Appendix 6.4 Modelling

Point Source Modelling

Modelling Approach Overview

A6.4.1 For the point source modelling of the plant flue, concentrations have been predicted at locations of sensitive exposure within the local area using the ADMS-5 atmospheric dispersion model (v5.2). Concentrations have been predicted for three different meteorological years (2017, 2018 and 2019) to take account of annual variations in meteorology.

A6.4.2 The model was developed and validated by Cambridge Environmental Research Consultants (CERC). The model is used extensively throughout the UK for regulatory compliance purposes and Local Air Quality Management and is accepted as an appropriate tool by local authorities and the EA.

A6.4.3 The model requires a range of input parameters which are discussed further below.

Combustion Parameters

A6.4.4 The Project will include an on-site combustion plant to provide heat and hot water to the occupants. This will comprise of a 383 kW_{th} Combined Heat and Power (CHP) plant and two 743 kW_{th} gas-fired boilers. Information on these plant have been taken from technical datasheets, set out in Appendix 6.6. Where necessary, the combustion parameters and pollutant emissions have been based on best practice and professional experience. Should the plant installed in the Project change significantly from the assumed parameters in this chapter, the assessment of impacts and conclusions of the chapter may change.

A6.4.5 The relevant parameters including calculated actual (A) and normalised (N) exhaust flow rates are given in **Table A6.4.1**. These are based on 100% load for each plant and the complete combustion of natural-gas.

Table A6.4.1: Plant Specifications, Emissions and Release Conditions

Parameter	CHP	Boiler
Power Output (kW_{out})	201.8	719.4
Combustion Input		
Net Input Fuel Rate (kWin)	383	743
Gross Input Fuel Rate (kWin)	424	823
Gross Fuel Consumption (kg/hr)	29.6	57.5
Combustion Air_{in} (kg/h)	840	1304
Excess Air (%) [a]	70	36
Combustion Products		
Exhaust Temperature (^oC)	120	60
Exhaust Flow (kg/h) for Actual Flow	869.8	1295.9
Molar Flow Rate (mol/s) for Actual Flow	8.58	12.51
Molecular Mass (g/mol) for Actual Flow	28.15	28.78

Exhaust Flow (Am^3/s) for Actual Flow [b]	0.277 [c]	0.342 [d]
Exhaust Velocity (Am/s) for Actual Flow	22.567 [c]	5.441 [d]
Exhaust Flow (kg/h) for Normalised Flow [e]	457.5	887.5
Molar Flow Rate (mol/s) for Normalised Flow [e]	4.23	8.21
Exhaust Flow (Nm^3/s) [e, f] for Normalised Flow	0.095	0.184
Condition Specific Emissions		
NOx Emission Rate (mg/kWh)	100.4 [g]	38.8
NOx Emission Rate (g/s)	0.01184	0.00887

[a] Derived from combustion air m^3/s.

[b] Calculated from molar flow rate x 8.3145 x (T+273.13) / 101,325.

[c] Actual flow conditions assumed to be 65 ºC, 8.0% O_2, wet (12.3% H_2O).

[d] Actual flow conditions assumed to be 60 ºC, 5.5% O_2, wet (8.1% H_2O).

[e] Normalised to 0 ºC, 101.325 kPa, 0% O_2, dry.

[f] Calculated from normalised molar flow rate x 8.3145 x (273.13) / 101,325.

[g] Equivalent to 95 mg/Nm^3 at 5% O_2.

A6.4.6 The operation of the combustion plant is unknown. A conservative assessment has thus been undertaken, assuming it is continuously operational.

Source Location

A6.4.7 The CHP and boilers will exhaust from a single flue rising to the roof of Block C, as shown in **Figure A6.4.1**. **Table A6.4.1** shows the coordinates and release height of the point source.

Figure A6.4.1: Point Source Location

Drawing provided by Alan Camp Architects

Table A6.4.1: Source location parameters values used in the model

Source ID	X (m)	Y (m)	Height (m)
Combined Source	523936.9	212526.8	27.3

Modelled Buildings

6.1.9. The "Building downwash effect" can result in elevated concentrations in the lee of large structures. The model can incorporate the impact of buildings on the concentrations in the downwind area of buildings. However, it should be noted that buildings with a height, H, significantly lower than the flue are automatically ignored in the model. The flue is 27.3 m high, therefore any building less than 11 m will automatically be ignored within the model. The Project buildings have therefore been included in the model. Two separate modelling scenarios have therefore been run:

- no buildings; and
- with on-site buildings.

A1.1 The modelled buildings are shown in **Figure A6.4.2.**

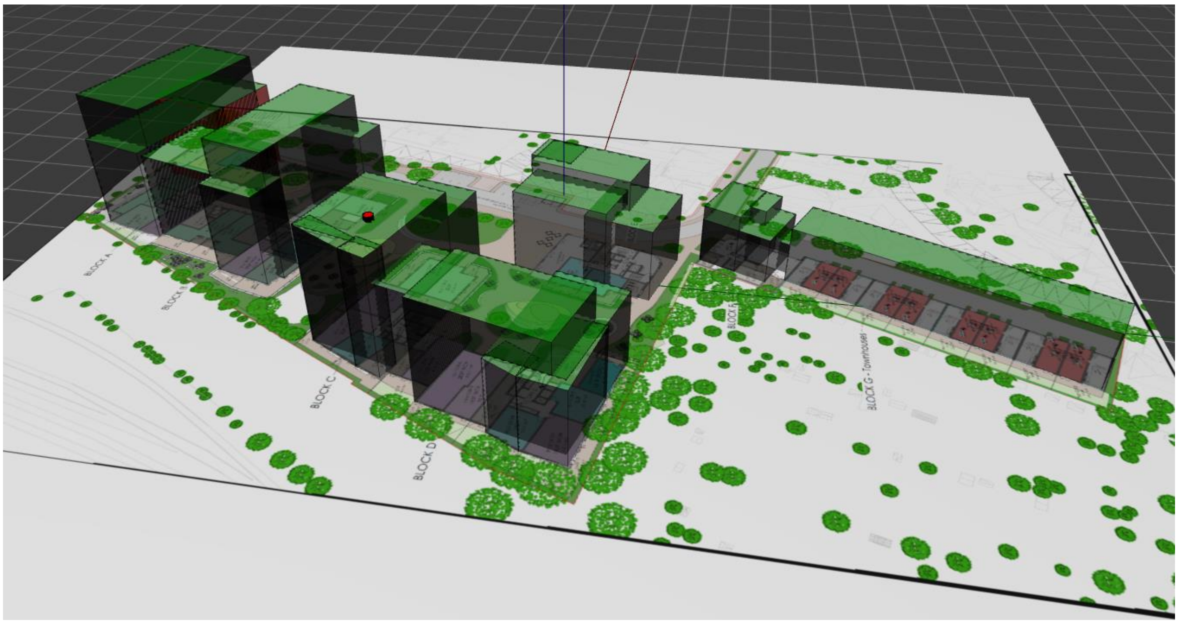

Figure A6.4.2: Modelled Buildings (Green) and Source Locations (Red)

Information obtained from Alan Camp Architects.

