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to support the Elmbridge Local Plan

Phase 1

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1 Summary

Elmbridge Borough Council is preparing a Local Plan to guide development in the Borough until 2035. CERC was commissioned to carry out air dispersion modelling to identify the baseline air quality profile across the area and to assess two future (2035) scenarios, with and without proposed developments in the Elmbridge Local Plan in place.

This report describes only the baseline modelling, carried out for the year 2017; the data required as input to the 2035 modelling is expected to be provided in September 2019.

The aim of the modelling is to ascertain whether or not the development associated with the Local Plan has the potential to cause air quality issues, i.e. approaching or exceeding air quality standards for nitrogen oxides (NO_x and NO_2) or particulate matter (PM_{10} and $PM_{2.5}$). Human health and habitats impacts are of concern.

The main source of air pollution in Elmbridge is road traffic emissions from major roads. The Council has declared seven Air Quality Management Areas (AQMAs) due to annual average NO_2 concentrations exceeding the Air Quality Objective.

The main air quality modelling was carried out with ADMS-Urban (version 4.2) dispersion modelling software, using meteorological data from the Heathrow Airport meteorological station.

Road traffic emissions input to the dispersion model were calculated from traffic flows provided from the Surrey Traffic Model, supplemented by Department for Transport (DfT) count data. The Emission Factor Toolkit version 8.0.1, published by Defra, was used to calculate emissions from traffic flows. All other emissions data were taken from the NAEI.

Detailed model verification was carried out by comparing modelled concentrations against monitored data across Elmbridge for the year 2017, with iterative improvements to the model set-up to ensure acceptable agreement between modelled and monitored concentrations.

1.1 Human health impacts

High resolution air quality maps for concentrations of NO_2, PM_{10} and $PM_{2.5}$ across Elmbridge were then generated to determine the extent to which the air quality objectives for these pollutants are exceeded.

For the 2017 baseline, with exception of some locations close to major roads, the air quality objectives are met throughout the borough. There are modelled exceedences of the annual mean NO_2 objective of 40 $\mu g/m^3$ along the M25 and other busy roads. Exceedences of short-term NO_2 and PM_{10} objectives are less extensive. The annual mean $PM_{2.5}$ objective of 25 $\mu g/m^3$ is met throughout 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 a range of 747 and 909 life-years lost, which equates to an economic cost of between £32 million and £39 million in 2017.

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 $\mu g/m^3$.

The model-predicted annual average NO_x concentrations exceed this critical level right across the South West London Waterbodies SPA, with higher concentrations found along the SPA perimeter, closer to the modelled roads.

Within the Thames Basin Heaths SPA, the close proximity of the M25 and A3 result in model-predicted annual average NO_x concentrations exceeding the critical level across the majority of this SPA. Concentrations below the critical level are found towards the centre of the SPA and at the boundaries away from major roads.

2 Introduction

Elmbridge Borough Council (the Council) is preparing a Local Plan to guide development in the Borough until 2035.

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 baseline air quality profile across the area and to assess two future (2035) scenarios, with and without proposed developments in the Elmbridge Local Plan in place, represented by:

1. Scenario 1: Urban intensification (under constructions, planning permissions and urban sites); and
2. Scenario 2: Urban and Green Belt (worse-case scenario: under constructions, planning permission, urban sites, Green Belt opportunity and promoted sites).

The aim of the modelling is to ascertain whether or not the development associated with the Local Plan has the potential to cause air quality issues, i.e. approaching or exceeding air quality objectives for nitrogen oxides (NO_x and NO_2) or particulate matter (PM_{10} and $PM_{2.5}$). Human health and habitats impacts are of concern.

This report describes only the baseline modelling carried out for the year 2017; the data required as input to the 2035 modelling is expected to be provided in September 2019.

The air quality limit values and target values with which the calculated concentrations are compared are presented in Section 3. Section 4 describes the modelled area and summarises local air quality across Elmbridge. The model setup and emissions data are described in Sections 5 and 6, respectively.

The results of the modelling are then presented: the model verification in Section 7; and baseline human health impacts in Section 8, which includes concentration maps, health receptor concentrations, and mortality burden calculations. Baseline sensitive habitat impacts are presented in Section 9. A discussion of the results is presented in Section 10.

Finally, a summary of the ADMS-Urban model is included as Appendix A.

3 Air quality standards and guidance

3.1 Air quality standards for the protection of human health

The EU *ambient air quality directive* (2008/50/EC) sets binding limits for concentrations of air pollutants. The directive has been transposed into English legislation as the *Air Quality Standards Regulations 2010*[1], which also incorporates the provisions of the *4th air quality daughter directive* (2004/107/EC).

The Air Quality Standards Regulations 2010 include limit values and target values. The NO_2, PM_{10} and $PM_{2.5}$ Air Quality Objectives are presented in Table 3.1.

Table 3.1: Air quality objectives (µg/m3)

	Value	Description of standard
NO_2	200	Hourly mean not to be exceeded more than 18 times a year (modelled as 99.79th percentile)
	40	Annual average
PM_{10}	50	24-hour mean not be exceeded more than 35 times a year (modelled as 90.41st percentile)
	40	Annual average
$PM_{2.5}$	25	Annual average

The short-term standards considered are specified in terms of the number of times during a year that a concentration measured over a short period of time is permitted to exceed a specified value. For example, the concentration of NO_2 measured as the average value recorded over a one-hour period is permitted to exceed the concentration of 200µg/m^3 up to 18 times per year. Any more exceedences than this during a one-year period would represent a breach of the objective.

It is convenient to model objectives of this form in terms of the equivalent percentile concentration value. A percentile is the concentration below which lie a specified percentage of concentration measurements. For example, consider the 98th percentile of one-hour concentrations over a year. Taking all of the 8760 one-hour concentration values that occur in a year, the 98th percentile value is the concentration below which 98% of those concentrations lie. Or, in other words, it is the concentration exceeded by 2% (100 – 98) of those hours, that is, 175 hours per year. Taking the NO_2 objective considered above, allowing 18 exceedences per year is equivalent to not exceeding for 8742 hours or for 99.79% of the year. This is therefore equivalent to the 99.79th percentile value.
Table 3.2 gives examples from the Defra TG(16) guidance of where the air quality objectives should apply.

[1] http://www.legislation.gov.uk/uksi/2010/1001/contents/made

Table 3.2: Examples of where the air quality objectives should apply

Averaging period	**Objectives should apply at:**	**Objectives should generally not apply at:**
Annual average	All 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 facade), or any other location where public exposure is expected to be short term.
24-hour mean	All locations where the annual mean objective would apply, together with hotels. Gardens of residential properties (where relevant for public exposure e.g. seating or play areas)	Kerbside sites (as opposed to locations at the building facade), or any other location where public exposure is expected to be short term.
Hourly average	All locations where the annual mean and 24-hour mean objectives apply and: Kerbside sites (for example pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. Which are not fully enclosed, where members of the public might reasonably be expected to spend one hour or longer.	Kerbside sites where the public would not be expected to have regular access.

3.2 Critical levels for the Protection of Vegetation and Ecosystems

The critical levels for the Protection of Vegetation and Ecosystems, as set out in the Environment Agency's guidance for environmental permits, are summarised in Table 3.3.

The guidance recommends the assessment of:

- Special Protection Areas (SPAs)[2], Special Areas of Conservation (SACs)[3] and Ramsar[4] sites within 10 km of the installation; and
- Sites of Special Scientific Interests (SSSIs)[5], National Nature Reserves (NNRs)[5], Local Nature Reserves (LNRs)[6], local wildlife sites and ancient woodland within 2 km of the installation.

Table 3.3: Critical levels for the Protection of Vegetation and Ecosystems

	Critical level (μg/m³)	**Comment**
NO_x	30	annual mean
	75	daily mean

[2] Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora
[3] Council Directive 79/409/EEC on the conservation of wild birds
[4] International Convention on Wetlands of International Importance especially as Waterfowl Habitat
[5] Declared by the statutory country conservation agencies, which have a duty under the Wildlife and Countryside Act 1981
[6] Declared under the National Parks and Access to the Countryside Act 1949 by local authorities after consultation with the relevant statutory nature conservation agency

4 Modelled area

4.1 Local air quality

The Local Air Quality Management (LAQM) process, as set out in Part IV of the Environment Act (1995), the Air Quality Strategy for England, Scotland, Wales and Northern Ireland 2007 and the relevant Policy and Technical Guidance documents places an obligation on all local authorities to regularly review and assess air quality in their areas, and to determine whether or not the air quality objectives are likely to be achieved. Where exceedences are considered likely, the local authority must then declare an Air Quality Management Area (AQMA) and prepare an Air Quality Action Plan (AQAP) setting out the measures it intends to put in place in pursuit of the objectives.

Figure 4.1 presents the locations of monitoring sites and AQMAs in Elmbridge, comprising 40 diffusion tubes, two continuous monitors and seven AQMAs. The AQMAs are:

- Walton-on-Thames High Street;
- Weybridge High Street;
- Hampton Court;
- Cobham High Street;
- Hinchley Wood;
- Esher High Street; and
- Walton Road, Molesey.

All seven AQMAs were declared for annual mean NO_2 concentrations.

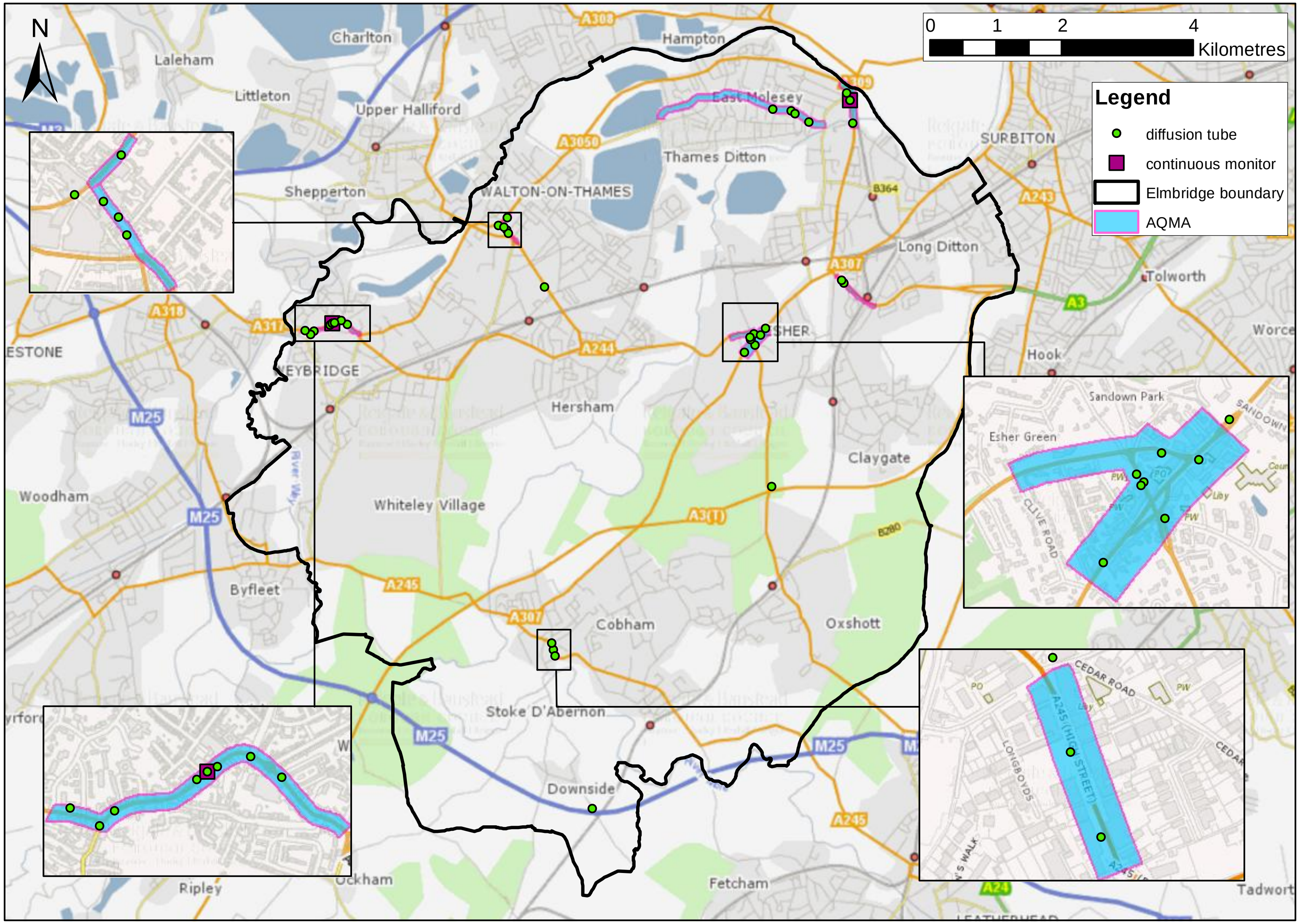

Figure 4.1: Continuous monitoring stations, diffusion tubes and AQMA locations in Elmbridge

Table 4.1 presents the monitored annual average NO_2 concentrations for Elmbridge in 2017. The table includes annual average NO_x concentrations for continuous monitors. Exceedences of the air quality objective of 40 µg/m³ for annual average NO_2 concentrations are highlighted in **bold**.

Two sites include triplicate diffusion tubes, collocated with continuous monitors: Hampton Court 2/3/4 are collocated with Hampton Court Parade; and Weybridge 10/11/12 are collocated with Weybridge High Street. Monitoring data presented in this section was provided by Elmbridge borough, with diffusion tube concentrations presented as bias adjusted values. A 0.91 bias adjustment factor was applied to raw diffusion tube data.

