of vehicle movement on the dispersion of traffic emissions;
- the behaviour of material released into street-canyons;
- the chemical reactions occurring between nitrogen oxides, ozone and Volatile Organic Compounds (VOCs);
- the pollution entering a study area from beyond its boundaries;
- the effects of complex terrain on the dispersion of pollutants;
- the effects of the urban canopy on the dispersion of pollutants; and
- the effects of a building on the dispersion of pollutants emitted nearby.

Further details of these features are provided below.

Studies of extensive urban areas are necessarily complex, requiring the manipulation of large amounts of data. To allow users to cope effectively with this requirement, ADMS-Urban runs in Windows 10 and Windows 8 environments. The manipulation of data is further facilitated by the ADMS-Urban Mapper, which allows for the visualisation and manipulation of geospatial information, and by the CERC Emissions Inventory Toolkit, EMIT.

[15] https://www.cerc.co.uk/environmental-software/ADMS-Urban-model.html

Dispersion Modelling

ADMS and ADMS-Urban use boundary layer similarity profiles to parameterise the variation of turbulence with height within the boundary layer, and the use of a skewed-Gaussian distribution to determine the vertical variation of pollutant concentrations in the plume under convective conditions.

The main dispersion modelling features of ADMS-Urban are as follows:

- ADMS-Urban is an **advanced dispersion model** in which the boundary layer structure is characterised by the height of the boundary layer and the Monin-Obukhov length, a length scale dependent on the friction velocity and the heat flux at the surface. This method supersedes methods based on Pasquill Stability Categories, as used in, for example, the US models Caline and ISC. Concentrations are calculated hour by hour and are fully dependent on prevailing weather conditions.
- For convective conditions, a **non-Gaussian vertical profile of concentration** allows for the skewed nature of turbulence within the atmospheric boundary layer, which can lead to high concentrations near to the source.
- A **meteorological processor** calculates boundary layer parameters from a variety of input data, typically including date and time, wind speed and direction, surface temperature and cloud cover. Meteorological data may be raw, hourly averaged or statistically analysed data.

Emissions

Emissions into the atmosphere across an urban area typically come from a wide variety of sources. There are likely to be emissions from road traffic, as well as from domestic heating systems and industrial emissions from chimneys. To represent the full range of emissions configurations, the explicit source types available within ADMS-Urban are:

- **Roads**, for which emissions are specified in terms of vehicle flows and the additional initial dispersion caused by moving vehicles is also taken into account.
- **Industrial points**, for which plume rise and stack downwash are included in the modelling.
- **Areas**, where a source or sources is best represented as uniformly spread over an area.
- **Volumes**, where a source or sources is best represented as uniformly spread throughout a volume.

In addition, sources can also be modelled as a regular grid of emissions. This allows the contributions of large numbers of minor sources to be efficiently included in a study while the majority of the modelling effort is used for the relatively few significant sources.

ADMS-Urban can be used in conjunction with CERC's Emissions Inventory Toolkit, EMIT, which facilitates the management and manipulation of large and complex data sets into usable emissions inventories.

Presentation of Results

The results from the model can be based on a wide range of averaging times, and include rolling averages. Maximum concentration values and percentiles can be calculated where appropriate meteorological input data have been input to the model. This allows ADMS-Urban to be used to calculate concentrations for direct comparison with existing air quality limits, guidelines and objectives, in whatever form they are specified.
ADMS-Urban has an integrated Mapper which facilitates both the compilation and manipulation of the emissions information required as input to the model and the interpretation and presentation of the air quality results provided. ADMS-Urban can also be integrated with ArcGIS or MapInfo.

Complex Effects - Street Canyons

ADMS-Urban incorporates two methods for representing the effect of street canyons on the dispersion of road traffic emissions: a basic canyon method based on the *Operational Street Pollution Model (OSPM)*[16], developed by the Danish National Environmental Research Institute (NERI); and an advanced street canyon module, developed by CERC. The basic canyon model was designed for simple symmetric canyons with height similar to width and assumes that road traffic emissions originate throughout the base of the canyon, i.e. that the emissions are spread across both the road and neighbouring pavements.

