APPENDIX 12.1:

AIR QUALITY MODELLING STUDY

Technical Appendix 12.1: Air Quality Modelling Study

12.1 This appendix presents technical information and data upon which the air quality assessment reported in Chapter 12: Air Quality is based.

Model

12.2 The air quality assessment was undertaken using an advanced atmospheric dispersion model, ADMS-Roads – this considered the effect on local air quality of emissions from changes to traffic movements as a result of the operation of the Development and heating plant and likely air quality conditions at the Development itself in relation to the proposed residential and school uses.

12.3 The ADMS-Roads model is a comprehensive tool for investigating air pollution in relation to road networks and small industrial sources. On review of the nature of the Site, and its surroundings, the ADMS-Roads model is considered appropriate for the assessment of the effects of the Development proposals on air quality. This has been agreed with the Environmental Health Officer (EHO) at London Borough of Camden (LBC). The science of ADMS-Roads is significantly more advanced than that of most other air dispersion models. The model uses advanced algorithms for the height-dependence of wind speed, turbulence and stability to produce improved predictions. It can predict long-term and short-term concentrations, as well as calculations of percentile concentrations.

12.4 The ADMS-Roads model was comprehensively verified in a large number of studies by the software manufacturer CERC (Cambridge Environmental Research Consultants). This includes comparisons with data from the UK's Automatic Urban Rural Network (AURN) and specific verification exercises using standard field, laboratory and numerical data sets. CERC is also involved in European programmes on model harmonisation, and their models were compared favourably against other EU and U.S. EPA systems. Further information in relation to this is available from the CERC web site at www.cerc.co.uk.

12.5 Additionally, the latest version of ADMS-Roads (Version 3 released on 23 of November 2010) was used, which incorporates the most recent Emission Factor Toolkit (EFT) (version 4.2 which uses the Department for Transport's latest vehicle emission factors (published 18 June 2010)) in its emission calculations.

Traffic Data

12.6 Traffic flow data comprising annual average daily traffic (AADT) flows, traffic composition (% HDVs) and average link speeds (kph) were used in the modelling for the surrounding road network.

12.7 Data were provided by Arup for the baseline year of 2010 and the future 'without Development' and 'with Development' scenarios for 2015 (the anticipated completion year of the Development).

12.8 The AADT flows and vehicle splits used within the assessment are presented in Table 1.

Table 1: Traffic Data used within the Air Quality Assessment

Link name	2010 Baseline AADT	2015 without AADT	%HDV	2015 with AADT	%HDV	Speed (kph)
Castlehaven Road	12,120	12,120	13.1%	12,046	13.3%	39
Hawley Road	11,964	11,964	12.4%	11,893	12.6%	35
Leybourne Road	506	506	6.4%	545	8.7%	26
Kentish Town Road	14,714	14,714	4.1%	14,704	4.1%	33
Hawley Cresent	4,646	4,646	11.5%	4,637	11.5%	28
Camden High Street North	12,277	12,277	17.9%	12,260	17.9%	28
Chalk Farm Road	17,116	17,116	9.1%	17,052	9.2%	28
Camden High Street South	12,292	12,292	7.6%	12,275	7.6%	48
Kentish Town Rd (junction with Buck Str.)	8,289	8,289	11.4%	8,288	11.4%	48
Kentish Town Rd North	18,899	18,899	9.3%	18,898	9.3%	48
Hawley Rd	13,618	13,618	7.7%	13,547	7.8%	48
Camden Street	18,142	18,142	10.7%	18,080	10.8%	48
Parkway	17,714	17,714	4.5%	17,714	4.5%	48
Camden High Street East	24,367	24,367	10.6%	24,350	10.6%	48
Camden Rd	27,583	27,583	12.5%	27,583	12.5%	48
Bayham Street	16,537	16,537	12.4%	16,537	12.4%	48

Source: Arup August 2011

The ADMS-Roads model uses an hourly traffic flow based on the daily (AADT) flows. Traffic flows follow a diurnal variation throughout the day and week. Therefore, a diurnal profile as shown in Figure 1 was used in the model to replicate how the average hourly traffic flow would vary throughout the day and at the weekend. This was based on data provided by Arup at the road links (Castlehaven Road, Hawley Road, Leybourne Road, Kentish Town Road, Hawley Cresent, Camden High Street and Chalk Farm Road) provided in the assessment from Wednesday, 20 of October 2010 to Tuesday, 26 October 2010.