Table 4.1: Monitored annual average NO_2 concentrations at Elmbridge continuous monitoring stations and diffusion tubes, 2017

Site ID	Monitor type	Location	Height (m)	Distance to kerb (m)	Concentration (µg/m³)
Hampton Court Parade	Continuous	515342, 168292	1.8	2	**41** [NO_x 108]
Weybridge High Street	Continuous	507480, 164923	1.8	0.6	34 [NO_x 78]
Cobham 1	DT	510833, 159998	2.4	0.6	30
Cobham 6	DT	510814, 160098	2.4	6	25
Cobham 7	DT	510866, 159908	2.4	3.1	33
Downside 3	DT	511429, 157606	2.3	1.1	19
Esher 1	DT	513841, 164693	2.6	1.5	38
Esher 4	DT	514060, 164853	2.4	4.7	34
Esher 5	DT	514148, 162467	2.4	1.4	**43**
Esher 7	DT	513981, 164750	2.3	0.6	**40**
Esher 8	DT	513834, 164685	2.4	3.2	39
Esher 9	DT	513822, 164713	2.6	0.6	29
Esher 10	DT	513886, 164767	2.4	2.1	29
Esher 11	DT	513896, 164600	2.6	5.1	33
Esher 13	DT	513737, 164488	2.4	0.9	32
Hampton Court 1	DT	515384, 167947	2.2	0.9	36
Hampton Court 2 Hampton Court 3 Hampton Court 4	DT	515342, 168292	1.7	1.9	35
Hampton Court 5	DT	515292, 168406	2.5	0.4	26
Hinchley Wood 1	DT	515247, 165535	2.4	4.5	36
Hinchley Wood 2	DT	515217, 165577	1.9	9.8	31
Molesey 1	DT	514449, 168132	2.5	1.1	29
Molesey 8	DT	514716, 167960	2.5	2.6	32
Molesey 9	DT	514508, 168088	2.4	2.6	33
Molesey 10	DT	514170, 168156	2.4	4.9	28
Walton 3	DT	510132, 166336	2.6	0.4	30
Walton 5	DT	510704, 165473	2.3	0.9	28
Walton 8	DT	510156, 166282	2.6	2.9	31
Walton 9	DT	510086, 166382	2.5	2.6	30
Walton 10	DT	510140, 166522	2.6	3.3	34
Walton 11	DT	509999, 166402	2.4	2.3	31
Weybridge 1	DT	507448, 164900	2.5	1	30
Weybridge 4	DT	507704, 164906	2.4	2	31
Weybridge 5	DT	507610, 164968	2.3	1.6	34

Table 4.2: continued

Site ID	Monitor type	Location	Height (m)	Distance to kerb (m)	Concentration (µg/m³)
Weybridge 6	DT	507510, 164937	2.3	0.5	28
Weybridge 7	DT	507199, 164805	2.4	1.5	**41**
Weybridge 8	DT	507153, 164760	2.4	4.6	36
Weybridge 9	DT	507065, 164813	1.6	13.1	23
Weybridge 10	DT	507480, 164923	1.8	0.6	32
Weybridge 11					31
Weybridge 12					32

4.2 Sensitive receptors for human health impacts

Figure 4.2 presents the locations of sensitive receptors across Elmbridge, including health centres, private surgeries, dental surgeries, hospitals and state schools.

4.3 Sensitive habitats sites

Detailed modelling to assess impacts on vegetation and ecosystems was carried out for two Special Protection Areas (SPAs) located within Elmbridge: South West London Waterbodies and Thames Basin Heaths. Thames Basin Heaths extends into the neighbouring borough of Guildford. The locations of the sites are shown in Figure 4.3. These are the parts of the SPAs that fall within or closely in the vicinity of the Elmbridge boundary; both SPAs extend outside Elmbridge.

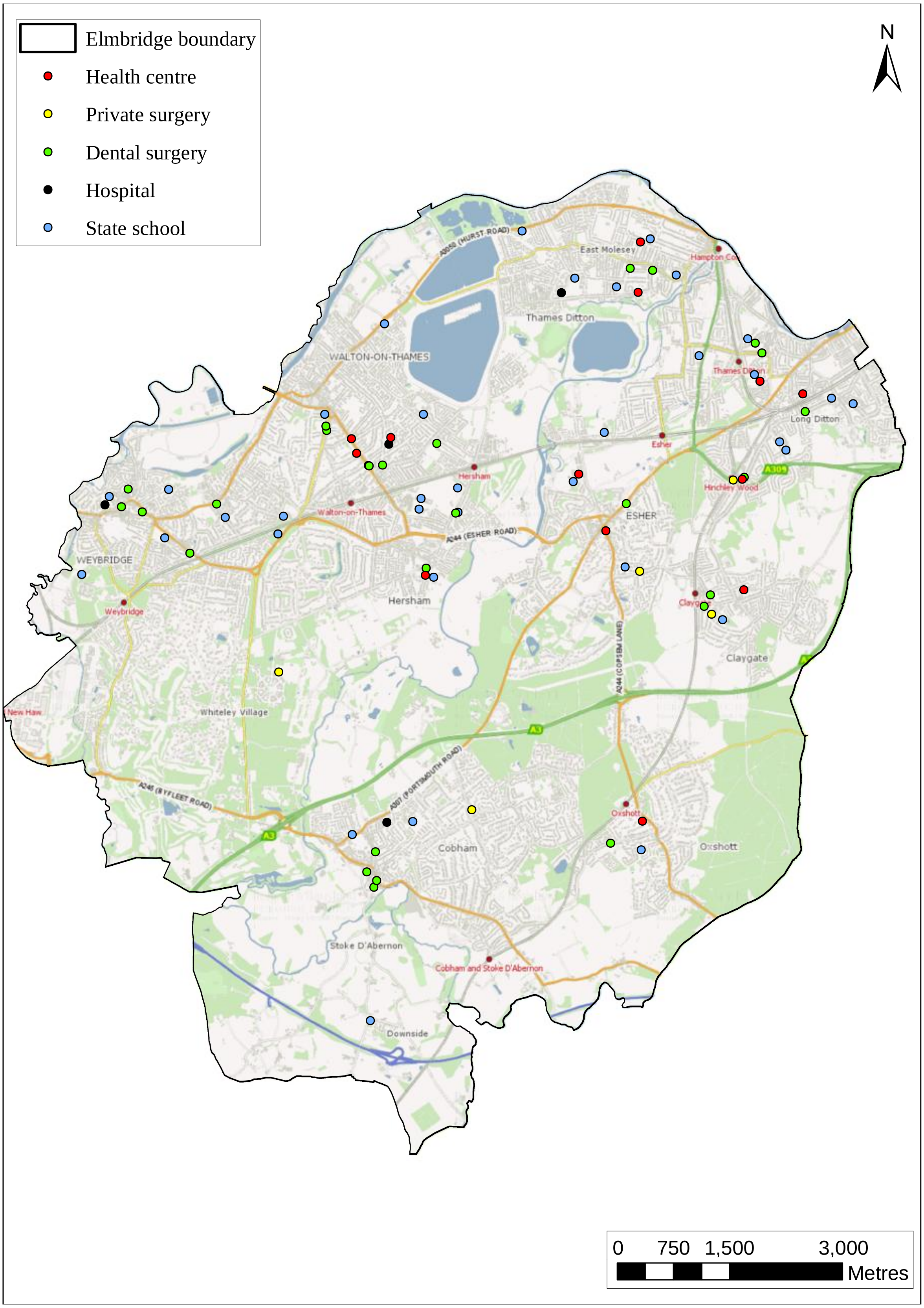

Figure 4.2: Locations of sensitive receptors throughout Elmbridge

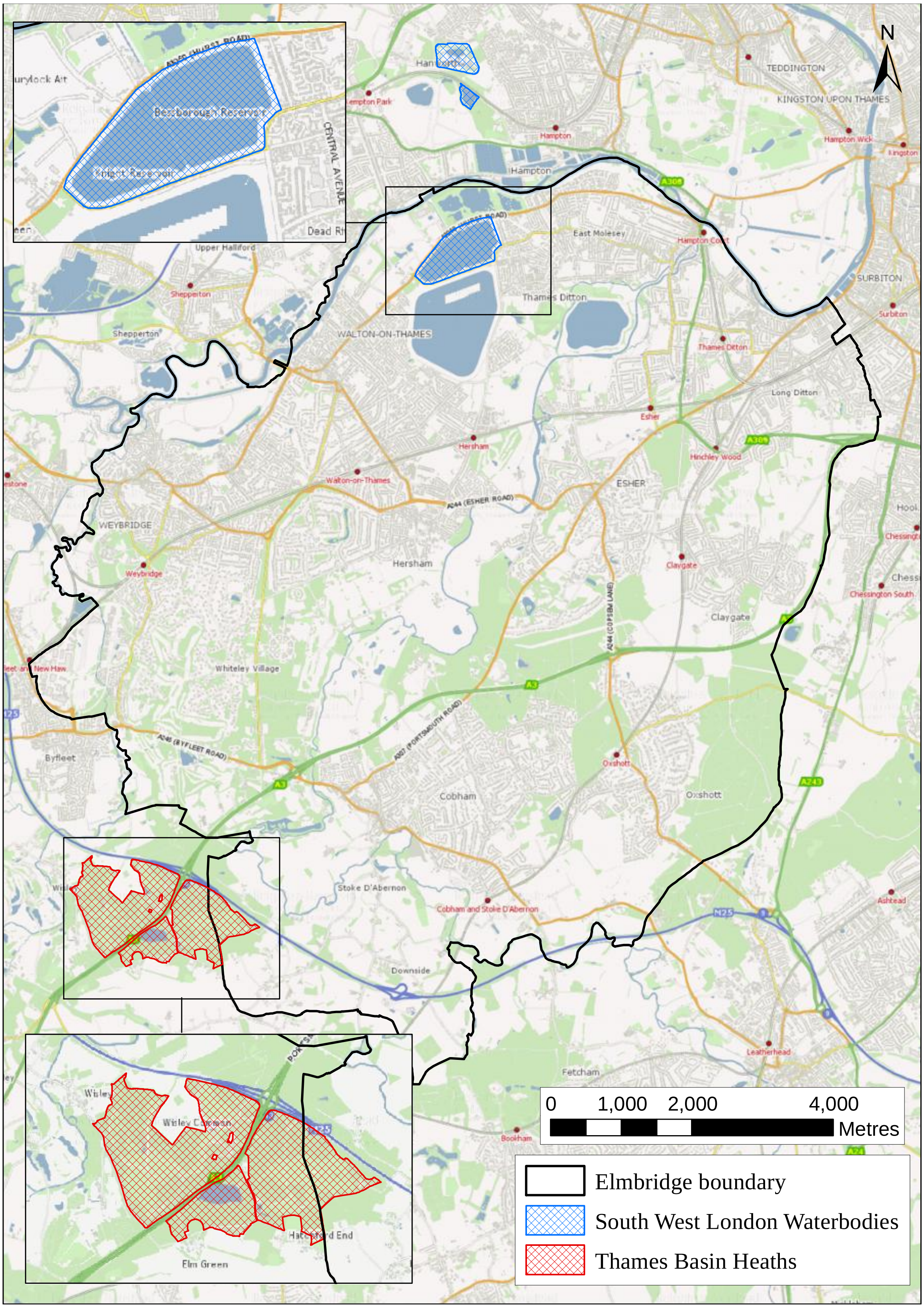

Figure 4.3: SPAs within Elmbridge

5 Air quality modelling

5.1 Modelling software

All modelling was carried out using ADMS-Urban[7] version 4.2, developed by CERC. This model allows the effects of wider urban areas on local air quality to be taken into account.

5.2 Surface roughness

A length scale parameter called the surface roughness length is used in the model to characterise the study area in terms of the effects it will have on wind speed and turbulence, which are key factors in the modelling. A roughness length of 0.5m was used for the dispersion site throughout the modelling, representing open suburbia.

The difference in land use at the meteorological station compared to the study area was taken into account by entering a different surface roughness for the meteorological station. See Section 5.4 for further details.

5.3 Monin-Obukhov length

In urban and suburban areas, a significant amount of heat is emitted by buildings and traffic, which warms the air within and above a city. This is known as the urban heat island and its effect is to prevent the atmosphere from becoming very stable. In general, the larger the area the more heat is generated and the stronger the effect becomes. In the ADMS-Urban model, the stability of the atmosphere is represented by the Monin-Obukhov parameter. The effect of the urban heat island is that, in stable conditions, the Monin-Obukhov length will never fall below some minimum value; the larger the city, the larger the minimum value. A minimum Monin-Obukhov length of 30 m was used in the modelling.

5.4 Meteorological data

A year of hourly sequential meteorological data measured at Heathrow Airport in 2017 was used for model verification and subsequent modelling.

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

Table 5.1 summarises the meteorological data from Heathrow Airport. To take account of the different surface characteristics at Heathrow Airport, compared to the modelled area, a surface roughness of 0.2 m was assumed for the meteorological station.

Table 5.1: Summary of meteorological data

Year	% of hours used	Parameter	Minimum	Maximum	Mean
2017	99.7	Temperature (°C)	-4	34	12.0
		Wind speed (m/s)	0	17	4.1
		Cloud cover (oktas)	0	8	5

The ADMS meteorological pre-processor, written by the UK Met Office, uses the data provided to calculate the parameters required by the program. Figure 5.1 presents a wind rose showing the frequency of occurrence of wind from different directions for a number of wind speed ranges for Heathrow Airport.