Chemistry (Conversion of NOx to NO_2)

A1.2 The receptors have not used the in-built model chemistry features and the chemistry has been dealt with during the post-processing stage.

<u>Road and Rail Traffic Modelling</u>

Modelling approach overview

A6.4.8 Concentrations of NO_2, PM_{10} and $PM_{2.5}$ have been predicted for the existing year of 2019 and the future year of 2023 (when the Project may first be operational). Concentrations have been predicted using the ADMS-Roads atmospheric dispersion model (v5) with the latest vehicle emission factors available from Defra's Emission Factor Toolkit (EFT) (v10.1). ADMS-Roads was developed and validated by Cambridge Environmental Research Consultants (CERC). The model is used extensively throughout the UK for dispersion modelling and is accepted as an appropriate tool by local authorities. The model requires a range of input parameters which are discussed below.

Modelled Roads

A6.4.9 The road links, widths and heights included in the dispersion model have been aligned with data from ordinance survey, google maps and professional judgement, taking account of the relative distances between receptors and sources. The modelled road links and speeds are shown in **Figure A6.4.3.**

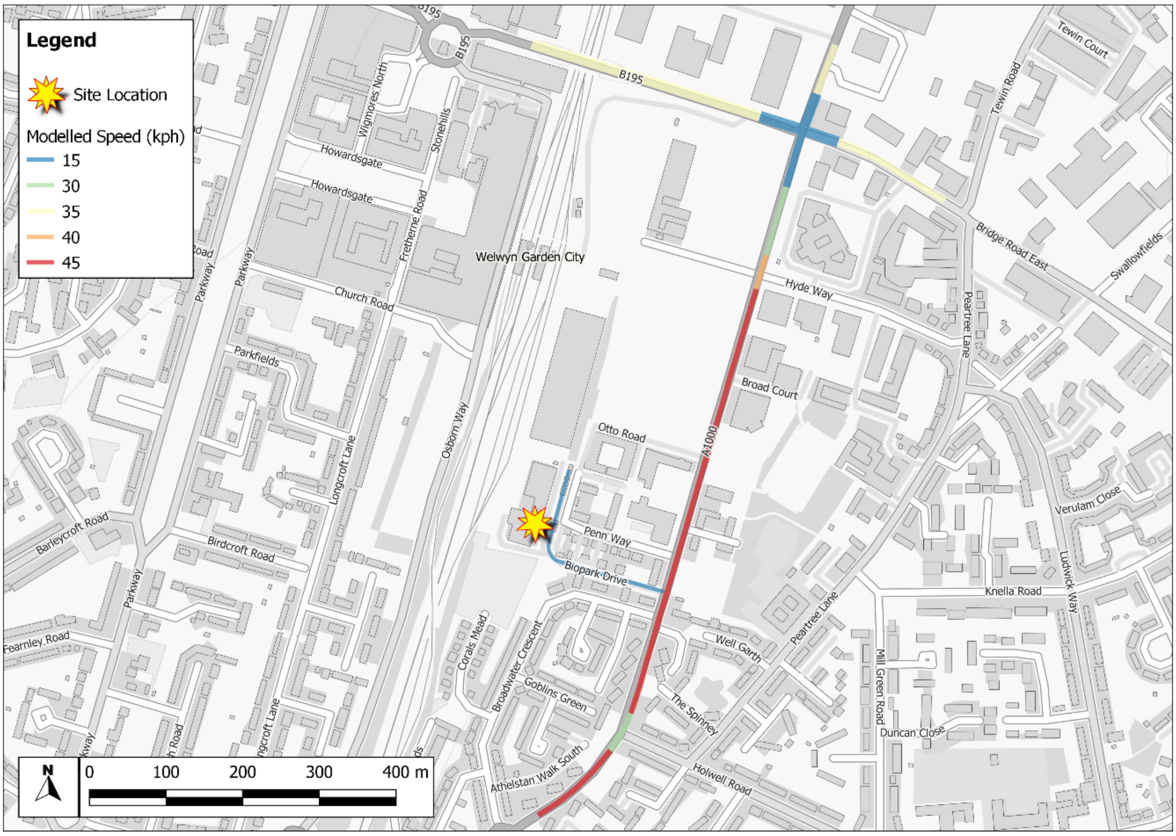

Figure A6.4.3: Modelled roads links, Speeds, and Project Location

Street Canyons

A6.4.10 Roads in the local area are enclosed by buildings and vegetation, leading to restricted dispersion of pollution away from the roads and higher pollutant concentrations close to the roads. This is known as a 'street canyon' effect. The Project will not change the streetscape along the site access road significantly. These roads and others in the local area have therefore been modelled as asymmetric street canyons using the Advanced Street Canyon Module in network mode, within the ADMS-Roads model, accounting for the fraction of covered 'canyons'. Details of the changes in street canyon settings input into the model with and without the Project are given in **Table A6.4.2**. The modelled street canyons, without and with the Project are shown in **Figure A6.4.4** and **Figure A6.4.5**, respectively.