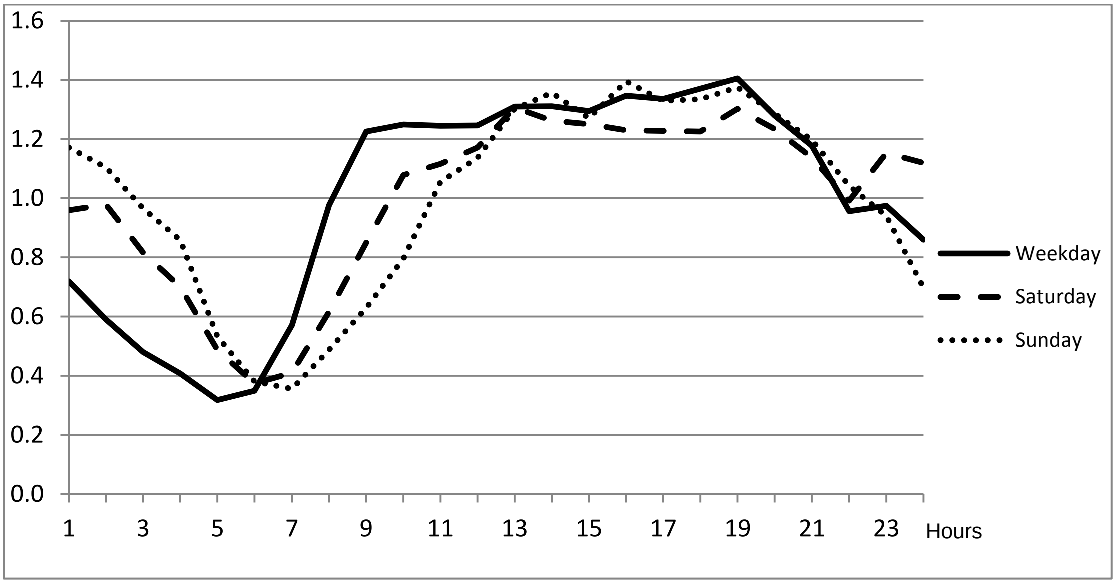

Figure 1: Diurnal Traffic Variation

Canyons

12.9 Narrow streets with tall buildings on either side have the potential to create a confined space, which can interfere with the dispersion of traffic pollutants and may result in pollutant emissions accumulating that area. In an air quality model these narrow streets are described as street canyons.

12.10 ADMS-Roads includes a street canyon model to take account of the additional turbulent flow patterns occurring inside a street with relatively tall buildings on both sides, known as a 'street canyon'.

12.11 A review of the surrounding area was undertaken in relation to canyons. The surrounding road carriageways are relatively wide (i.e. with several lanes), and existing buildings are not considered to be tall. Therefore, no canyons were included within the model for the existing or with Development scenarios.

Heating Plant

12.12 A total of two gas-fired boilers and one bio-diesel fuelled Combined Cooling and Heat and Power (CCHP) system are proposed within the Development.

12.13 The emissions data used within the ADMS-Roads model for the boilers and CCHP flues were provided by Grontmij and are presented in Table 2 below. All flues would be located on the top of the tallest elements of the proposed Development Site C, Block 2 (32.265 m above ground level). The proposed biodiesel CCHP would be equipped with a catalytic convertor, which reduces emissions by approximately 70%. In addition, the velocity of release from the CCHP has been increased to 10m/s (from a minimum of 6m/s) in order to further reduces emissions at ground level.

Table 2: Heating Plant Emission Parameters

Facility	Size	Flue diameter (m)	Velocity of release (m/s)	NO_x (g/s)	Height (m)	Temperature of the release (deg ºC)
CCHP	350kWe	0.4	10	0.243426	32.265	180
Gas Boiler 1	1500 kW	0.8	6	0.0535	32.265	180
Gas Boiler 2	1500 kW	0.8	6	0.0535	32.265	180

Note: Emission factors are not provided for PM_{10} for gas-fired boilers and CCHP because gas-fired plant does not emit any significant level of particulates and CCHP particulate emissions will reduce to ≈0 with the catalytic convertor

12.17 As provided by Grontmij, the operational pattern applied for the heating plant within the ADMS-Roads model assumes 3,400 hours of use per year for CCHP and 3,000 hours for the boilers.

Pollutant Background Concentrations

12.18 The ADMS-Roads model requires background pollutant concentration data (i.e. concentrations not including local pollutant sources such as roads or stacks), that correspond to the year of assessment, to which the model adds contributions from the road sources.

12.19 Background concentrations of NO_x and NO_2 for 1 x 1km grid squares are available from the UK Air Quality Archive for assessment years between 2006 and 2020.