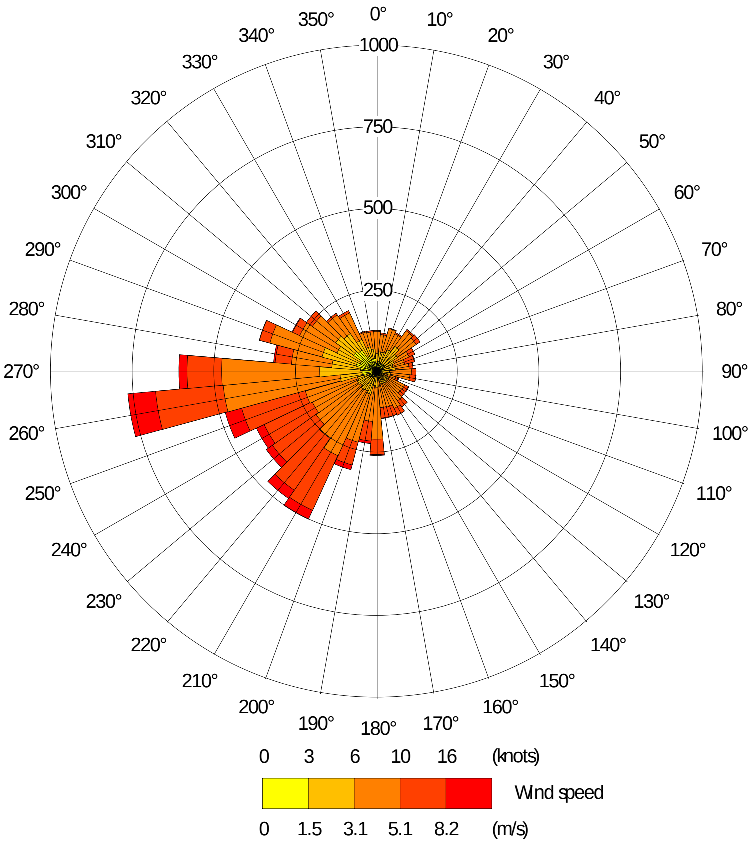

Figure 5.1: Wind rose for Heathrow 2017

5.5 Chemistry

The ADMS-Urban explicit chemistry scheme was used to model the interconversion between NO and NO_2, using wind dependent background concentrations derived from AURN rural monitoring sites. This approach allows for direct model verification against monitored concentrations for NO_x and NO_2, with simultaneous consideration of source dependent primary NO_2.

5.6 Background data

Hourly background data for the modelled pollutants and sulphur dioxide and ozone were input to the model to represent the concentrations in the air being blown into the area. NO_x, NO_2, SO_2, PM_{10}, $PM_{2.5}$ and O_3 concentrations from Rochester Stoke, Chilbolton, Lullington Heath and Haringey Priory Park South for 2017 were input to the model, the monitored concentration used for each hour depending upon the wind direction for that hour, as shown in Figure 5.2.

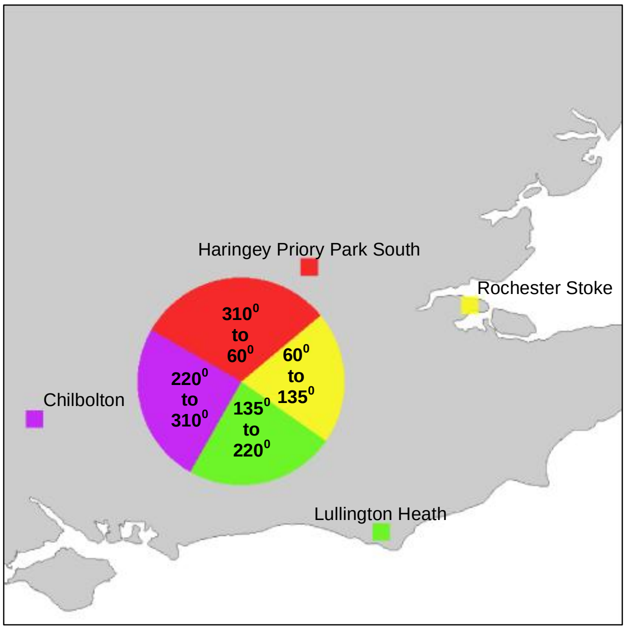

Figure 5.2: Wind direction segments used to calculate background concentrations for NO_x, NO_2, O_3, PM_{10}, $PM_{2.5}$ and SO_2

Table 5.2 summarises the annual statistics for background data used for the modelling, calculated using wind data from Heathrow Airport.

Table 5.2: Summary of 2017 background data used in the modelling (µg/m^3)

Statistic	NO_x	NO_2	O_3	PM_{10}	$PM_{2.5}$	SO_2
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

5.7 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. Building footprint and height information was taken from OS Mastermap data. At some locations, the properties of canyons were altered due to inconsistencies between the width of the modelled road and the related canyon.

6 Emissions

Emission inventories were compiled for each of the scenarios modelled, using CERC's EMIT[8] emissions inventory tool, version 3.6.

6.1 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.

6.1.1 Emission factors

Traffic emissions of NO_x, NO_2, PM_{10} and $PM_{2.5}$ were calculated from traffic flows using EFT v8.0.1 emission factors based on Euro vehicle emissions categories. This dataset includes speed-emissions data that are based COPERT 5[9] emission factrors. EFT v8.0.1 include exhaust, brake, tyre and road wear for PM_{10} and $PM_{2.5}$; resuspension emission factors were taken from a report produced by TRL Limited on behalf of Defra[10].

Note that there is large uncertainty surrounding the current emissions estimates of NO_x from all vehicle types, in particular diesel vehicles; refer to, for example, an AQEG report from 2007 [11] and a Defra report from 2011[12]. In order to address this discrepancy, the NO_x emission factors were modified based on published Remote Sensing Data (RSD)[13] for vehicle NO_x emissions in London. Scaling factors were applied to each vehicle category and speed.

6.1.2 Activity data

Traffic activity data were derived the Surrey Traffic Model, supplemented by Department for Transport (DfT) count data and local data from borough council detailed and further assessments. The split between these traffic data sources is illustrated in Figure 6.1.

[8] http://cerc.co.uk/environmental-software/EMIT-tool.html
[9]http://www.emisia.com/copert/General.html
[10] Road vehicle non-exhaust particulate matter: final report on emission modelling, TRL Limited Project Report PPR110 http://uk-air.defra.gov.uk/reports/cat15/0706061624_Report2__Emission_modelling.PDF
[11] Trends in primary nitrogen dioxide in the UK
[12] Trends in NO_x and NO_2 emissions and ambient measurements in the UK
[13] Carslaw, D and Rhys-Tyler, G 2013: New insights from comprehensive on-road measurements of NO_x, NO_2 and NH_3 from vehicle emission remote sensing in London, UK. *Atmos. Env.* **81** pp 339–347.

Surrey County Council provided AM peak, PM peak and inter-peak traffic flows and speeds, by vehicle type, from the Surrey Traffic Model for major roads across Elmbridge. The AM and PM peak flows were used to derive AADTs using conversion factors provided by Surrey County Council.

For each road, one of six conversion factors was applied depending on the type of road. Speeds used for the emission calculations for each road were derived by calculating a weighted average speeds, based on the flow of each vehicle throughout the day.

DfT provides traffic count data for the primary and strategic road network for the whole of the UK. Checking of traffic inputs during the model verification stage showed poor agreement between measured daily flows and the values derived from the Surrey Traffic Model on some motorways and major A roads. Therefore for the final emission calculations where DfT traffic counts were available, they were used in preference to values derived from the Surrey Traffic Model outputs.

6.1.3 Time-varying emissions

The variations of traffic flows during the day were taken into account by applying a diurnal profile to the road emissions. The profile was constructed by combining profiles derived from automatic traffic count (ATC) data for A25 Nutfield Road, provided by Surrey County Council, and average traffic distribution on all roads in Great Britain, as published by the DfT.[14] Averaging these two sets of profiles, generated a profile that was more consistent with the traffic flow conversion factors provided by Surrey County Council for all A & B roads in the county, leading to a greater confidence in the time-varying emissions profile used in the modelling. A comparison between the derived conversion factors for these profiles is shown in Table 6.1.

The calculated profile, shown in Figure 6.2, was applied to all modelled roads and grid sources, representing emissions aggregated on 1-km square basis, as described in Section 6.2.

Table 6.1: Comparison of traffic flow conversion factors for variation of traffic flows during the day

	Weekday to daily		**Weekday**					**AM & PM peak to AADT**
	12hr to 24hr	**24hr to 24hr**	**12hr to 24hr**	**AM peak to 24 hr**	**PM peak to 24 hr**	**AM peak spread**	**PM peak spread**	
DfT: UK roads	1.20	0.94	1.28	14.00	12.89	0.35	0.35	6.31
ATC – A25 Nutfiield Road	1.13	0.94	1.20	10.84	10.87	0.40	0.39	5.12
Diurnal profile used in model	1.16	0.94	1.24	12.22	12.69	0.38	0.36	5.66
Surrey CC: All A & B roads	1.16	0.92	1.26	12.83	12.07	0.36	0.36	5.73

[14] https://www.gov.uk/government/statistical-data-sets/road-traffic-statistics-tra

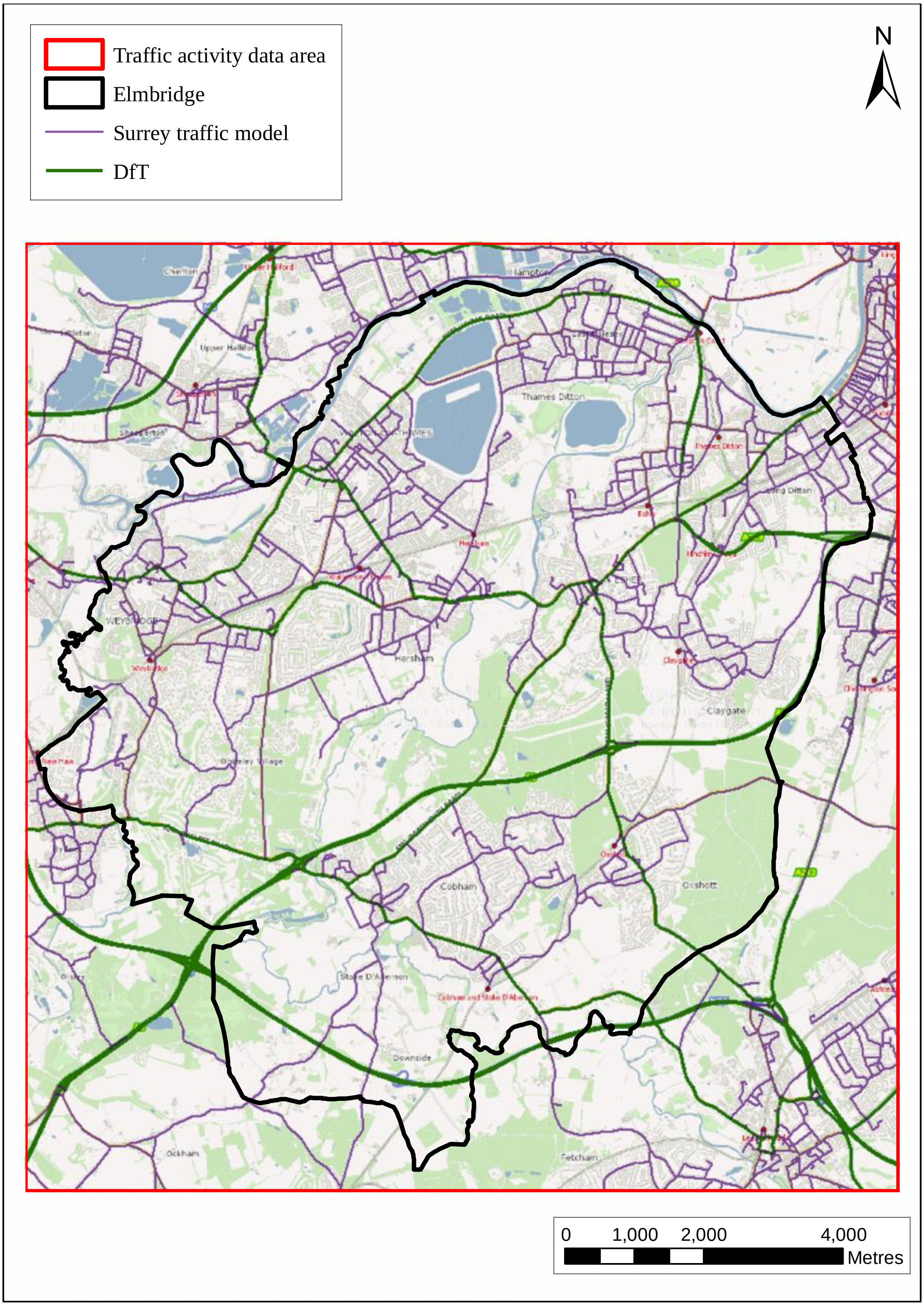

Figure 6.1: Traffic activity data split between Surrey traffic model output and DfT count statistics

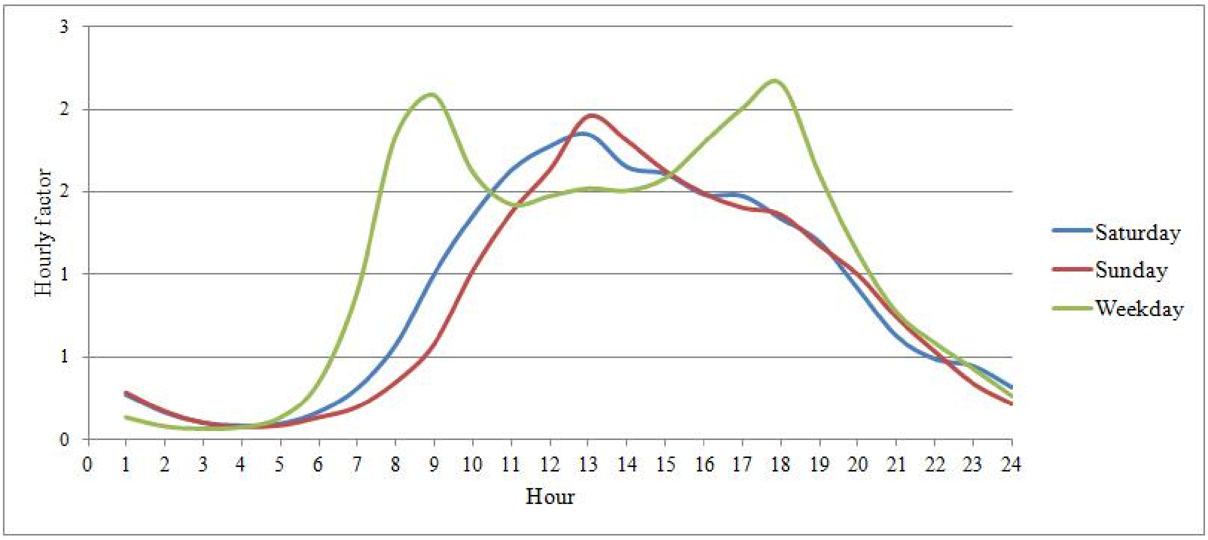

Figure 6.2: Diurnal emission factor profile used for road and grid sources

6.2 Other emissions

Emissions from other sources across the modelling domain were taken from the National Atmospheric Emissions Inventory (NAEI) 2015. Emissions from all other source types were modelled as an aggregated grid source with a resolution of 1 km.