Table A6.4.2: Changes in street canyon settings used in the model

Road	Left Side					Right Side					Canyon Top Coverage (%) [b]
	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%) [a]	Width (m)	Average Height (m)	Min Height (m)	Max Height (m)	Porosity (%) [a]	
Without Project											
BioPark Drive	8	18	18	21	7.7	19.5	9	9	9	53.8	0
With Project [c]											
BioPark Drive	4	26	22.1	28.4	69.2	19.5	9	9	9	53.8	0

a The porosity of a street canyon represents how much air can filter through the sides of the canyon and is defined as $1-L_B/L_R$, where L_B is the length of road with adjacent massing and L_R is the total length of the road.

b The top of a street canyon can sometimes be restricted by tree canopies, balconies, awnings, etc. The fractional coverage of the top of street canyons has therefore been account for in the model.

c Only the street canyon for the sections of the site access road adjacent to the Project are altered with the Project. All other modelled street canyons remain the same as in the without Project scenario.

Figure A6.4.4: Modelled Street Canyons without the Project

Imagery © 2020 Google, Map data © 2020.

Figure A6.4.5: Modelled Street Canyons with the Project

Imagery © 2020 Google, Map data © 2020. Information obtained from Alan Camp Architects.

Traffic Flows

A6.4.11 Baseline traffic data for 2019 has been based upon baseline traffic surveys carried out by the Department for Transport (DfT) in the local area. The future year traffic data utilised within the assessment is based upon baseline traffic surveys carried out by the Department for Transport (DfT) and uplifted using a growth factor from obtained from DfT's Trip End Model Presentation Program (TEMPro) which extracts information from the National Trip End Model[11]. This is expected to take account of increases in traffic in the local area set out in WHBC's Local Plan. In addition, traffic flows associated with cumulative schemes in the local area have been explicitly included where possible. Data for most cumulative schemes was not available. However, to provide a conservative assessment, cumulative traffic flows from the Former Shredded Wheat Factory development have been added to the uplifted baseline traffic flows, given that the redevelopment of the Former Shredded Wheat Factory site is largest cumulative development in the local area and is located approximately 100 m away from the Project Site and will thus likely utilise the same local roads. This includes traffic flows associated with the approved outline application for the Former Shredded Wheat Factory (N6/2015/0294/PP) and the approved full application for the Former Shredded Wheat Factory (6/2018/0171/MAJ), to provide a worst-case assessment. Information of these applications are publicly available on WHBC's website. The future year traffic data is thus considered to take account of cumulative schemes and the assessment has therefore predicted the cumulative concentrations arising from committed developments in the area in 2023.

[11] DfT. (2017). Trip End Model Presentation Program (TEMPro) download. Retrieved from https://www.gov.uk/government/publications/tempro-downloads

A6.4.12 Where appropriate, the vehicle speeds have been reduced to take account of slower speeds at junctions and queuing. A summary of the traffic data used in the model is presented in **Table A6.4.3**.

Table A6.4.3: Traffic data used in the model

Link	2019		2023 Without Project		2023 With Project	
	AADT	HDV (%)	AADT	HDV (%)	AADT	HDV (%)
Broadwater Road S	20,077	3.5	21,319	3.5	21,219	3.5
Broadwater Road N	20,886	3.5	22,179	3.5	22,078	3.5
Bridge Road (W)	17,404	3.9	18,482	3.9	18,448	3.9
Bridge Road (E)	13,585	2.4	14,426	2.4	14,392	2.4
Bessemer Road	15,423	3.7	16,378	3.7	16,345	3.7
Site Access Road	1,000	0.0	1,062	0.0	861	0.0

Road Traffic Emissions

A6.4.13 Emissions of road-NOx (i.e. the contribution from vehicles using roads), road-PM_{10} and road-$PM_{2.5}$ have been derived from the latest version of Defra's Emission Factor Toolkit (EFT) (v10.1) using the traffic data presented in **Table A6.4.3**. The EFT is based on the COPERT 5 (Computer Programme to calculate Emissions from Road Transport) vehicle emission model and provides speed-average based emission rates. The EFT provides vehicle emission rates for the years 2017 – 2030; future years are based on a range of factors, such as expected vehicle fleet release dates, anticipated improvements in emission reduction technologies, expected uptake rates of different vehicles based on government policies, etc. It is therefore possible that the expected future emission rates in the EFT may differ from reality.

Railway Locomotive Emissions

A6.4.14 Emissions of rail-NOx (i.e. the contribution from locomotives using the railway line), rail-PM_{10} and rail-$PM_{2.5}$ have been derived from the latest information available from the National Atmospheric Emissions Inventory[12]. The NAEI provides annual emissions of different source types, one of which is railways, on a 1x1km grid across the UK. Annual emissions of NOx, PM_{10} and $PM_{2.5}$ for the two grid cells that the modelled railway lies within have been used and are presented in **Table A6.4.4**. Emission rates (in g/km/s) have been derived from these emissions for the railway lines modelled in the assessment, as set out in **Table A6.4.4**. The rail tracks modelled are shown in **Figure A6.4.6**.

[12] NAEI. (2020). UK Emissions Interactive Map. Retrieved from National Atmospheric Emissions Inventory: https://naei.beis.gov.uk/emissionsapp/