12.20 In addition, London Boroughs monitor background concentrations with automatic continuous monitors. Therefore, a review has been undertaken of background monitoring locations within Camden and surrounding Boroughs, to compare to the background concentrations from the Archive, in order to find a suitable background to use in the ADMS-Roads study.

12.21 The nearest background monitor to the Site that has acceptable data capture for 2010, and does not predict a concentration higher than the monitor at which the ADMS-Roads model is to be verified (54.52µg/m^3 shown in the Model Verification section below) is the Westminster Covent Garden monitoring location (at grid reference 530444, 180903).The annual mean background concentrations of NO_X, NO_2, and PM_{10} have been obtained from this monitor for the baseline year of 2010 and compared to the data from the Archive, in Table 3.

Table 3: Pollutant Background Concentrations (µg/m^3) for Grid Reference (528500, 183500) Compared to the LBC Inverness Street Monitor

Pollutant	Covent Garden Monitor	Background from Archive
NO_X (µg/m^3)	85.75	54.11
NO_2 (µg/m^3)	50.05	32.79
PM_{10} (µg/m^3)	-	20.38

Note: PM10 data ins not available for 2010 due to low capture rate

12.22 As can be seen from Table 3, there is a higher concentration of NO_2 measured at the Covent Garden Monitor compared to the background from Archive. Therefore, using data from this monitor would be more conservative approach. This was agreed with the EHO at LBC.

12.23 According to LAQM.TG (09)[1], to adjust monitoring data from background locations, the year adjustment factors appropriate to any 1x1km grid square can be simply calculated by comparing the two maps for the two years in question. Therefore, the DEFRA's Archive 2010 and 2015 data for the grid square matching the verification location (Inverness Street monitor location (528500, 183500)) have been used to establish factors to project forwards background measured concentrations of NO_X, NO_2, and PM_{10} from Westminster Covent Garden monitor. All background air pollutant concentrations used within the modelling assessment are presented in Table 4.

Table 4: Pollutant Background Concentrations (µg/m^3) use in the ADMS-Roads Assessment

Pollutant	2010	Factor	2015*
NO_X (µg/m^3)	85.75	0.7916	67.89
NO_2 (µg/m^3)	50.05	0.8301	41.54
PM_{10} (µg/m^3)	20.38	0.9477	19.31

* 2015 data factored using 2010 to 2015 ratio for NO_X, NO_2 and PM_{10} from the Grid Square 528500, 183500

Meteorological Data

12.24 Meteorological data provides hourly sequential data including wind direction, wind speed, temperature, precipitation and the extent of cloud cover for each hour of a given year. As a minimum ADMS-Roads requires wind speed, wind direction, and cloud cover.

12.25 Meteorological data, to input into the model, was obtained from the Heathrow Meteorological Station. The 2010 data has been used, to be consistent with the base traffic year.

12.26 Cloud cover information is required in order for the ADMS-Roads model to run and the Heathrow cloud cover data for 2010 was not complete. Therefore, cloud cover data was obtained from the Northolt meteorological site and merged with the Heathrow data (on the advice of the Meteorological data supplier). Figure 2 presents the windrose for the met data.