The advanced canyon model[17] was developed to overcome these limitations and is our model of choice. It represents the effects of channelling flow along and recirculating flow across a street canyon, dispersion out of the canyon through gaps in the walls, over the top of the buildings or out of the end of the canyon. It can take into account canyon asymmetry and restricts the emissions area to the road carriageway.

Complex Effects - Chemistry

ADMS-Urban includes the *Generic Reaction Set (GRS)*[18] atmospheric chemistry scheme. The original scheme has seven reactions, including those occurring between nitrogen oxides and ozone and parameterisations of the large number of reactions involving a wide range of Volatile Organic Compounds (VOCs). In addition, an eighth reaction has been included within ADMS-Urban for the situation when high concentrations of nitric oxide (NO) can convert to nitrogen dioxide (NO_2) using molecular oxygen.

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[16] Hertel, O., Berkowicz, R. and Larssen, S., 1990, 'The Operational Street Pollution Model (OSPM).' *18th International meeting of NATO/CCMS on Air Pollution Modelling and its Applications.* Vancouver, Canada, pp741-749.
[17] Hood C, Carruthers D, Seaton M, Stocker J and Johnson K, 2014. *Urban canopy flow field and advanced street canyon modelling in ADMS-Urban.* 16th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, Varna, Bulgaria, September 2014.
http://www.harmo.org/Conferences/Proceedings/_Varna/publishedSections/H16-067-Hood-EA.pdf
[18] Venkatram, A., Karamchandani, P., Pai, P. and Goldstein, R., 1994, 'The Development and Application of a Simplified Ozone Modelling System.' *Atmospheric Environment,* Vol 28, No 22, pp3665-3678.

In addition to the basic GRS scheme, ADMS-Urban also includes a trajectory model[19] for use when modelling large areas. This permits the chemical conversions of the emissions and background concentrations upwind of each location to be properly taken into account.

Complex Effects - Terrain

As well as the effect that complex terrain has on wind direction and, consequently, pollution transport, it can also enhance turbulence and therefore increase dispersion. These effects are taken into account in ADMS-Urban using the FLOWSTAR[20] model developed by CERC.

Complex Effects – Urban Canopy

As wind approaches an urban area of relatively densely packed buildings, the wind profile is vertically displaced. The wind speed and turbulence levels are also reduced within the area of buildings. These effects are taken into account in ADMS-Urban by modifying the wind speed and turbulence profiles based on parameters describing the amount and size of buildings within an urban area.

Data Comparisons – Model Validation

ADMS-Urban is a development of the Atmospheric Dispersion Modelling System (ADMS), which is used throughout the UK by industry and the Environment Agency to model emissions from industrial sources. ADMS has been subject to extensive validation, both of individual components (e.g. point source, street canyon, building effects and meteorological pre-processor) and of its overall performance.

ADMS-Urban has been extensively tested and validated against monitoring data for large urban areas in the UK and overseas, including London, Birmingham, Manchester, Glasgow, Riga, Cape Town, Hong Kong and Beijing, as part of projects supported by local governments and research organisations. A summary of model validation studies is available online[21]. CERC have co-authored[22] a number of papers presenting results from ADMS-Urban, and other organisations have published the outcomes of their applications of the model[23].

[19] Singles, R.J., Sutton, M.A. and Weston, K.J., 1997, 'A multi-layer model to describe the atmospheric transport and deposition of ammonia in Great Britain.' In: *International Conference on Atmospheric Ammonia: Emission, Deposition and Environmental Impacts. Atmospheric Environment*, Vol 32, No 3.
[20] Carruthers D.J., Hunt J.C.R. and Weng W-S. 1988. 'A computational model of stratified turbulent airflow over hills – FLOWSTAR I.' Proceedings of Envirosoft. In: *Computer Techniques in Environmental Studies,* P. Zanetti (Ed) pp 481-492. Springer-Verlag.
[21] www.cerc.co.uk/Validation
[22] www.cerc.co.uk/CERCCoAuthorPublications
[23] www.cerc.co.uk/CERCSoftwarePublications