7 Model verification

The first stage of a modelling assessment is to model a current case in order to verify that the input data and model set-up are appropriate for the area, by comparing measured and modelled concentrations for local monitoring locations. The monitor locations used for this purpose are described in Section 4. Concentrations were calculated at these monitoring locations for 2017.

The model verification involves an iterative process to improve the model set-up, for better agreement between measured and modelled concentrations. Table 7.1 summarises the main changes made to the model during the model verification process.

Table 7.1: Main changes to the model setup during the verification process

Verification version	Model changes
V1	AADT for all road links derived from Surrey Traffic model data. Automated calculation of street canyon parameters. Detailed checking and adjustment, where necessary, of the modelled distances between road sources and monitoring locations. Further manual changes to street canyons to ensure that monitoring locations were correctly located inside or outside of them.
V2	AADT changed for road links within the Elmbridge boundary, using DfT 2017 traffic counts.

Figure 7.1 and Table 7.2 present the monitored and modelled concentrations of NO_2 at the 40 diffusion tubes and two continuous monitoring sites operated in Elmbridge.

Modelled annual average NO_2 concentrations are within 25% of the monitored value at 30 of 42 locations (71%), showing generally good performance of the model set-up across Elmbridge.

The model has a greater tendency to underpredict than overpredict, with the only significant overprediction occurring within 80 metres of the M25; this is potentially caused by the model set-up not fully capturing the shielding impact of noise barriers and other noise abatement features along this road. Some of the highest monitored concentrations, typically representing busy junctions or congested roads, are underpredicted by the model. These underpredictions may be due to complex traffic characteristics, e.g. slow moving stop-start traffic, not being fully represented in the model inputs. This is likely to be the case at Esher 5, which is located on the roundabout leading to the Esher bypass. Further examples include Esher 1 and Esher 8, which are located on either side of Church Street.

Discrepancies between modelled and monitored concentrations also represent uncertainty in the monitored values. Diffusion tube measurements are less accurate than measurements from continuous monitors; therefore good model agreement at continuous monitor sites is typically a better indicator of performance than comparisons against diffusion tube measurements.

Overall the model set-up provides a level of agreement that gives confidence for Elmbridge model outputs.

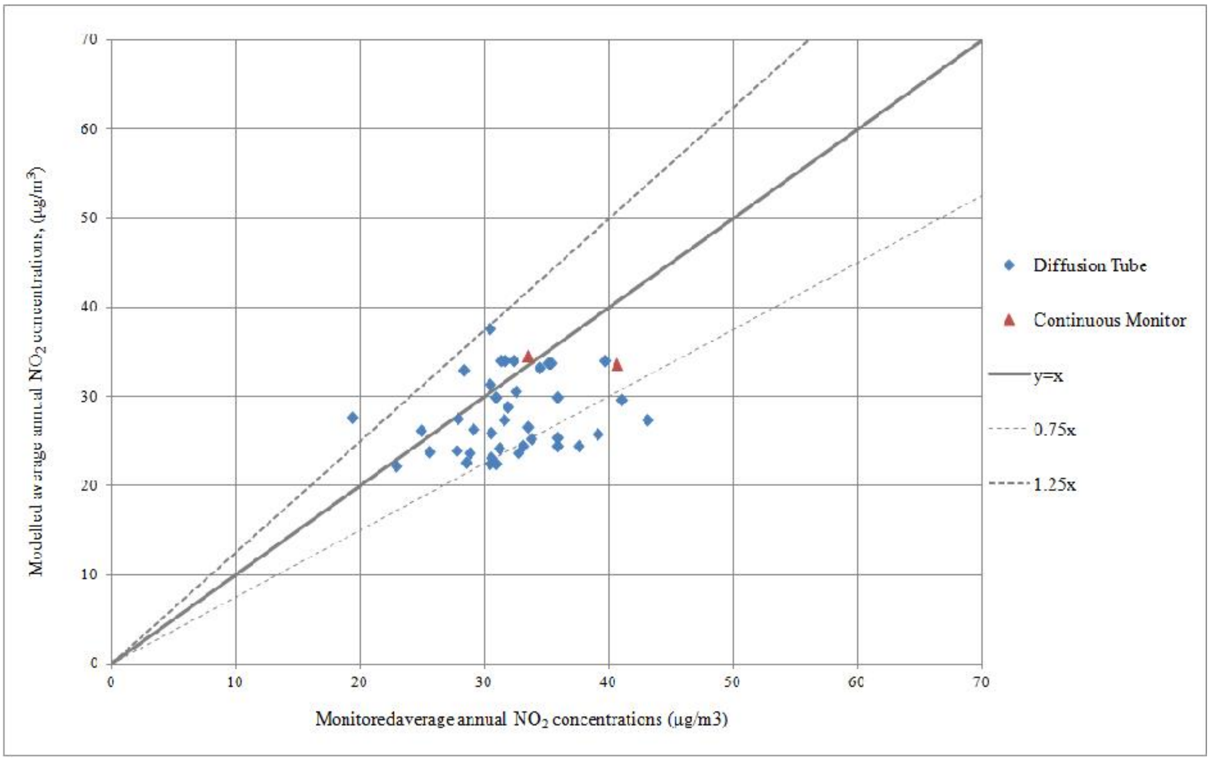

Figure 7.1: Measured and modelled annual average NO_2 concentrations at diffusion tubes and continuous monitors throughout Elmbridge, 2017 (µg/m³)

Table 7.2: Model verification, annual average NO_2, 2017. The ratio of monitored to modelled results is presented, with the blue-red scale representing model underprediction (blue) to overprediction (red)

Site ID	Concentration, µg/m³		Modelled / Monitored Ratio
	Monitored	**Modelled**	
Hampton Court Parade	40.6	33.7	83%
Weybridge High Street	33.5	34.5	103%
Cobham 1	30.4	31.3	103%
Cobham 6	24.9	26.1	105%
Cobham 7	32.5	30.5	94%
Downside 3	19.3	27.7	144%
Esher 1	37.5	24.4	65%
Esher 4	33.7	25.2	75%
Esher 5	43.1	27.4	64%
Esher 7	39.6	34.0	86%
Esher 8	39.1	25.8	66%
Esher 9	29.0	26.3	91%
Esher 10	28.8	23.7	82%
Esher 11	33.1	24.5	74%
Esher 13	31.9	28.9	91%
Hampton court 1	35.8	29.9	84%
Hampton court 2	35.2	33.8	96%
Hampton court 3	35.3	33.8	96%
Hampton court 4	35.1	33.8	96%
Hampton court 5	25.6	23.8	93%
Hinchley wood 1	35.8	24.4	68%
Hinchley wood 2	31.2	24.2	78%
Molesey 1	28.5	22.6	79%
Molesey 8	31.5	27.3	87%
Molesey 9	32.7	23.7	72%
Molesey 10	27.8	23.9	86%
Walton 3	30.4	22.5	74%
Walton 5	27.8	27.5	99%
Walton 8	30.9	22.5	73%
Walton 9	30.5	23.2	76%
Walton 10	33.5	26.6	79%
Walton 11	30.9	29.8	96%
Weybridge 1	30.4	37.6	124%
Weybridge 4	30.6	25.9	85%
Weybridge 5	34.4	33.2	97%
Weybridge 6	28.4	32.9	116%
Weybridge 7	41.0	29.6	72%
Weybridge 8	35.9	25.4	71%

Site ID	Concentration, µg/m³		Modelled / Monitored Ratio
	Monitored	Modelled	
Weybridge 9	22.9	22.2	97%
Weybridge 10	31.6	34.0	108%
Weybridge 11	31.2	34.0	109%
Weybridge 12	32.3	34.0	105%

Table 7.3: Model verification, annual average NO_x, 2017. The ratio of monitored to modelled results is presented, with the blue-red scale representing model underprediction (blue) to overprediction (red)

Site ID	Concentration, µg/m³		Modelled / Monitored Ratio
	Monitored	Modelled	
Hampton Court Parade	108.4	69.9	65%
Weybridge High Street	77.5	66.8	86%

8 2017 baseline: human health impacts

8.1 Concentration contours

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

Contour plots of pollutant concentrations were generated using a model output 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 are 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 objectives are shown in blue, green and yellow.

Figure 8.1 presents a contour plot of the modelled annual mean NO_2 concentrations across Elmbridge for 2017. Modelled concentrations show exceedences of the 40 µg/m³ annual mean NO_2 objective along the M25 and the A3. Modelled exceedences are seen at busy junctions such as Esher Green and High Street which falls within the Esher AQMA and Brooklands Road and Byfleet Road.

Figure 8.2 presents a contour plot of the modelled 99.79th percentile of hourly mean NO_2 concentrations across Elmbridge for 2017. Modelled concentrations show exceedences of the 200 µg/m³ objective concentration along the M25, as well as stretches of other busy roads. There are no exceedences at any locations of relevant exposure across Elmbridge.

Figure 8.3 presents a contour plot of the modelled annual mean PM_{10} concentrations across Elmbridge for 2017. There are no exceedences of the 40 µg/m³ annual mean PM_{10} objective outside the footprint of modelled roads.

Figure 8.4 presents a contour plot of the modelled 90.41st 24-hourly mean PM_{10} concentrations across Elmbridge for 2017. Modelled concentrations show exceedences of the 50 µg/m³ objective along motorways and busy A roads.

Figure 8.5 presents a contour plot of the modelled annual mean $PM_{2.5}$ concentrations across Elmbridge for 2017. Modelled concentrations show no exceedences of the 25 µg/m³ objective.

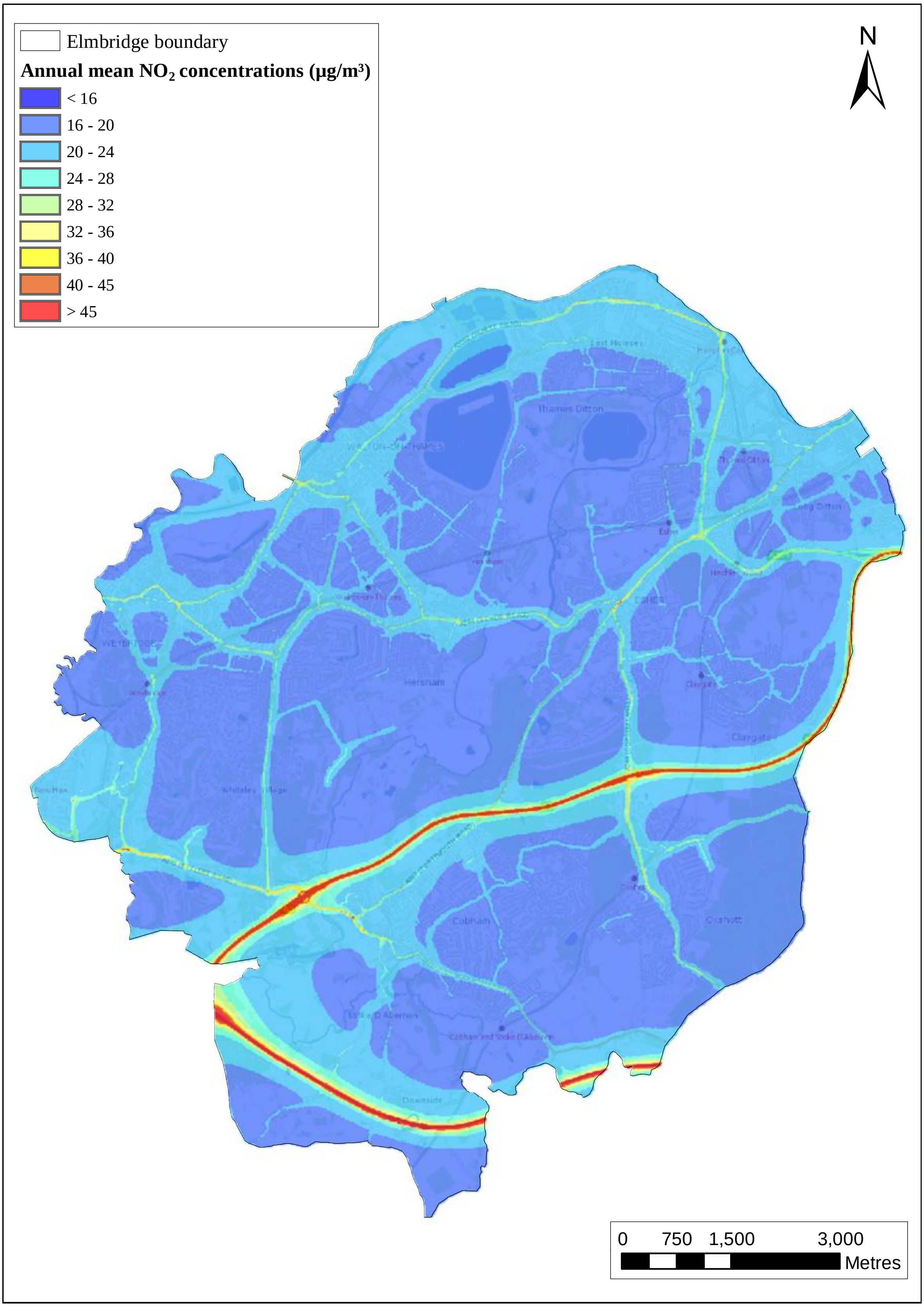

Figure 8.1: Annual mean NO_2 concentrations for Elmbridge, 2017 (µg/m³)