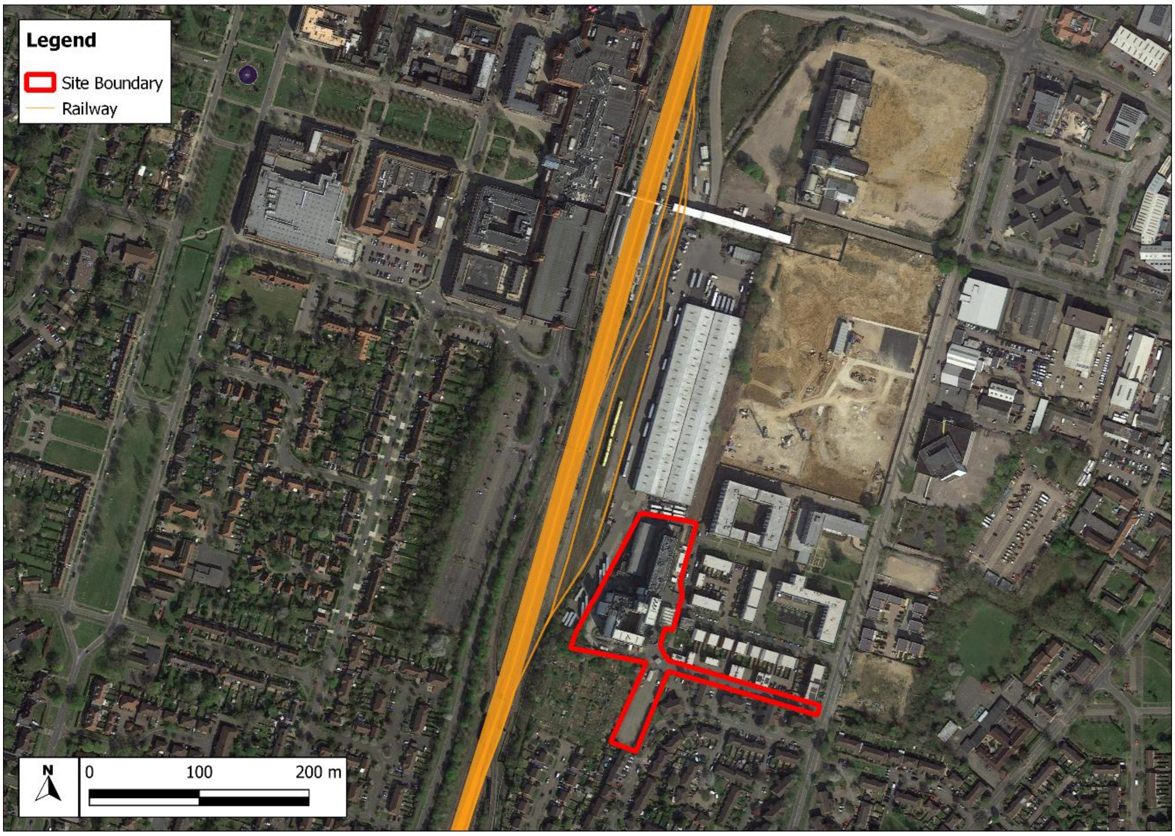

Figure A6.4.6: Modelled Railway Lines

Imagery © 2020 Google, Map data © 2020

Table A6.4.4: Derivation of Railway Locomotive Emission Rates

Parameter	1x1km Grid Cell	NOx	PM_{10}	$PM_{2.5}$
Emission (tonnes/annum)	524500,213500	2.16421	0.069194	0.065734
	523500,212500	2.188339	0.069965	0.066467
Emission (g/s)	524500,213500	0.068626658	0.002194115	0.002084408
	523500,212500	0.069391774	0.002218576	0.002107648
Railway line length within grid cell (m)	524500,213500	1,041		
	523500,212500	1,044		
Emission rate (g/km/s)	524500,213500	0.065924	0.002108	0.002002
	523500,212500	0.066467	0.002125	0.002019
Average emission rate (g/km/s)		0.066196	0.002116	0.002011

Carpark Emissions

A6.4.15 Emissions of road-NOx (i.e. the contribution from vehicle movement and idling in the carpark), road-PM_{10} and road-$PM_{2.5}$ have been modelled as an area source within ADMS-Roads. The number of vehicle movements through the car park have been provided by i-Transport LLP. There are expected to be ~450 vehicles entering and ~450 vehicles exiting the car park per day. Emissions for vehicles travelling through the car park have been derived from Defra's EFT assuming a vehicle speed of 5 kph. In addition, excess emissions from cold-starting of vehicle engines has been taken into account; these emissions have been calculated based on cold-start emission factors from Defra's EXEMPT Cold Start Tool and applied over a length of approximately 111 m (the calculated average length over which vehicles will travel to exit to car park). The air within the car park will be exhausted at an air exchange rate of 5.94 m^3/s. The exact location and type of car park exhaust louver has yet to be fully designed. However, the approximate area of the louver is expected to be located within the amenity space at the ground floor (44 m^2 area) and likely to exhaust horizontally. A conservative assumption has been made that the emissions may be released across the entirety of this area, resulting in a low exhaust velocity of 0.13 m/s, which is considered to provide a worst-case assessment. Should the emissions be released from a smaller area, then the exhaust velocity will be higher, and the pollutants will be dispersed quicker, resulting in lower concentrations. The emissions entered into the model to represent this area source are given in **Table A6.4.5**.

Table A6.4.5: Estimated Emissions from the Basement Carpark

Pollutant	EFT (µg/s)	Cold Start (µg/s)	Combined (µg/s)	Combined (µg/m^2/s)
NOx	715.9	77.0	792.9	17.9
$PM_{2.5}$	36.9	3.9	40.8	0.9
PM_{10}	62.7	3.9	66.7	1.5
NO_2	208.0	22.4	230.4	5.2

Fraction of Primary NO_2

A6.4.16 In addition to emission rates, the fraction of primary NO_2 (f-NO_2) has be obtained from the EFT. This represents the amount of NO_2 released from vehicle exhausts, before any further chemical reactions in the atmosphere, which becomes an important variable when post-processing the model predictions. In order to obtain the f-NO_2 value at each receptor location, the NOx emission rates have been multiplied by f-NO_2 values to derive NO_2 emission rates. These NO_2 emissions have been included in the model and primary NO_2 concentrations have been predicted at the receptors. The predicted NOx concentrations have been divided by the predicted primary NO_2 concentrations to calculate the f-NO_2 values at the receptor locations. The f-NO_2 values have then been used in the model post-processing.

Time-Based Profiles

A6.4.17 Vehicle emissions vary over time depending on the volume of traffic, this includes hourly, daily and seasonal variations. Seasonal (monthly) and diurnal (hourly) traffic flow profiles have been taken from DfT national statistics[13]. Both the profiles have been assumed to follow an urban traffic profile for all modelled roads. These have been used in the model to adjust the emissions for each hour of the year modelled. These profiles are shown in **Figure A6.4.7** and **Figure A6.4.8**.