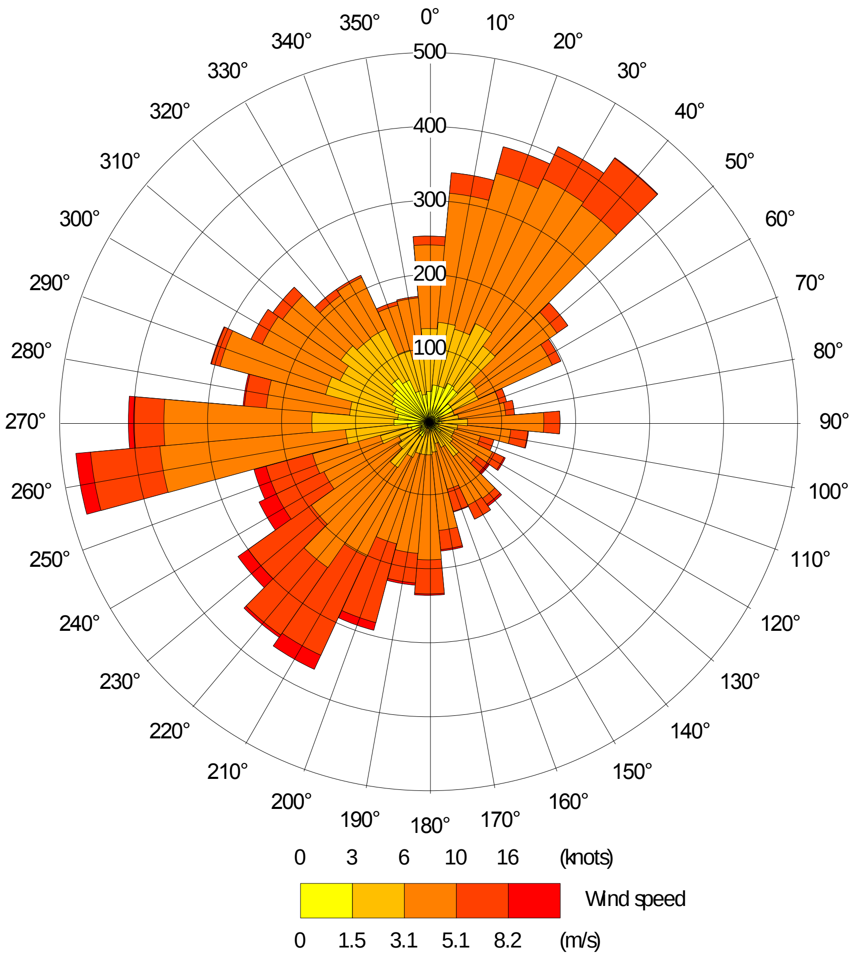

Figure 2: 2010 Wind Rose for the Heathrow Airport Meteorological Site

12.27 The 2010 meteorological data was used to provide a consistent assessment with the year of in which the ADMS-Road model is being verified. It was subsequently applied to 2015 scenarios.

Model Data Processing

12.28 The modelling results were processed to calculate the averaging periods required for comparison with air quality objectives.

12.29 NO_X emissions from combustion sources (including vehicle exhausts) comprise principally nitric oxide (NO) and nitrogen dioxide (NO_2). The emitted nitric oxide reacts with oxidants in the air (mainly ozone) to form more nitrogen dioxide. Since only nitrogen dioxide is associated with effects on human health, the air quality standards for the protection of human health are based on NO_2 and not total NO_X or NO.

12.30 The ADMS-Roads model was run without the Chemistry Reaction option to allow verification (see below). Therefore, a suitable NO_X:NO_2 conversion needed to be applied to the modelled NO_X concentrations. There are a variety of different approaches to dealing with NO_X:NO_2 relationships, a number of which are widely recognised as being acceptable. However, a new approach was developed and is detailed within the Technical Guidance LAQM.TG (09)[1], which supersedes the previous 2003 guidance document. The new guidance provides a spreadsheet calculator to allow the calculation of NO_2 from NO_X concentrations, accounting for the difference between primary emissions of NO_X and background NO_X, the concentration of O_3, and the different proportions of primary NO_2 emissions, in different years. This approach is only applicable to annual mean concentrations.

12.31 In order to calculate the number of daily exceedences of 50µg/m^3 PM_{10} the relationship between the number of 24-hour exceedences of 50µg/m^3 and the annual mean PM_{10} concentration from LAQM.TG (09) was applied as follows:

$$\textbf{Number of Exceedences} = -18.5+0.00145 \times (\text{annual mean}^3) + \frac{206}{\text{annual mean.}}$$

Other Model Parameters

12.32 There are a number of other parameters that are used within the ADMS-Roads model which are described here for completeness and transparency:

- The model requires a surface roughness value to be inputted. A value of 1 was used, which is representative of cities.
- The model requires the Monin-Obukov length (a measure of the stability of the atmosphere) to be inputted. A value of 100m (representative of large conurbations) was used for the modelling.

Model Verification

12.33 Model verification is the process of comparing monitored and modelled pollutant concentrations for the same year, at the same locations, and the process of adjusting model outputs.

12.34 The model was verified by comparing modelled and monitored annual mean values for the nearest LBC monitoring location to the Site at the Inverness Street diffusion tube, which is located within the provided traffic network.

12.35 The 2010 year was the year modelled for verification purposes, being the last year of fully ratified monitoring data available, (as well as for the baseline assessment scenario.

Nitrogen Dioxide

12.36 The modelled annual mean NO_2 concentration and the monitored annual mean NO_2 concentration at the Inverness Street monitoring location were compared as shown in Table 5 below, using the NO_X:NO_2 calculator to estimate NO_2 from the NO_X output from the model (as described above). The background data for 2010 from Table 4 were used.

Table 5: Model Verification Results for Annual Mean NO_2 with No Adjustment Applied

Location	Monitored Annual Mean (μg/m^3)	Modelled Annual Mean (μg/m^3)	% Difference (modelled – monitored)
Inverness Street	54.52	52.37	-3.94%

12.37 Table 5 indicates that the model is underestimating annual mean NO_2 concentrations. This can be for a number of reasons, for example:

- traffic data uncertainties;
- background concentration estimates;
- meteorological data uncertainties;
- overall model limitations (e.g. treatment of roughness and meteorological data); and
- uncertainty in monitoring data, particularly diffusion tubes.