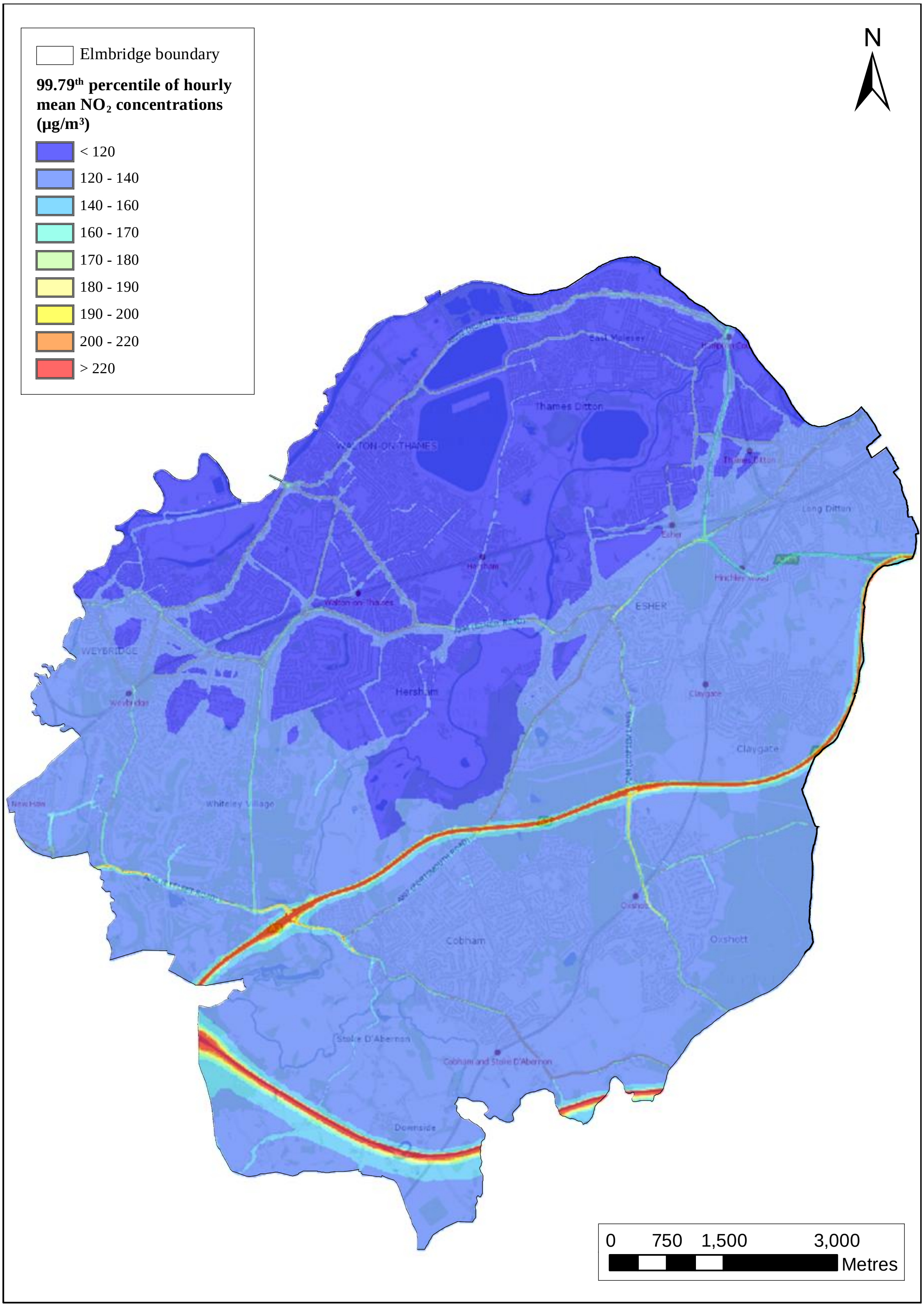

Figure 8.2: 99.79^th^ percentile of hourly mean NO_2 concentrations for Elmbridge, 2017 (µg/m³)

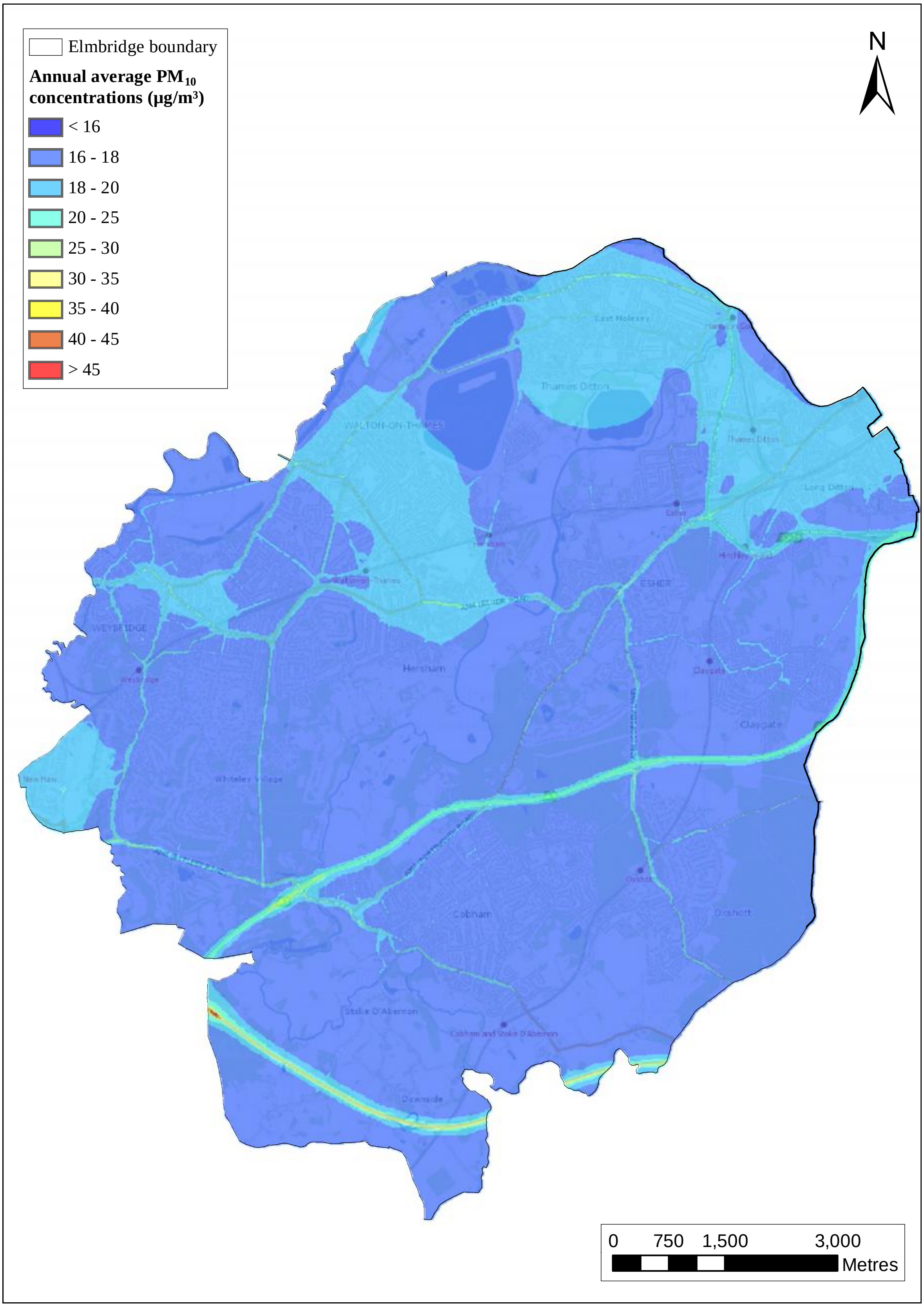

Figure 8.3: Annual mean PM_{10} concentrations for Elmbridge, 2017 ($\mu g/m^3$)

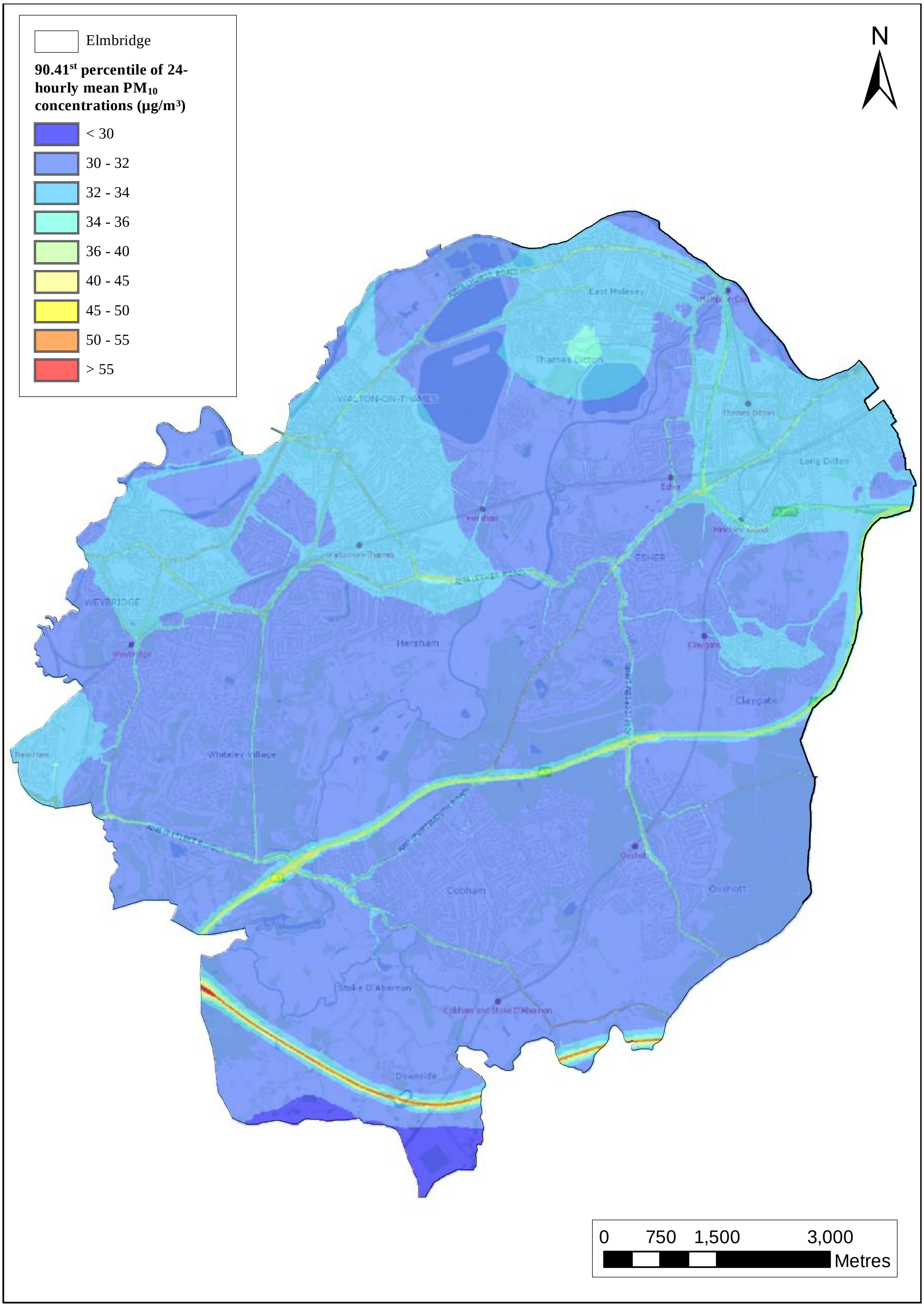

Figure 8.4: 90.41st percentile of 24-hourly mean PM_{10} concentrations for Elmbridge, 2017 (µg/m³)