[13] DfT. (2019). Road traffic statistics (TRA). Retrieved from https://www.gov.uk/government/statistical-data-sets/road-traffic-statistics-tra

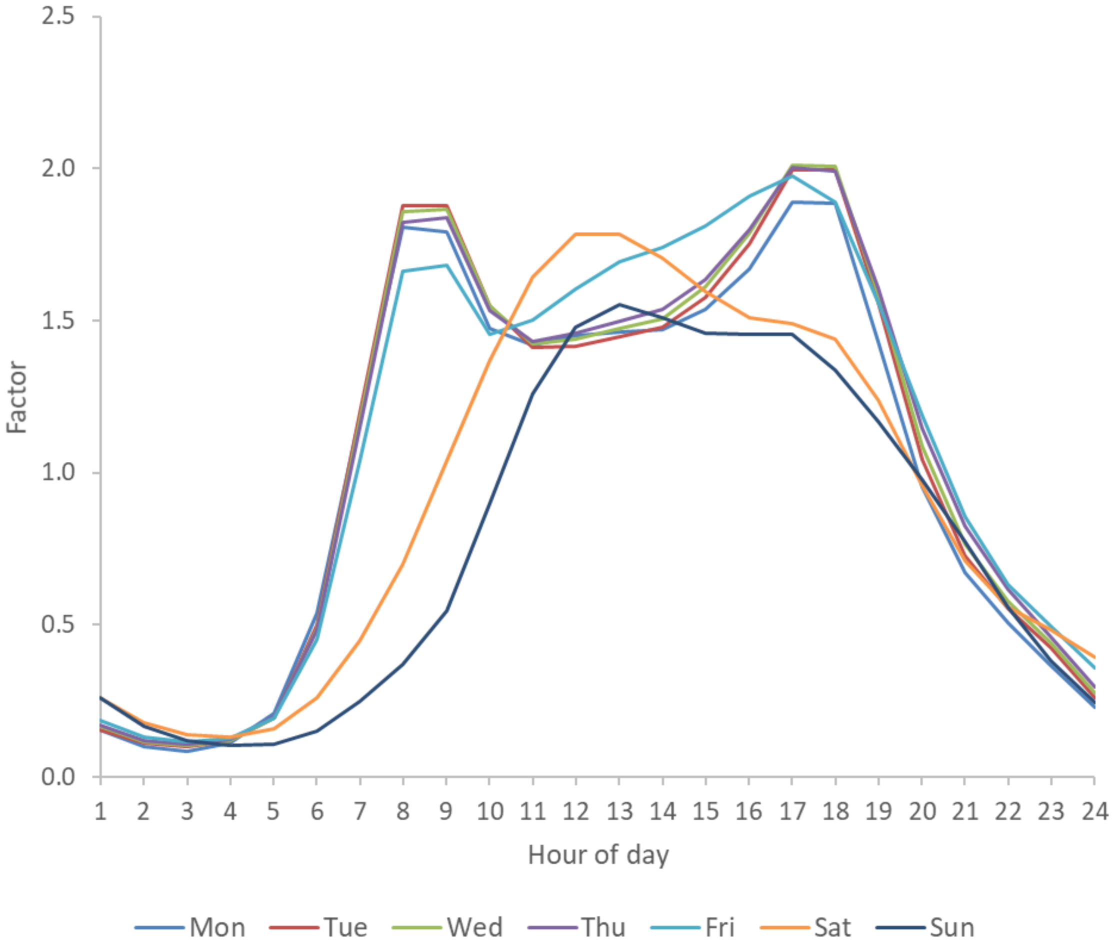

Figure A6.4.7: Urban diurnal profile for each day of the week used in the model, where the factor is the value that the average daily emissions are multiplied by in the model

Figure A6.4.8: Urban seasonal profile for each month of the year used in the model

Wake effects

A6.4.18 As vehicles travel along a road a wake is left behind the vehicles as air in the path of travel is forced around the vehicle. The wake can be considered the turbulence induced by the movement of the vehicle, which affects the dispersion of pollution away from roads. The AADT traffic flows have been entered into the ADMS-roads dispersion modeling in order to account for vehicle wake effects which will vary on each link depending on the proportion of large vehicles to small vehicles.

Percentiles

A6.4.19 The short-term impacts are complex to assess, given that the AQO is based on the number of hours (18) that a threshold concentration (200 $\mu g/m^3$) can be exceeded in a year. The 1-hour mean NO_2 AQO is often assessed by considering the 99.79th percentile of 1-hour concentrations, which represents the 19th highest hourly concentration from a full year of hourly values (a full year is 8,760 hours). In most cases, especially where specific operating hours are not defined, it is important to run the model for a full year of continuous operation, in order to capture the varied meteorological conditions that can occur throughout the year.

Meteorology and Surface Characteristics

Meteorology

A6.4.20 Meteorological data has been taken from the Luton Airport Meteorological Station for the year of 2019. This station is located approximately 15 km northwest of the application site and is considered to be representative of meteorological conditions in Welwyn Garden City; both the station and application site are located north of London and will experience very similar meteorological conditions. Meteorological data for the year of 2019 is considered to provide typical conditions. Illustrations of wind speed and direction for 2019 and other recent years are presented in **Figure A6.4.9**.

