Volume 3
Appendix A
Air Quality Appendices
Greengate Energy Recovery Facility

SWECO

Air Quality Appendices:
Pilkington Greengate

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Experts in air quality
management & assessment

Document Control

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A1 Glossary

AADT	Annual Average Daily Traffic
ADMS-Roads	Atmospheric Dispersion Modelling System model for Roads
ADMS-5	Atmospheric Dispersion Modelling System model for point sources
APIS	Air Pollution Information System
AQC	Air Quality Consultants
AQAL	Air Quality Assessment Level
AQMA	Air Quality Management Area
AURN	Automatic Urban and Rural Network
CAZ	Clean Air Zone
CURED	Calculator Using Realistic Emissions for Diesels
DCLG	Department for Communities and Local Government
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DMP	Dust Management Plan
EFT	Emission Factor Toolkit
EPUK	Environmental Protection UK
Exceedance	A period of time when the concentration of a pollutant is greater than the appropriate air quality objective. This applies to specified locations with relevant exposure
EU	European Union
EV	Electric Vehicle
HDV	Heavy Duty Vehicles (> 3.5 tonnes)
HMSO	Her Majesty's Stationery Office
HGV	Heavy Goods Vehicle
IAQM	Institute of Air Quality Management
kph	Kilometres Per hour
kW	Kilowatt
LAQM	Local Air Quality Management

LDV	Light Duty Vehicles (<3.5 tonnes)
LGV	Light Goods Vehicle
LNR	Local Nature Reserve
µg/m^3	Microgrammes per cubic metre
NO	Nitric oxide
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides (taken to be NO_2 + NO)
NPPF	National Planning Policy Framework
Objectives	A nationally defined set of health-based concentrations for nine pollutants, seven of which are incorporated in Regulations, setting out the extent to which the standards should be achieved by a defined date. There are also vegetation-based objectives for sulphur dioxide and nitrogen oxides
OLEV	Office for Low Emission Vehicles
PC	Process Contribution
PEC	Predicted Environmental Concentration
PM_{10}	Small airborne particles, more specifically particulate matter less than 10 micrometres in aerodynamic diameter
$PM_{2.5}$	Small airborne particles less than 2.5 micrometres in aerodynamic diameter
PPG	Planning Practice Guidance
RDE	Real Driving Emissions
SAC	Special Area of Conservation
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
Standards	A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal
TEA	Triethanolamine – used to absorb nitrogen dioxide
TEMPro	Trip End Model Presentation Program
WHO	World Health Organisation

A2 Construction Dust Assessment Procedure

A2.1 The criteria developed by IAQM (2016) divide the activities on construction sites into four types to reflect their different potential impacts. These are:

- demolition;
- earthworks;
- construction; and
- trackout.

A2.2 The assessment procedure includes the four steps summarised below:

STEP 1: Screen the Need for a Detailed Assessment

A2.3 An assessment is required where there is a human receptor within 350 m of the boundary of the site and/or within 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site entrance(s), or where there is an ecological receptor within 50 m of the boundary of the site and/or within 50 m of the route(s) used by construction vehicles on the public highway, up to 500 m from the site entrance(s).

A2.4 Where the need for a more detailed assessment is screened out, it can be concluded that the level of risk is *negligible* and that any effects will be 'not significant'. No mitigation measures beyond those required by legislation will be required.

STEP 2: Assess the Risk of Dust Impacts

A2.5 A site is allocated to a risk category based on two factors:

- the scale and nature of the works, which determines the potential dust emission magnitude (Step 2A); and
- the sensitivity of the area to dust effects (Step 2B).

A2.6 These two factors are combined in Step 2C, which is to determine the risk of dust impacts with no mitigation applied. The risk categories assigned to the site may be different for each of the four potential sources of dust (demolition, earthworks, construction and trackout).

Step 2A – Define the Potential Dust Emission Magnitude

A2.7 Dust emission magnitude is defined as either 'Small', 'Medium', or 'Large'. The IAQM guidance explains that this classification should be based on professional judgement, but provides the examples in Table A2.1.