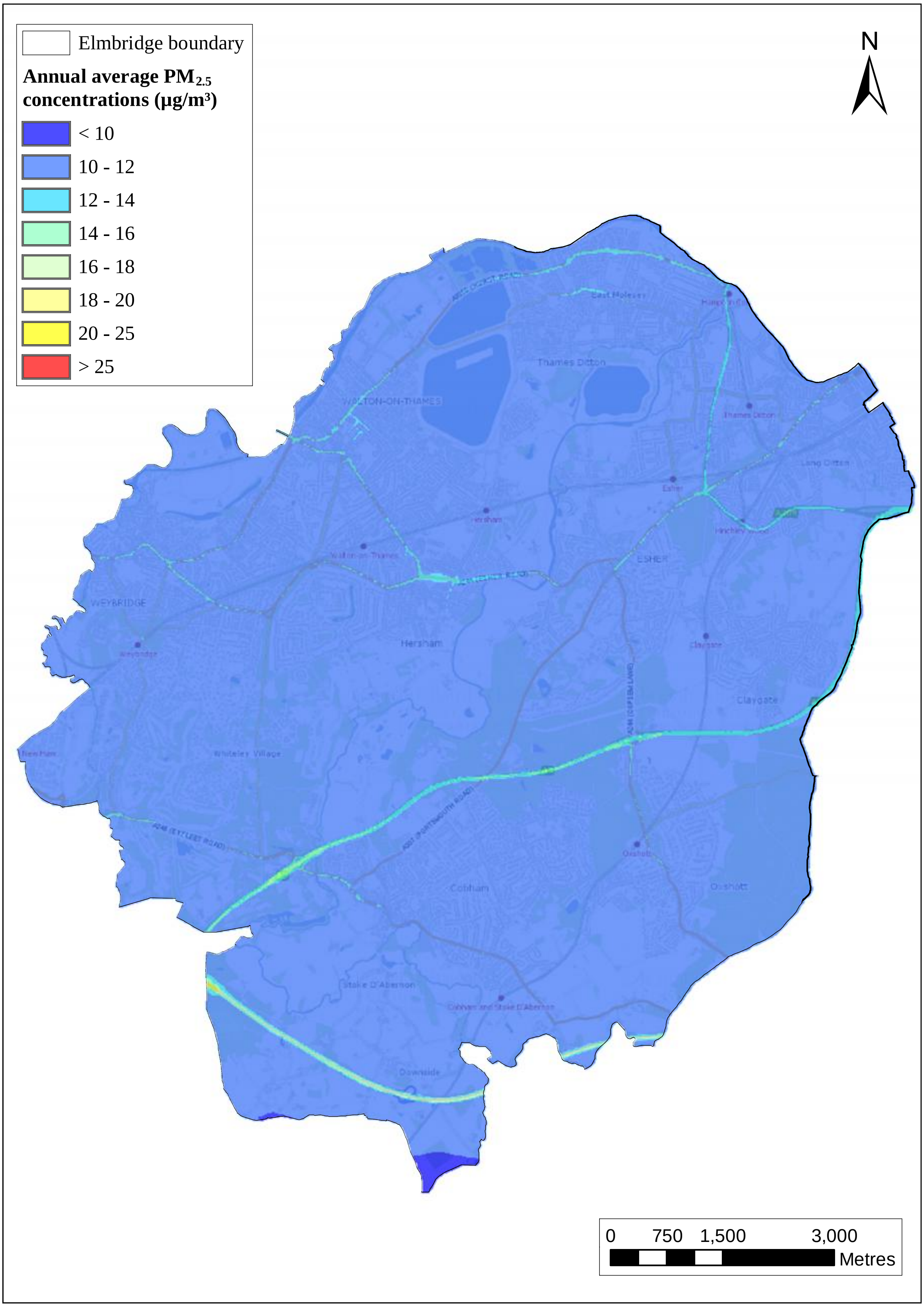

Figure 8.5: Annual mean $PM_{2.5}$ concentrations for Elmbridge, 2017 (µg/m³)

8.2 Health receptors

The following tables present the modelled baseline concentrations of NO_2, PM_{10} and $PM_{2.5}$:

- Table 8.1 at health centres throughout Elmbridge.
- Table 8.2 at private surgeries throughout Elmbridge
- Table 8.3 at dental surgeries throughout Elmbridge.
- Table 8.4 at hospitals throughout Elmbridge.
- Table 8.5 at state schools throughout Elmbridge.

Table 8.1: Modelled baseline NO_2, PM_{10} and $PM_{2.5}$ concentrations at health centres throughout Elmbridge (µg/m³)

Receptor name	Location x,y	Road name	Postcode	Practice name	NO_2 (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)
Health_1	513541, 165342	Esher Green Drive	KT10 8BX	Esher Green Surgery	19.5	17.3	10.8
Health_2	511039, 165832	Rodney Road	KT12 3LB	The Health Centre	19.6	18.0	11.4
Health_3	511497, 163998	Pleasant Place	KT12 4HT	Hersham Surgery	19.9	17.8	11.2
Health_4	510582, 165620	Hersham Road	KT12 1UX	The Fort House Surgery	20.2	17.9	11.3
Health_5	510512, 165817	Crutchfield Lane	KT12 2QY	Ashley Medical Centre	21.5	18.3	11.6
Health_6	516522, 166412	Thorkhill Road	KT7 0UW	Thorkhill Surgery	20.0	18.1	11.5
Health_7	514391, 160725	Holtwood Road	KT22 0QL	N/A	20.0	17.2	10.6
Health_8	515719, 165276	Station Approach	KT10 0SP	N/A	20.7	17.8	11.1
Health_9	515740, 163804	Elm Road	KT10 0EH	Capelfield Surgery	19.1	17.5	11.0
Health_10	513902, 164588	Esher Park Avenue	KT10 9NY	Littleton Surgery	23.2	18.0	11.2
Health_11	514363, 168435	Pemberton Road	KT8 9LJ	Vine Medical Centre	21.7	18.4	11.7
Health_12	514331, 167762	Molesey Park Road	KT8 0JX	Glenlyn Medical Centre	19.4	17.9	11.2
Health_13	515954, 166579	Raphael Drive	KT7 0EB	Giggs Hill Surgery	19.7	17.9	11.3

Table 8.2: Modelled baseline NO_2, PM_{10} and $PM_{2.5}$ concentrations at private surgeries throughout Elmbridge (µg/m³)

Receptor name	Location x,y	Road name	Postcode	Practice name	NO_2 (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)
Surgery_1	509543, 162710	North Avenue	KT12 4EJ	N/A	18.8	16.8	10.3
Surgery_2	515598, 165266	Station Approach	KT10 0SR	Hinchley Wood Practice	22.5	18.3	11.4
Surgery_3	515309, 163481	Foley Road	KT10 0NA	N/A	19.2	17.5	11.0
Surgery_4	514351, 164049	Milbourne Lane	KT10 9ED	N/A	22.9	17.5	10.8
Surgery_5	512114, 160877	Fairmile Lane	KT11 2DA	N/A	19.8	17.2	10.7

Table 8.3: Modelled baseline NO_2, PM_{10} and $PM_{2.5}$ concentrations at dental surgeries throughout Elmbridge (µg/m³)

Receptor name	Location x,y	Road name	Postcode	Practice name	NO_2 (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)
Dentist_1	508361, 164293	Queens Road	KT13 9UT	N/A	28.2	19.2	12.0
Dentist_2	508719, 164946	Oatlands Drive	KT13 9LB	Preventative Dental Practice	20.9	17.8	11.2
Dentist_3	507541, 165144	Dorchester Road	KT13 8PE	N/A	20.3	17.7	11.1
Dentist_4	507729, 164842	Monument Hill	KT13 8RN	Portmore Dental Practice	28.1	19.0	11.8
Dentist_5	511903, 164827	Molesey Road	KT12 4QY	N/A	21.0	18.1	11.5
Dentist_6	510739, 165460	Hersham Road	KT12 1LL	N/A	21.9	18.2	11.4
Dentist_7	511510, 164095	The green	KT12 4HW	N/A	20.0	18.0	11.4
Dentist_8	510184, 165926	Ashley Road	KT12 1JB	N/A	22.2	18.2	11.5
Dentist_9	510173, 165983	Ashley Road	KT12 1HS	N/A	20.2	18.0	11.4
Dentist_10	515890, 167090	Ashley Road	KT7 0NH	N/A	20.1	17.8	11.2
Dentist_11	513962, 160433	Steels Lane	KT22 0RD	N/A	21.4	17.5	10.8
Dentist_12	515293, 163737	Hare Lane	KT10 0QY	Hare Lane Dental Surgery	19.5	17.5	11.0
Dentist_13	515210, 163586	Albany Crescent	KT10 0PF	N/A	19.1	17.4	10.9
Dentist_14	514175, 164950	Portsmouth Road	KT10 9PJ	Fairoak Dental Surgery	25.1	18.3	11.3
Dentist_15	515747, 165300	Manor Road North	KT10 0AA	N/A	20.7	17.8	11.1
Dentist_16	510719, 160050	Hollyhedge Road	KT11 3DG	Lloyds Dental Surgery	22.6	17.7	10.9
Dentist_17	510811, 159844	Church Street	KT11 3EG	Beech House Dental Surgery	22.8	17.6	10.8
Dentist_18	510834, 160316	Anyards Road	KT11 2LA	N/A	20.9	17.5	10.9

Receptor name	Location x,y	Road name	Postcode	Practice name	NO_2 (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)
Dentist_19	510850, 159935	High Street	KT11 3EB	N/A	29.0	18.7	11.5
Dentist_20	516558, 166178	Sugden Road	KT7 0AB	N/A	20.7	18.1	11.4
Dentist_21	510749, 165452	Hersham Road	KT12 1LL	N/A	20.9	18.1	11.4
Dentist_22	510926, 165463	Sidney Road	KT12 3SD	N/A	20.3	18.0	11.3
Dentist_23	507453, 164909	High Street	KT13 8AB	N/A	21.8	18.0	11.2
Dentist_24	511650, 165752	Walton Park	KT12 3ET	N/A	20.0	18.0	11.4
Dentist_25	515978, 166955	Station Road	KT7 0NR	N/A	21.6	18.0	11.3
Dentist_26	514522, 168057	Spencer Road	KT8 0SP	N/A	20.3	18.0	11.3
Dentist_27	514224, 168083	Seymour Road	KT8 0PF	N/A	20.1	18.2	11.4

Table 8.4: Modelled baseline NO_2, PM_{10} and $PM_{2.5}$ concentrations at hospitals throughout Elmbridge (µg/m³)

Receptor name	Location x,y	Road name	Postcode	Practice name	NO_2 (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)
Hospital_1	511011, 165743	Rodney Road	KT12 3LD	Walton Community Hospital	19.7	18.0	11.4
Hospital_2	507232, 164935	Church Street	KT13 8DY	Weybridge Community Hospital	20.5	17.6	11.0
Hospital_3	513311, 167756	High Street	KT8 2LU	Molesey Hospital	19.5	18.4	11.3
Hospital_4	510986, 160712	Portsmouth Road	KT11	Cobham Community Hospital	20.8	17.5	10.9

Table 8.5: Modelled baseline NO_2, PM_{10} and $PM_{2.5}$ concentrations at state schools throughout Elmbridge (µg/m³)

Receptor name	Location x,y	Road name	Postcode	School name	NO_2 (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)
School_1	511934, 164835	174 Molesey Road, Walton-On-Thames	KT12 4QY	North East Surrey Short Stay School	20.1	18.0	11.4
School_2	514840, 167995	Bridge Road, East Molesey	KT8 9HT	The Orchard School	20.2	17.8	11.2
School_3	514375, 160345	Oakshade Road, Oxshott	KT22 0LE	The Royal Kent C of E Primary School	18.9	17.0	10.5
School_4	510160, 166139	Ashley Road, Walton-on-Thames	KT12 1HX	Ashley C Of E (A) Primary School	20.6	18.1	11.5
School_5	511415, 164878	Hersham Road, Walton-on-Thames	KT12 5NB	Bell Farm Junior School	20.2	18.3	11.7
School_6	511925, 165162	Arch Road, Walton-on-Thames	KT12 4QT	Cardinal Newman Catholic Primary School	19.5	17.8	11.3
School_7	513490, 167952	High Street, West Molesey	KT8 2LX	Chandlers Field Primary School	19.6	18.5	11.5
School_8	515457, 163406	Foley Road, Claygate	KT10 0NB	Claygate Primary School	19.1	17.6	11.0
School_9	509608, 164782	Oatlands Avenue, Weybridge	KT13 9TS	Cleves School	19.7	17.4	10.9
School_10	513882, 165899	The Drive, Esher	KT10 8DJ	Cranmere Primary School	19.2	17.2	10.7
School_11	514158, 164110	Milbourne Lane, Esher	KT10 9DU	Esher C Of E (Aided) Primary School	19.8	17.2	10.7
School_12	516298, 165666	Claygate Lane, Esher	KT10 0AQ	Hinchley Wood Primary School	20.0	17.7	11.1
School_13	512787, 168582	Hurst Road, West Molesey	KT8 1QW	Hurst Park Primary School	22.9	18.5	11.6
School_14	516905, 166356	Sugden Road, Thames Ditton	KT7 0AD	Long Ditton St Mary's C Of E (Aided) Junior School	20.2	18.0	11.4
School_15	514045, 167836	Beauchamp Road, West Molesey	KT8 2PG	St Albans Catholic Primary School	19.5	18.1	11.3
School_16	511329, 160719	Lockhart Road, Cobham	KT11 2AX	St Andrews C of E Primary School	19.9	17.3	10.8
School_17	507290, 165046	Portmore Way, Weybridge	KT13 8JD	St Charles Borromeo Catholic Primary School	20.3	17.6	11.0
School_18	508081, 165139	Grotto Road, Weybridge	KT13 8PL	St James C Of E Primary School	19.8	17.6	11.0
School_19	514495, 168475	Church Road, East Molesey	KT8 9DR	St Lawrence C Of E (A) Junior School	20.4	18.2	11.6