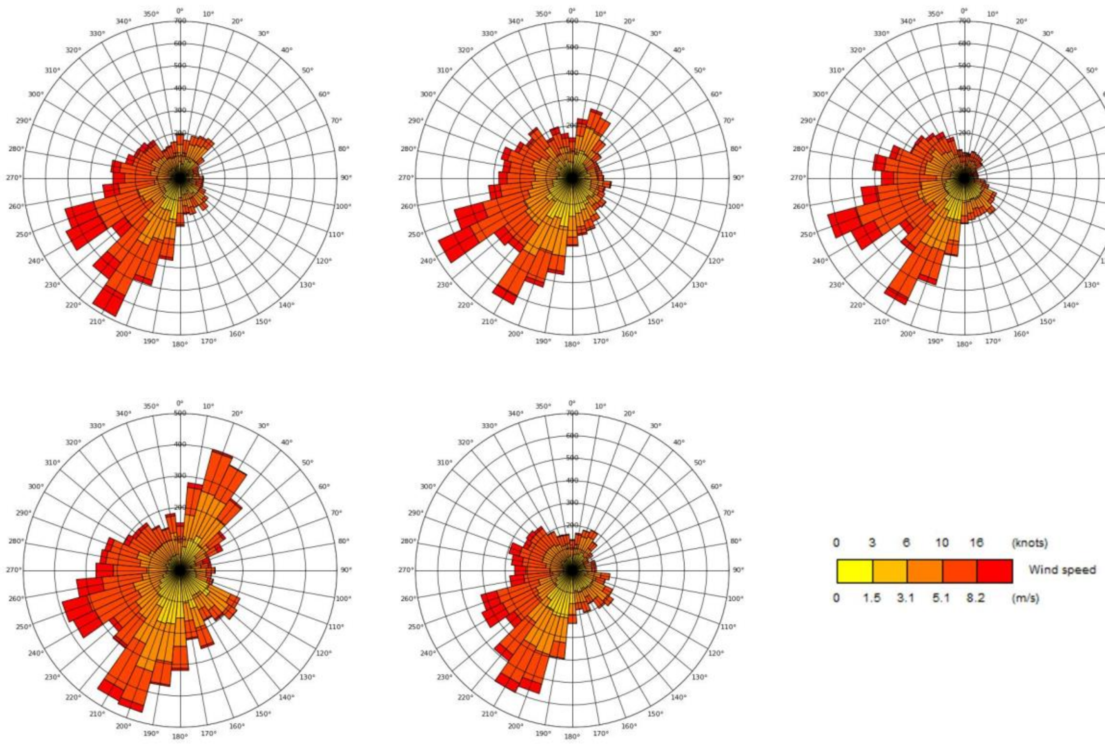

Figure A6.4.9: Windrose of wind speed and direction for each year from 2015 (top left) to 2019 (bottom right) at the Meteorological Station

Meteorological Parameters

A6.4.21 In addition to the meteorological data, the model requires values to be set for a number of meteorological related parameters, for both the meteorological station and the dispersion site (the Project Site). Details of the parameter values used in the modelling are provided in **Table A6.4.6** below.

A6.4.22 Land-use and surface characteristics have an important influence in determining turbulent fluxes and, hence, the stability of the boundary layer and atmospheric dispersion.

A6.4.23 Surface roughness length used within the model represents the aerodynamic effects of surface friction and is defined as the height at which the extrapolated surface layer wind profile tends to zero. This value is an important parameter used by the built-in meteorological pre-processor of ADMS to interpret the vertical profile of wind speed and estimate friction velocities which are, in turn, used to define heat and momentum fluxes and, consequently, the degree of turbulent mixing. Surface roughness values for different land-use classifications are provided in the 2018 Corine Land Use dataset[14]. A surface roughness file has been used within the model based on the spatially variable land-uses and the equivalent roughness values from the dataset.

[14] Copernicus. (2018). CLC 2018. Retrieved from Copernicus Land Monitoring Service: https://land.copernicus.eu/pan-european/corine-land-cover/clc2018

Figure A6.4.10:Modelled Surface Roughness

Imagery © 2020 Google, Map data © 2020

A6.4.24 The surface albedo is the ratio of reflected to incident shortwave solar radiation at the surface of the earth. This varies depending on the land use, and thus area-weighted average albedos have been derived for the meteorological and dispersion sites and used in the models. Albedo values have been taken from US Environmental Protection Agency (EPA) guidance [15] and associated with the different land uses in the 2018 Corine Land Use dataset[14].

A6.4.25 The Priestley-Taylor parameter is a parameter representing the surface moisture available for evaporation. A Priestley-Taylor parameter of 1 has been set in the model.

A6.4.26 The CERC user guide explains that "the Monin-Obukhov length provides a measure of the stability of the atmosphere. In very stable conditions in a rural area its value would typically be 2 to 20 m. In urban areas, there is a significant amount of heat generated from buildings and traffic, which warms the air above the town/city". For large urban areas this is known as the urban heat island. It has the effect of preventing the atmosphere from ever becoming very stable. The model has the ability to define the minimum Monin-Obukhov length to account for the urban heat island effect which is not represented by the meteorological data. This varies depending on the land use, and thus area-weighted average minimum Monin-Obukhov lengths have been derived for the meteorological and dispersion sites and used in the models.

[15] EPA. (2018). User's Guide for the AERMOD Meteorological Preprocessor (AERMET).

Table A6.4.6: Meteorological parameters values used in the model

Parameter	Meteorological Site Value	Dispersion Site Value
Latitude (°)	n/a	51.8
Surface roughness (m)	0.023	0.413 [a]
Surface albedo	0.180	0.171
Minimum Monin-Obukhov length (m)	22.0	22.6
Priestley-Taylor parameter	1	1

[a] Where possible, variable surface roughness has been used,

A6.4.27 The meteorological parameters alter the meteorological data inputted into the model to reflect conditions at the dispersion site. For example, if the dispersion site has a higher surface roughness value than the meteorological site, then the model will reduce the wind speed at the dispersion site to reflect this. **Figure A6.4.11** shows the frequency of wind speeds and directions measured at the Luton Airport meteorological station in 2019 (left), which has been inputted into the model, as well as the frequency of wind speeds and directions processed by the ADMS-roads model for the dispersion site (right). These illustrate that wind predominantly comes from the southwest and that the model has marginally higher wind speed at the dispersion site.

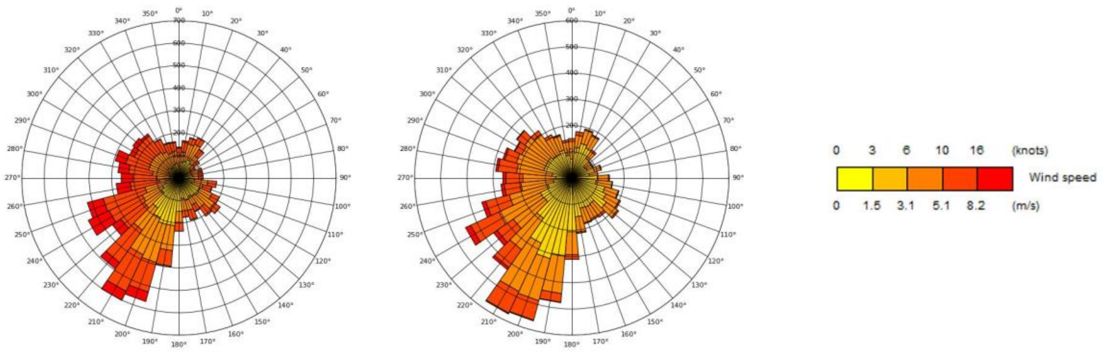

Figure A6.4.11: Wind Rose showing the frequency of wind speed and wind direction for the meteorological station (Left) and the modelled dispersion site (Right) for the year of 2019

Terrain

A6.4.28 The effects of complex topography on atmospheric flows can result in elevated pollutant concentrations. These effects are most pronounced when the terrain gradient exceeds 1 in 10, i.e. a 100 m change in elevation per 1 km step in horizontal plane. The gradients in the area surrounding the Project may have an impact on pollutant concentrations and therefore the terrain module within ADMS has been used. The local terrain data is based on Ordinance Survey Terrain 50 data. **Figure A6.4.10** shows the terrain data entered into the model.