12.38 Technical Guidance LAQM.TG (09) suggests that where there is disparity between modelled and monitored results, appropriate adjustment should be undertaken.

12.39 LAQM.TG (09) presents a number of methods for approaching model verification and adjustment. One of these (Example 2) indicates a method based on adjusting the NO_2 road contribution and calculating a single adjustment factor. This method refers to modelling based on road traffic sources only and can be applied to either a single diffusion tube location, or where numerous diffusion tube monitoring locations are sited within the modelled area.

12.40 This requires the roadside NO_X contribution to be calculated, for which the ADMS-Roads model is run without the chemical reaction scheme using NO_X concentrations at the Inverness Street continuous monitor.

12.41 The following adjustment procedure (based on Example 2) was applied, which utilised the background NO_X and NO_2 annual mean concentrations from the Covent Garden monitor as presented in Table 4. The steps involved in the adjustment process are presented in Table 6 below.

Table 6: Calculating Adjustment Factor

	A1	A2	A3	A4	A5
Monitoring Site	**Total Monitored NO_X**	**Monitored NOx from Road Emissions** (=A1 – Background NO_X)	**Modelled NOx from Road Emissions** (=[NO_X] Total Mod – Background NO_X)	**Adjustment Factor** (=A2/A3)	**Corrected Road Emissions NO_x** (=A3 * A4)
Inverness Street	98.24	12.48	10.58	1.180	12.48

12.42 An adjustment of the road NO_X component has therefore been undertaken following the guidance above in order to predict more reliable results for the future scenarios.

12.43 Consequently, as shown in Table 7 below, the adjustment factor (1.180) obtained in Table 6 is applied to the modelled NO_X roadside concentrations to obtain improved agreement between monitored and modelled annual mean NO_X. This was then converted to annual mean NO_2 using the NO_X:NO_2 spreadsheet calculator.

Table 7: Adjusted Annual Average NO_2 Concentrations Compared to Measured Annual Mean NO_2 Concentrations (μg/m^3)

Location	Measured Annual Mean (μg/m^3)	Adjusted Modelled Annual Mean (μg/m^3)	μg/m^3 Difference (modelled adjusted – measured)
Inverness Street	54.52	54.52	-

12.44 The data in Table 7 indicate an improved agreement between monitored and modelled annual mean NO_2 results compared to the unadjusted/unverified model. This process of verification improves confidence in the modelling results and further reduces uncertainty.

12.45 The adjustment process was then applied to all of the roadside NO_X modelling results for the Camden Lock study area for 2010, and 2015 without and with the Development in place, at the specific receptors locations assessed, before the predicted contribution to NOx from the heating plant were added (for the 'with Development' scenario only) and the total concentrations converted to NO_2.

PM_{10}

12.46 No PM_{10} monitoring data is available to compare to the model output. Therefore, the adjustment factor (1.180) calculated in Table 6 was subsequently applied to all the roadside PM_{10} modelling results, before adding on the background PM_{10} concentrations for 2010 and each of the 2015 scenarios, at the specific receptors locations assessed, and before the number of daily exceedences was calculated.

Verification Summary

12.47 Any atmospheric dispersion model study will always have a degree of inaccuracy due to a variety of factors. These include uncertainties in traffic emissions data, in the differences between available meteorological data and the specific microclimate at each receptor location, simplifications made in the model algorithms that describe the atmospheric dispersion and chemical processes. There will also be uncertainty in the comparison of predicted concentrations with monitored data, given the potential for errors and uncertainty in sampling methodology (technique, location, handling, and analysis) as well as processing of any monitoring data.

12.48 Whilst systematic under or over prediction can be taken in to account through the model verification/adjustment process, random errors will inevitably occur and a level of uncertainty will still exist in corrected/adjusted data.

12.49 Model uncertainties arise because of limited scientific knowledge, limited ability to assess the uncertainty of model inputs, for example, emissions from vehicles, poor understanding of the interaction between model and/or emissions inventory parameters, sampling and measurement error associated with monitoring sites and whether the model itself completely describes all the necessary atmospheric processes.

12.50 Overall, it is concluded that the ADMS-Roads model is predicting pollutant concentrations in the area of the Site well within an acceptable margin of error that allows it to be used as a tool for the prediction of air quality effects of the Development.

References

1 DEFRA, 2009, Local Air Quality Management Technical Guidance LAQM.TG (09)