Receptor name	Location x,y	Road name	Postcode	School name	NO_2 (µg/m³)	PM_{10} (µg/m³)	$PM_{2.5}$ (µg/m³)
School_20	515140, 166919	Hampton Court Way, Thames Ditton	KT7 0LP	St Paul's Catholic Primary School	20.1	17.8	11.2
School_21	515881, 166666	Mercer Close, Thames Ditton	KT7 0BS	Thames Ditton Junior School	19.7	17.9	11.3
School_22	510765, 158070	Downside, Cobham	KT11 3NA	St Mathews Ce (A) Infant School	21.7	16.9	10.2
School_23	517193, 166283	Ditton Hill Road, Surbiton	KT6 5JB	Long Ditton Infant And Nursery School	20.0	17.8	11.2
School_24	508028, 164494	Princes Road, Weybridge	KT13 9DA	Manby Lodge Infant School	20.6	17.9	11.3
School_25	508831, 164766	St. Marys Road, Weybridge	KT13 9PZ	Oatlands Infant School	20.2	17.7	11.1
School_26	511610, 163975	Pleasant Place, Walton-on-Thames	KT12 4HR	Burhill Community Infant School	19.4	17.6	11.1
School_27	511474, 166140	Ambleside Avenue, Walton-on-Thames	KT12 3LN	Walton Oak School	19.4	18.0	11.4
School_28	510952, 167344	Terrace Road, Walton-on-Thames	KT12 2EB	Grovelands School	21.6	18.0	11.3
School_29	515793, 167143	Speer Road, Thames Ditton	KT7 0NW	Thames Ditton Infant School	20.0	17.8	11.2
School_30	513465, 165247	More Lane, Esher	KT10 8AP	Esher Church Of England High School	19.4	17.3	10.8
School_31	506924, 164011	Brooklands Lane, Weybridge	KT13 8UZ	Heathside School	19.2	17.1	10.6
School_32	511443, 165018	Hersham Road, Hersham, Walton-on-Thames	KT12 5PY	Rydens School	20.0	18.3	11.6
School_33	516218, 165773	Claygate Lane, Esher	KT10 0AQ	Hinchley Wood School & Sixth Form Centre	20.0	17.8	11.2
School_34	509534, 164546	Queens Road, Walton-on-Thames	KT12 5AB	Walton Leigh School	19.9	17.4	10.9
School_35	510526, 160549	89-95 Portsmouth Road, Cobham	KT11 1JJ	Cobham Free School	23.9	18.1	11.3

8.3 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 is assessed using the approach set out in Appendix A of the Public Health England guidance *Estimating local mortality burdens associated with particulate air pollution (April 2014)*[15]. This guidance uses concentration response functions (CRFs) which relate the increased risk of mortality to a given change in pollutant concentrations; specifically, it assumes that an increment of 10 µg/m³ in the annual concentration of $PM_{2.5}$ will increase the mortality risk by 6%.

The mortality burden of air quality will actually be a consequence of exposure to both NO_2 and $PM_{2.5}$. The 2018 COMEAP report *Associations of long-term average concentrations of nitrogen dioxide with mortality*[16] recommends revised CRFs for anthropogenic $PM_{2.5}$ and NO_2 which are adjusted from the single-pollutant CRFs to avoid double counting air quality effects from different pollutants. The report recommends using pairs of CRFs for $PM_{2.5}$ and NO_2 taken from four studies, as shown in Table 8.6 with the results from the two pollutants added for each study.

Table 8.6: Coefficients for use in burden calculations

Pollutant	Unadjusted coefficient	Jerrett et al (2013)	Fischer et al (2015)	Beelen et al (2014)	Crouse et al (2015)
NO_2	1.023	1.019	1.016	1.011	1.020
$PM_{2.5}$	1.06	1.029	1.033	1.053	1.019

Mortality burdens calculations were carried out for Lower Layer Super Output Areas (LSOAs), each representing an area with a population of approximately 1,500. The Office for National Statistics (ONS) publishes population[17] and death[18] data split by age for each LSOA.

For each LSOA, the relative risk for each pollutant is calculated as

$$RR(c) = R^{c/10}$$

where *R* is the relative risk, as given in Table 8.6, and *c* is the average pollutant concentration for that LSOA calculated from the concentration contour maps, presented in Section 8.

[15]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/332854/PHE_CRCE_010.pdf

[16] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/734799/COMEAP_NO2_Report.pdf

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

[18] https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/adhocs/009235numberofdeathsregisteredineachlowersuperoutputareabysexandagedeathsregisteredin2017

The attributable fraction is then calculated as

$$AF = (RR-1)/RR$$

The number of attributable deaths in each LSOA was then calculated by multiplying the attributable fraction by the number of deaths over 30 years of age. The total number of attributable deaths for Elmbridge is the sum of the attributable deaths in each LSOA.

The total loss in life-years due to air pollution for each LSOA was calculated by multiplying the attributable deaths for each 5-year age band by the corresponding expected life expectancy for each age group. The life expectancy data are taken from the Public Health England Life Expectancy Calculator[19], which uses ONS population and deaths data as input.

The economic cost is calculated by multiplying the life-years lost by a value for a life year lost. The recommended value in the Defra guidance[20] of £42,780 at 2017 prices was used.

The mortality burdens provided in this report, were then calculated by aggregating the results for all LSOAs within Elmbridge. All reported values are rounded to whole numbers. Ward level results are reported separately, for which the LSOAs results were aggregated by ward using ONS best fit lookup[21].

Table 8.7 presents a mortality burden associated with NO_2 and $PM_{2.5}$ concentrations by ward, across Elmbridge.

The range of values given for attributable deaths, life years lost and economic cost for each pollutant were derived from the minimum and maximum values for each of the individual pollutants across the four studies.

Total life years lost and total economic cost were derived from the combination of pollutants within each study.

[19] https://fingertips.phe.org.uk/.../PHE%20Life%20Expectancy%20Calculator.xlsm

[20] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/770649/impact-pathway-approach-guidance.pdf

[21] http://geoportal.statistics.gov.uk/datasets/lower-layer-super-output-area-2011-to-ward-2018-lookup-in-england-and-wales-v3

Table 8.7: Summary of attributable deaths, life years lost and economic cost resulting from NO_2 and $PM_{2.5}$ concentrations by Elmbridge wards

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	16-28	0.67-1.20	1-2	12-33	0.53-1.43	40-49	1.73-2.10
E05011075	Cobham and Downside	2-3	20-36	0.87-1.55	1-4	15-40	0.63-1.69	51-60	2.18-2.56
E05011076	Esher	2-3	20-36	0.86-1.54	1-3	16-43	0.68-1.84	52-63	2.22-2.69
E05011077	Hersham Village	1-2	15-27	0.65-1.16	1-3	13-34	0.54-1.45	40-49	1.70-2.10
E05011078	Hinchley Wood and Weston Green	1-1	10-18	0.42-0.75	1-2	8-21	0.33-0.91	25-31	1.09-1.32
E05011079	Long Ditton	1-2	14-26	0.62-1.11	1-2	12-31	0.50-1.34	38-46	1.61-1.96
E05011080	Molesey East	2-3	20-36	0.86-1.55	1-3	16-44	0.7-1.89	53-64	2.25-2.75
E05011081	Molesey West	2-3	25-44	1.06-1.90	2-4	21-55	0.88-2.37	65-80	2.78-3.43
E05011082	Oatlands and Burwood Park	1-3	16-29	0.70-1.25	1-3	13-35	0.56-1.52	42-52	1.82-2.22
E05011083	Oxshott and Stoke D'Abernon	1-3	16-29	0.68-1.22	1-3	12-32	0.51-1.39	41-48	1.74-2.07
E05011084	Thames Ditton	2-3	19-35	0.82-1.48	1-4	16-42	0.66-1.80	50-61	2.14-2.62
E05011085	Walton Central	1-2	14-26	0.62-1.11	1-2	12-32	0.50-1.35	38-46	1.61-1.97
E05011086	Walton North	1-2	16-29	0.69-1.25	1-2	14-37	0.58-1.56	43-53	1.82-2.26
E05011087	Walton South	2-3	22-39	0.92-1.65	2-4	18-49	0.77-2.08	57-70	2.42-3.00
E05011088	Weybridge Riverside	1-2	16-28	0.68-1.22	1-3	12-34	0.53-1.44	41-49	1.75-2.11
E05011089	Weybridge St George's Hill	3-5	29-52	1.23-2.20	2-6	22-59	0.93-2.51	73-87	3.13-3.74

9 2017 baseline: sensitive habitat impacts

9.1 Critical levels

Contour plots of annual average NO_x concentration were generated using a 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 roadside. 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 9.1 presents a contour plot of the modelled annual average NO_x concentration across the South West London Waterbodies SPA for 2017. Modelled concentrations show exceedences of the 30 µg/m³ NO_x critical level across the entirety of the SPA. The greatest exceedences are found where the SPA boundary meets Hurst Road.

Figure 9.2 presents a contour plot of the modelled annual average NO_x concentrations across the Thames Basin Heaths SPA for 2017. Modelled concentrations show exceedences of the 30 µg/m³ NO_x critical level across the majority of the SPA. NO_x concentrations below the critical level occur away from major roads.

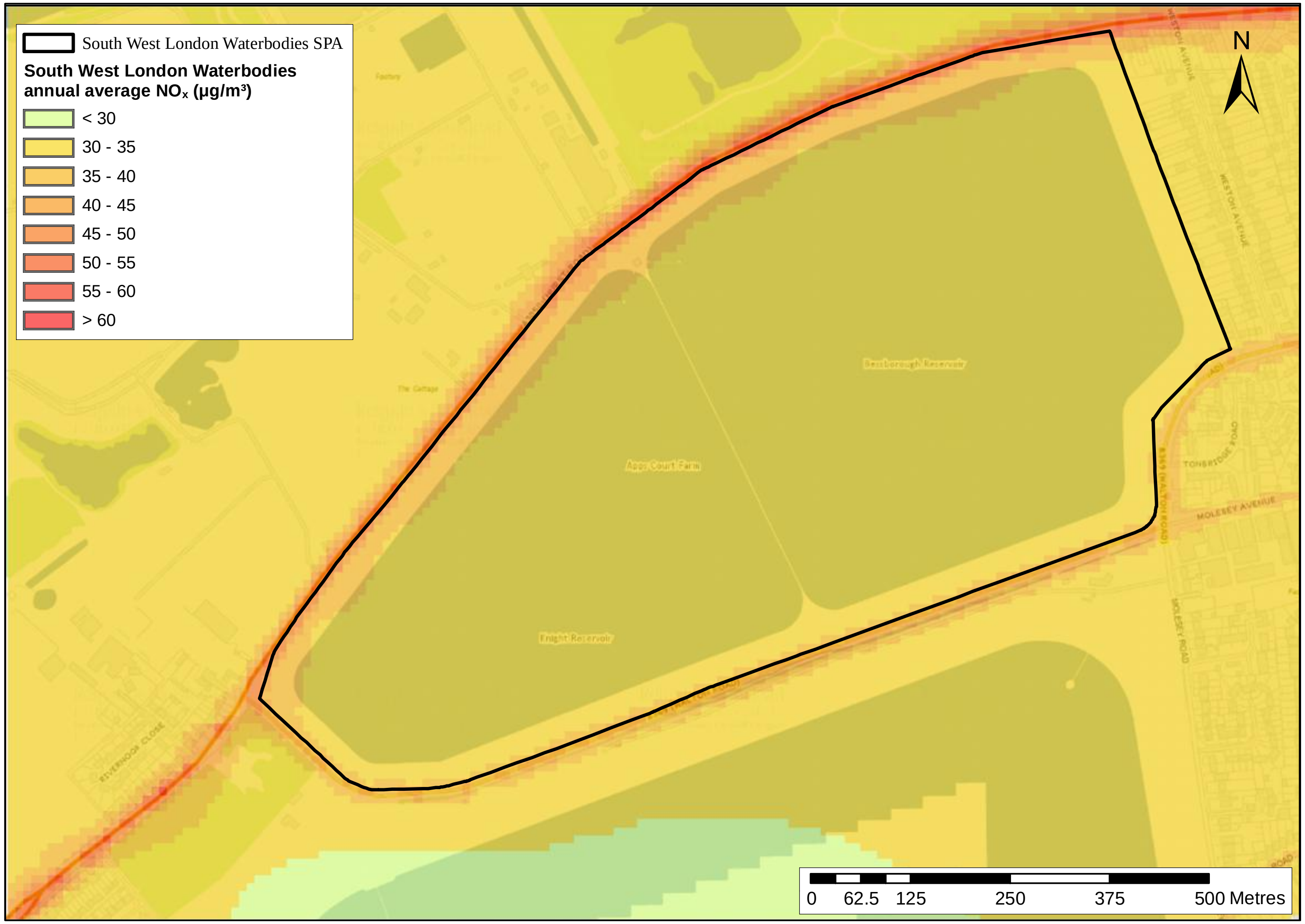

Figure 9.1: Annual average NO_x concentration across the South West London Waterbodies SPA within Elmbridge