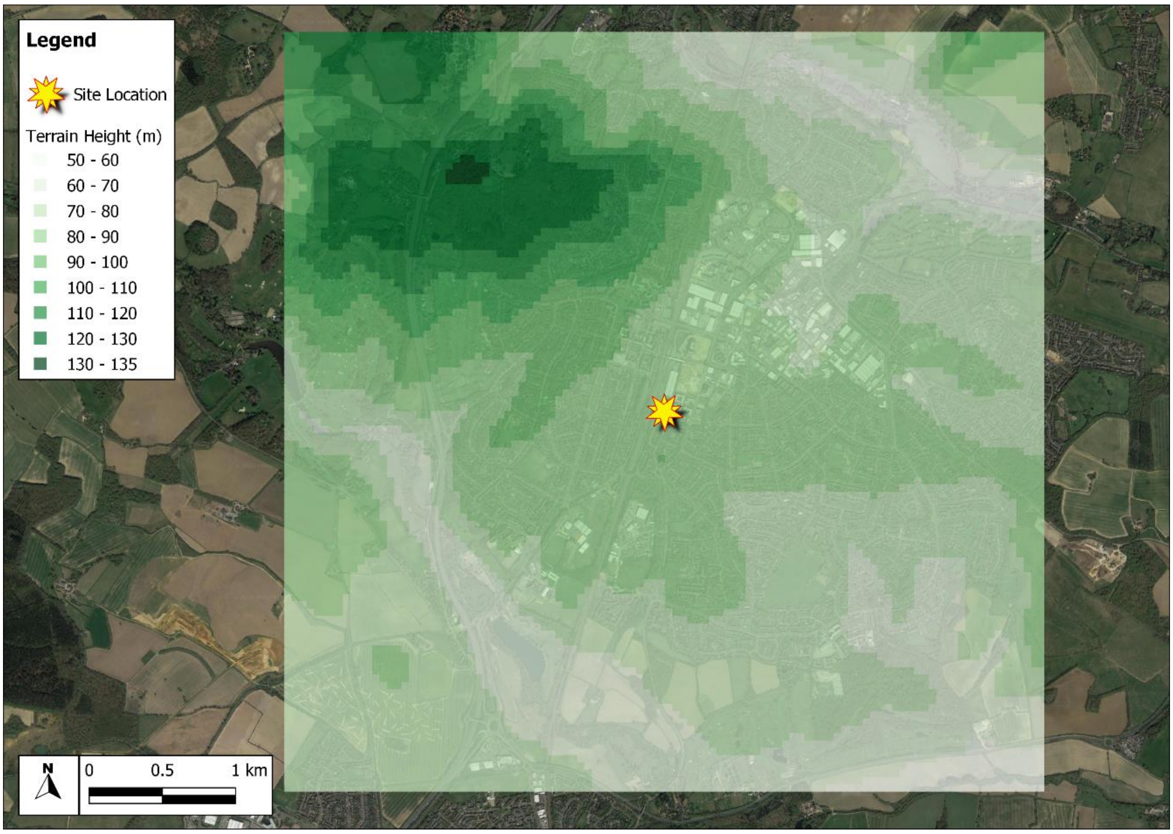

Figure A6.4.12: Modelled Terrain

Imagery © 2020 Google, Map data © 2020

Model Performance

A6.4.29 The modelling will inherently have some uncertainties and may not reflect real conditions in the local area. An important part of modelling is reviewing the model results carefully and checking the model setup parameters and input data to minimise uncertainties.

A6.4.30 LAQM.TG.16[16], provides local authorities with advice on good practice for modelling air quality. This advice is widely applied for air quality assessments of Projects, although it is specifically aimed at local authority's duties to review and assess air quality. LAQM.TG.16 states that model verification, defined as a comparison of modelled results with monitoring results at relevant locations, is necessary (paragraph 7.520).

A6.4.31 There are many reasons why there may be a difference between modelled and monitored concentrations and LAQM.TG.16 states *"Model verification is the process by which these and other uncertainties are investigated and where possible minimised."* (paragraph 7.512). It provides a list of the factors that may explain the differences including meteorological data, source activity data (e.g. traffic flow and speed), emission factors, model input parameters such as roughness length, and monitoring data.

A6.4.32 The advice in LAQM.TG.16 is generic for all dispersion models. ADMS has been shown to predict concentrations well given sufficiently accurate data inputs.

[16] Defra. (2018). Local Air Quality Management Technical Guidance (TG16). Retrieved from https://laqm.defra.gov.uk/technical-guidance/

A6.4.33 It is important to review the results of the modelling carefully and check the model setup parameters and input data. Once reasonable efforts have been made to reduce the uncertainties of input data for a model, further comparison of modelled and monitored results should be undertaken. Where discrepancies remain, consideration may be given to adjusting the model.

A6.4.34 Using good modelling techniques provides confidence that the model is performing as well as possible everywhere in the modelling area in the base year, not just at the monitoring locations. Modelling is often an iterative process of improving the model setup and evaluating the impact on model performance. The same principles need to be applied to the entire modelling study area to ensure the model performs well throughout the study area.

A6.4.35 All reasonable efforts have been made to improve the model inputs. The model has gone through several modelling iterations to consider whether the performance of the modelled inputs can be improved. Improvements are based on comparison with the measured concentrations at specific monitoring locations and where improvements have been made, they have been applied as a wholistic approach with systematic updates to the entire model study area to ensure that the model is not performing well exclusively at the monitoring locations.

A6.4.36 A final model verification exercise has been undertaken to determine whether there are any remaining discrepancies and to derive a factor with which to adjust the predicted concentrations from the model so that they match local conditions as closely as possible.

Final Model Verification

A6.4.37 A final model verification exercise has been undertaken, following the guidance set out by Defra in Box 7.14 and Box 7.15 of LAQM.TG(16)[16].

A6.4.38 Concentrations of road-NOx, road-PM_{10}, road-$PM_{2.5}$ and primary NO_2 have been predicted for the year of 2019 using the ADMS-roads dispersion model at WH18 monitoring site located north to the Project. Predictions have been made at the height of the monitor inlet.

NO_2

A6.4.39 Initially, the measured NO_2 concentrations at the monitoring sites have been inputted into Defra's NOx to NO_2 Calculator, along with the background NO_2 concentrations and f-NO_2 values, in order to obtain 'measured' road-NOx concentrations at the monitoring sites. The primary NO_2 emission factor (f-NO_2) at the monitoring site was calculated by taking the ratio of predicted primary NO_2 concentration to predicted road-NOx concentration.

A6.4.40 The predicted road-NOx concentration has then been compared to the 'measured' road-NOx concentration. An adjustment factor of 1.276 has been derived from the comparison, as set out below:

- Measured NO_2: 31.0 µg/m^3
- Background NO_2: 19.5 µg/m^3
- Measured Road-NOx: 23.3 µg/m^3
- Modelled Road-NOx: 18.2 µg/m^3
- Adjustment Factor (23.3/18.2): 1.276

A6.4.41 This factor indicates that the model is marginally underpredicting concentrations at the monitoring site. To provide a conservative assessment, all predicted road-NOx concentrations have been adjusted to match the measured 2019 concentrations at the monitoring site.

PM_{10} and $PM_{2.5}$

A6.4.42 WHBC do not operate any monitoring sites that measure roadside concentrations of $PM_{2.5}$, that are located in close proximity to the Project. In the absence of relevant monitoring sites with which to verify the model predictions of PM against, the model adjustment factor for road-NOx has been used to uplift all predicted road-PM_{10} and road-$PM_{2.5}$ concentrations.

Post Processing

Roads

A6.4.43 Concentrations of road-NOx and primary NO_2 have been predicted at each receptor using the ADMS-Roads model. The primary NO_2 emission factor (f-NO_2) at each receptor has been calculated by taking the ratio of predicted primary NO_2 concentration to road-NOx concentration.

A6.4.44 The f-NO_2 values along with the adjusted modelled road-NOx concentrations and background NO_2 concentrations have been inputted into Defra's NOx to NO_2 calculator (v8.1) in order to obtain predicted road-NO_2 concentrations at each receptor. This tool has been run assuming the traffic is described as 'All other urban UK traffic', which is considered appropriate for the traffic associated with the study area.

A6.4.45 The road-NO_2 concentrations have then been added to the background NO_2 concentrations to obtain total NO_2 concentrations at the receptors. Similarly, the adjusted road-PM_{10} and road-$PM_{2.5}$ concentrations have been added to the background PM_{10} and $PM_{2.5}$ concentrations to obtain total PM_{10} and $PM_{2.5}$ concentrations at the receptors.

Point Sources

A6.4.46 Where total concentrations are considered, the following post-processing has been carried out:

- total annual mean concentration = annual mean contributions + annual mean baseline concentration; and
- total short-term mean concentration = short-term contributions + (2 x annual mean baseline concentration).

Uncertainty and limitations

A6.4.47 The assessment involves a range of uncertainties, including the model inputs, assumptions, the model, model verification and post-processing of model results. A brief overview of the key uncertainties is discussed below.

A6.4.48 There are inherent uncertainties associated with the traffic data which has been provided as AADT flows and the percentage of vehicle types. These flows provide estimated vehicle trips as an average, but the specific routing, timing, driving conditions and driving behaviour of vehicles will vary and potentially lead to different emission levels.

A6.4.49 The emission factors also involve a considerable amount of uncertainty. Emissions from the EFT are link averages and do not explicitly take account of acceleration or deceleration. Modelled speeds have been adjusted to account for this where possible. Future year vehicle emission rates are also based on a range of factors, such as expected vehicle fleet release dates, anticipated improvements in emission reduction technologies, expected uptake rates of different vehicles based on government policies, etc. It is therefore possible that the expected future emission rates in the EFT may differ from reality. Historically, evidence had suggested that Defra's EFT exaggerated reductions in NOx emissions as expectations of reductions from diesel vehicles were included which were not seen in practice. However, analyses of recent NOx measurements now provide evidence that vehicle controls are working and as a result Defra's EFT (v9 onwards) is reflecting the rate of observed reductions and can be relied upon to give the most likely emissions. The approach of this assessment has been to utilise the EFT as recommended by Defra in the LAQM.TG(16) guidance[16].

A6.4.50 The model itself is based on assumptions of a range of parameters, including road geometries, road widths, street canyons and meteorological related parameters. There is uncertainty in all these parameters, but the modelling has been setup in a robust way based on professional experience to best represent the conditions. One of the main uncertainties in the model is meteorological data; this has been based on measurements made at a representative meteorological station, and although meteorological conditions will remain similar, it entirely likely that meteorological conditions will vary in subsequent years and lead to marginally different concentrations.

A6.4.51 The ambient background concentrations are also uncertain. While these are provided by Defra, the 1x1 km resolution is coarse, and the maps do not include all sources of pollution. Given the urban location of the Project, it is considered likely that the background maps for this area are likely to be reasonable. To minimise uncertainty in the spatial resolution of the maps, the background concentrations have been interpolated to each receptor; essentially smoothing out the coarseness of the maps.

A6.4.52 Emerging evidence (Grange, S, et al., 2017) suggests that the f-NO_2 has been decreasing in recent years, which is not taken into account within Defra's EFT or NOx to NO_2 Calculator. If lower f-NO_2 values were assumed, then the predicted concentrations would likely be slightly lower throughout the Project and local area. Until more detailed scientific analysis is undertaken to understand the full extent of why f-NO_2 is decreasing and how it will behave in the future, it remains an uncertainty.

A6.4.53 A model verification exercise has been undertaken to adjust the predicted concentrations from the model so that they match local conditions as best as possible. This has adjusted concentrations to match average conditions; some locations will remain underpredicted and some overpredicted.

A6.4.54 Although there is uncertainty associated with air quality modelling, the predictions made by this assessment have been carried out in a robust manner to minimise uncertainties where possible.