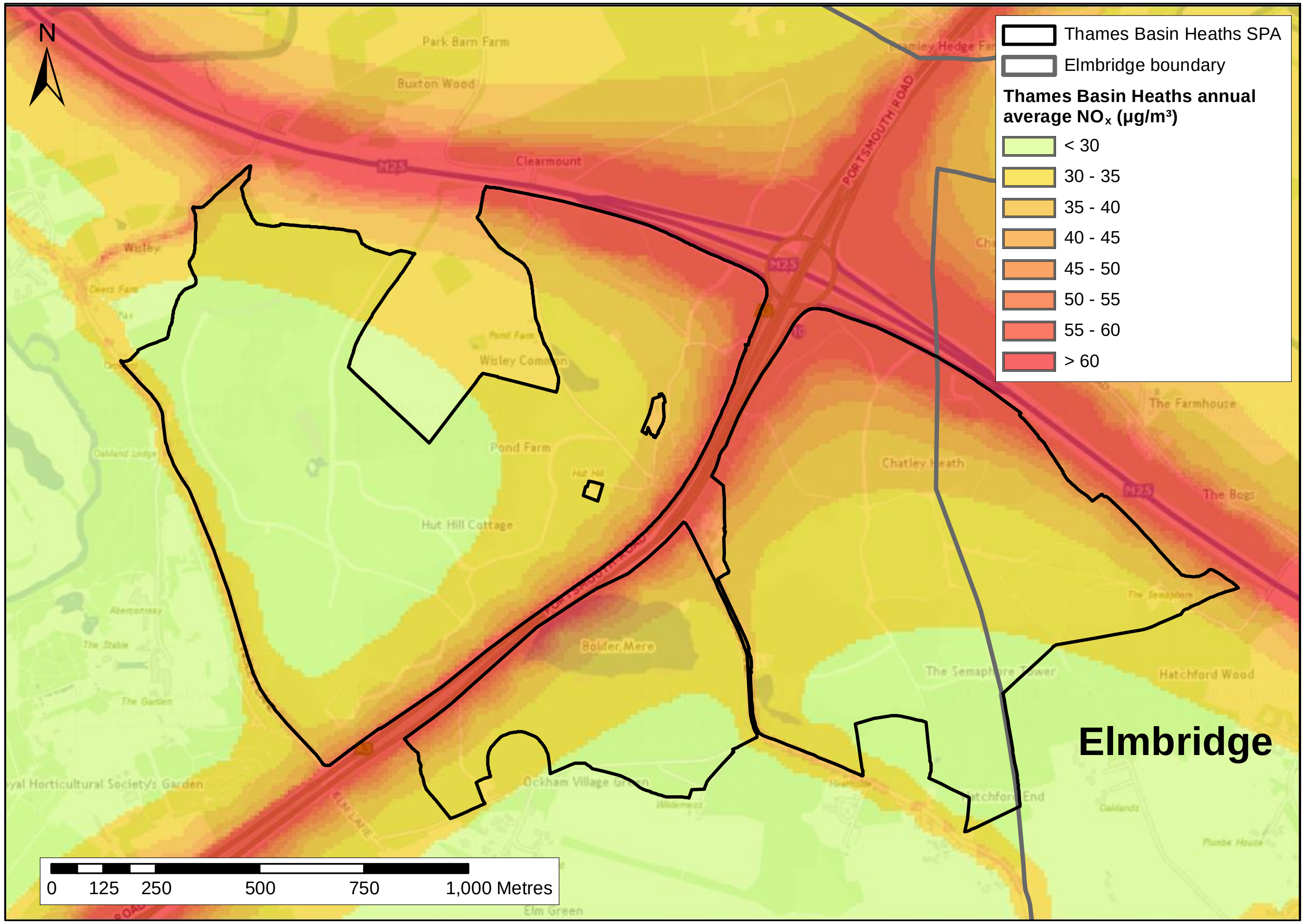

Figure 9.2: Annual average NO_x concentrations across the Thames Basin Heaths SPA within Elmbridge

10 Discussion

Air quality modelling was carried out for NO_2, PM_{10} and $PM_{2.5}$ using ADMS-Urban (version 4.2) to assess air quality throughout Elmbridge for the 2017 baseline.

Model verification was carried out to ensure a suitable model set-up for detailed modelling; this was done by comparing modelled concentrations with measured data from diffusion tubes and continuous monitors at a variety of site types throughout Elmbridge. The model verification shows a generally good performance of the model set-up across Elmbridge, with modelled annual average NO_2 concentrations falling within 25% of the monitored values at 71% of the locations.

10.1 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 the 2017 baseline, with exception of some locations close to major roads, the air quality objectives are met throughout the borough. There are modelled exceedences of the annual mean NO_2 objective of 40 µg/m^3 along the M25 and other busy roads. Exceedences of short-term NO_2 and PM_{10} objectives are less extensive. The annual mean $PM_{2.5}$ objective of 25 µg/m^3 is met throughout the borough.

There are no exceedences for NO_2, PM_{10} or $PM_{2.5}$ at health centres, private surgeries, dental surgeries, hospitals or state schools throughout Elmbridge.

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 a range of 747 and 909 life-years lost, which equates to an economic cost of between £32 million and £39 million in 2017.

10.2 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.

The model-predicted annual average NO_x concentrations exceed this critical level right across the South West London Waterbodies SPA, with higher concentrations found along the SPA perimeter, closer to the modelled roads.

Within the Thames Basin Heaths SPA, the close proximity of the M25 and A3 result in model-predicted annual average NO_x concentrations exceeding the critical level across the majority of this SPA. Concentrations below the critical level are found towards the centre of the SPA and at the boundaries away from major roads.

APPENDIX A: Summary of ADMS-Urban

ADMS-Urban is a practical air pollution modelling tool, which has been developed to provide detailed predictions of pollution concentrations for all sizes of study area. 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 has been extensively used for the Review and Assessment of Air Quality carried out by Local Authorities in the UK. The following is a summary of the capabilities and validation of ADMS-Urban. More details can be found on the CERC web site at www.cerc.co.uk.

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 boasts 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; and
- the effects of a building on the dispersion of pollutants emitted nearby.

More details of these features are given 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 has been designed to operate in the widely familiar PC environment, under Microsoft Windows. The manipulation of data is further facilitated by the possible integration of ADMS-Urban with a Geographical Information System (GIS) such as MapInfo or ArcGIS, and with the CERC Emissions Inventory Toolkit, EMIT.

Dispersion Modelling

ADMS-Urban uses boundary layer similarity profiles 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 ground. This has significant advantages over earlier methods in which the dispersion parameters did not vary with height within the boundary layer.

In stable and neutral conditions, dispersion is represented by a Gaussian distribution. In convective conditions, the vertical distribution takes account of the skewed structure of the vertical component of turbulence. This is necessary to reflect the fact that, under convective conditions, rising air is typically of limited spatial extent but is balanced by descending air extending over a much larger area. This leads to higher ground-level concentrations than would be given by a simple Gaussian representation.

Emissions

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

- **Industrial points**, for which plume rise and stack downwash are included in the modelling.
- **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.
- **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

For most situations ADMS-Urban is used to model the fate of emissions for a large number of different meteorological conditions. Typically, meteorological data are input for every hour during a year or for a set of conditions representing all those occurring at a given location. ADMS-Urban uses these individual results to calculate statistics for the whole data set. These are usually average values, including rolling averages, percentiles and the number of hours for which specified concentration thresholds are exceeded. 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 can be integrated with the ArcGIS or MapInfo GIS to facilitate 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.

Complex Effects - Street Canyons

ADMS-Urban includes two options for modelling the effects of street canyons:
1. The *basic* street canyon option uses the *Operational Street Pollution Model (OSPM)*[22], developed by the Danish National Environmental Research Institute (NERI). The OSPM uses a simplified flow and dispersion model to simulate the effects of the vortex that occurs within street canyons when the wind-flow above the buildings has a component perpendicular to the direction of the street. The model takes account of vehicle-induced turbulence. The model has been validated against Danish and Norwegian data.
2. The *advanced* street canyon option modifies 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. It differs from the basic canyon option in the following ways:
(i) It can consider a wide range of canyon geometries, including tall canyons and asymmetric canyons;
(ii) The modelled concentrations vary with height within the canyon;
(iii) Emissions can be restricted only to the carriageway with no emissions on pedestrian areas; and
(iv) Concentrations both inside and outside a particular street canyon are affected.

Complex Effects - Chemistry

ADMS-Urban includes the *Generic Reaction Set (GRS)*[23] atmospheric chemistry scheme. The original scheme has seven reactions, including those occurring between nitrogen oxides and ozone. The remaining reactions are 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.

In addition to the basic GRS scheme, ADMS-Urban also includes a trajectory model[24] 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.

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[22] 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.
[23] 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.
[24] 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.

Complex Effects – Terrain and Roughness

Complex terrain can have a significant impact on wind-flow and consequently on the fate of dispersing material. Primarily, terrain can deflect the wind and therefore change the route taken by dispersing material. Terrain can also increase the levels of turbulence in the atmosphere, resulting in increased dilution of material. This is of particular significance during stable conditions, under which a sharp change with height can exist between flows deflected over hills and those deflected around hills or through valleys. The height of dispersing material is therefore important in determining the route it takes. In addition, areas of reverse flow, similar in form and effect to those occurring adjacent to buildings, can occur on the downwind side of a hill. Changes in the surface roughness can also change the vertical structure of the boundary layer, affecting both the mean wind and levels of turbulence.

The ADMS-Urban Complex Terrain Module models these effects using the wind-flow model FLOWSTAR[25]. This model uses linearised analytical solutions of the momentum and continuity equations, and includes the effects of stratification on the flow. Ideally hills should have moderate slopes (up to 1 in 2 on upwind slopes and hill summits, up to 1 in 3 in hill wakes), but the model is useful even when these criteria are not met. FLOWSTAR has been extensively tested with laboratory and field data.

Complex Effects - Buildings

A building or similar large obstruction can affect dispersion in three ways:

1. It deflects the wind flow and therefore the route followed by dispersing material;
2. This deflection increases levels of turbulence, possibly enhancing dispersion; and
3. Material can become entrained in a highly turbulent, recirculating flow region or cavity on the downwind side of the building.

The third effect is of particular importance because it can bring relatively concentrated material down to ground-level near to a source. From experience, this occurs to a significant extent in more than 95% of studies for industrial facilities.

The buildings effects module in ADMS-Urban has been developed using extensive published data from scale-model studies in wind-tunnels, CFD modelling and field experiments on the dispersion of pollution from sources near large structures. It operates in the following stages:

(i) A complex of buildings is reduced to a single rectangular block with the height of the dominant building and representative streamwise and crosswind lengths.

(ii) The disturbed flow field consists of a recirculating flow region in the lee of the building with a diminishing turbulent wake downwind, as shown in Figure A1.

(iii) Concentrations within the well-mixed recirculating flow region are uniform and based upon the fraction of the release that is entrained.

[25] 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.

(iv) Concentrations further downwind in the main wake are the sum of those from two plumes: a ground level plume from the recirculating flow region and an elevated plume from the non-entrained remainder.

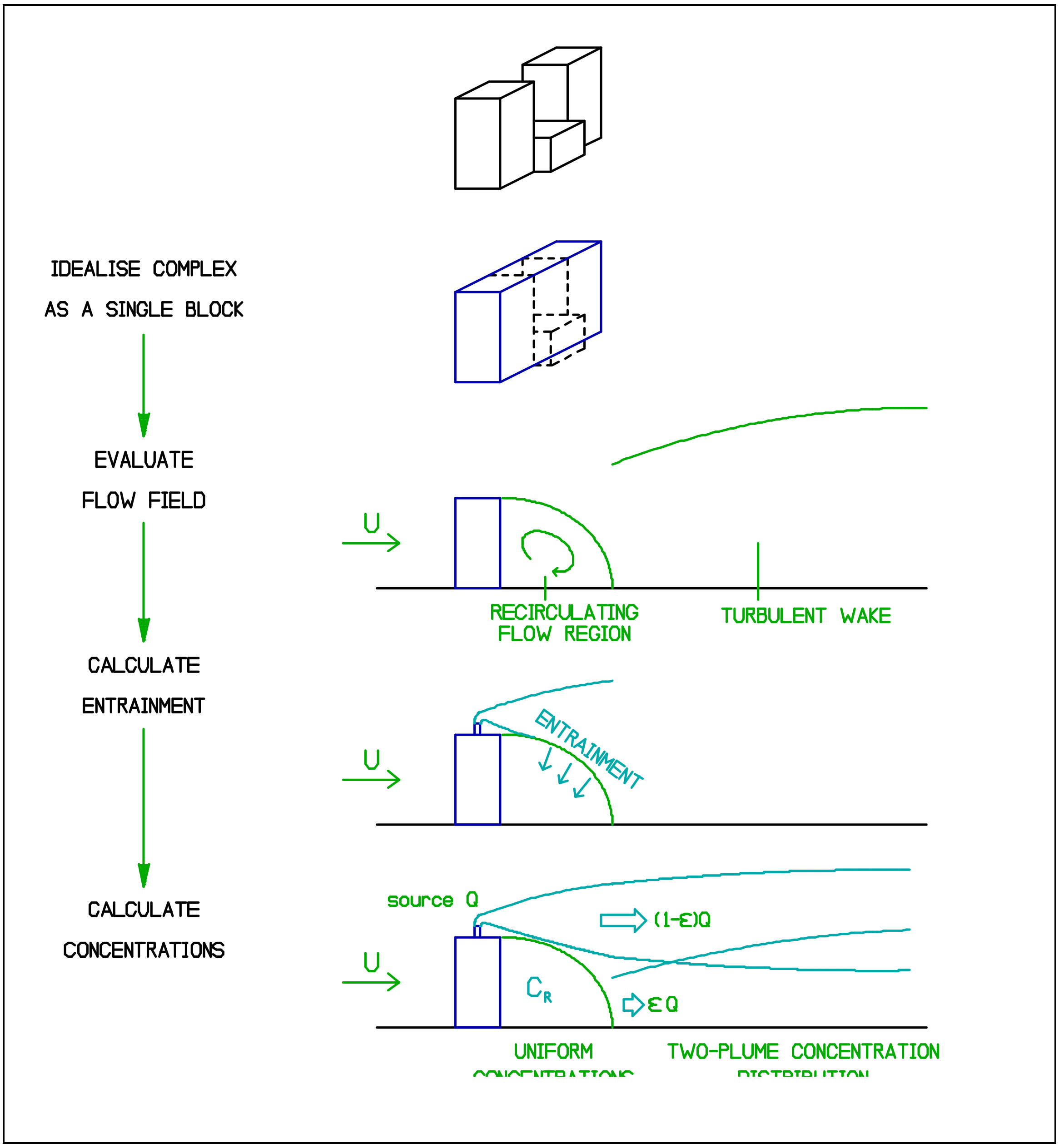

Figure A.1: Stages in the modelling of building effects

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, including Central London and Birmingham, for which a large scale project was carried out on behalf of the DETR (now DEFRA).

Further details of ADMS-Urban and model validation, including a full list of references, are available from the CERC website at www.cerc.co.uk.