Table A2.1: Examples of How the Dust Emission Magnitude Class May be Defined

Class	Examples
Demolition	
Large	Total building volume >50,000 m^3, potentially dusty construction material (e.g. concrete), on site crushing and screening, demolition activities >20 m above ground level
Medium	Total building volume 20,000 m3 – 50,000 m^3, potentially dusty construction material, demolition activities 10-20 m above ground level
Small	Total building volume <20,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber), demolition activities <10 m above ground, demolition during wetter months
Earthworks	
Large	Total site area >10,000 m^2, potentially dusty soil type (e.g. clay, which will be prone to suspension when dry to due small particle size), >10 heavy earth moving vehicles active at any one time, formation of bunds >8 m in height, total material moved >100,000 tonnes
Medium	Total site area 2,500 m^2 – 10,000 m^2, moderately dusty soil type (e.g. silt), 5-10 heavy earth moving vehicles active at any one time, formation of bunds 4 m – 8 m in height, total material moved 20,000 tonnes – 100,000 tonnes
Small	Total site area <2,500 m^2, soil type with large grain size (e.g. sand), <5 heavy earth moving vehicles active at any one time, formation of bunds <4 m in height, total material moved <10,000 tonnes, earthworks during wetter months
Construction	
Large	Total building volume >100,000 m^3, piling, on site concrete batching; sandblasting
Medium	Total building volume 25,000 m^3 – 100,000 m^3, potentially dusty construction material (e.g. concrete), piling, on site concrete batching
Small	Total building volume <25,000 m^3, construction material with low potential for dust release (e.g. metal cladding or timber)
Trackout [a]	
Large	>50 HDV (>3.5t) outward movements in any one day, potentially dusty surface material (e.g. high clay content), unpaved road length >100 m
Medium	10-50 HDV (>3.5t) outward movements in any one day, moderately dusty surface material (e.g. high clay content), unpaved road length 50 m – 100 m
Small	<10 HDV (>3.5t) outward movements in any one day, surface material with low potential for dust release, unpaved road length <50 m

[a] These numbers are for vehicles that leave the site after moving over unpaved ground.

Step 2B – Define the Sensitivity of the Area

A2.8 The sensitivity of the area is defined taking account of a number of factors:

- the specific sensitivities of receptors in the area;
- the proximity and number of those receptors;
- in the case of PM_{10}, the local background concentration; and
- site-specific factors, such as whether there are natural shelters to reduce the risk of wind-blown dust.

A2.9 The first requirement is to determine the specific sensitivities of local receptors. The IAQM guidance recommends that this should be based on professional judgment, taking account of the principles in Table A2.2. These receptor sensitivities are then used in the matrices set out in Table A2.3, Table A2.4 and Table A2.5 to determine the sensitivity of the area. Finally, the sensitivity of the area is considered in relation to any other site-specific factors, such as the presence of natural shelters etc., and any required adjustments to the defined sensitivities are made.

Step 2C – Define the Risk of Impacts

A2.10 The dust emission magnitude determined at Step 2A is combined with the sensitivity of the area determined at Step 2B to determine the *risk* of impacts with no mitigation applied. The IAQM guidance provides the matrix in Table A2.6 as a method of assigning the level of risk for each activity.

STEP 3: Determine Site-specific Mitigation Requirements

A2.11 The IAQM guidance provides a suite of recommended and desirable mitigation measures which are organised according to whether the outcome of Step 2 indicates a low, medium, or high risk. The list provided in the IAQM guidance has been used as the basis for the requirements set out in Appendix A7.

STEP 4: Determine Significant Effects

A2.12 The IAQM guidance does not provide a method for assessing the significance of effects before mitigation, and advises that pre-mitigation significance should not be determined. With appropriate mitigation in place, the IAQM guidance is clear that the residual effect will normally be 'not significant'.

A2.13 The IAQM guidance recognises that, even with a rigorous dust management plan in place, it is not possible to guarantee that the dust mitigation measures will be effective all of the time, for instance under adverse weather conditions. The local community may therefore experience occasional, short-term dust annoyance. The scale of this would not normally be considered sufficient to change the conclusion that the effects will be 'not significant'.

Table A2.2: Principles to be Used When Defining Receptor Sensitivities

Class	Principles	Examples
Sensitivities of People to Dust Soiling Effects		
High	users can reasonably expect enjoyment of a high level of amenity; or the appearance, aesthetics or value of their property would be diminished by soiling; and the people or property would reasonably be expected a to be present continuously, or at least regularly for extended periods, as part of the normal pattern of use of the land	dwellings, museum and other culturally important collections, medium and long term car parks and car showrooms
Medium	users would expect to enjoy a reasonable level of amenity, but would not reasonably expect to enjoy the same level of amenity as in their home; or the appearance, aesthetics or value of their property could be diminished by soiling; or the people or property wouldn't reasonably be expected to be present here continuously or regularly for extended periods as part of the normal pattern of use of the land	parks and places of work
Low	the enjoyment of amenity would not reasonably be expected; or there is property that would not reasonably be expected to be diminished in appearance, aesthetics or value by soiling; or there is transient exposure, where the people or property would reasonably be expected to be present only for limited periods of time as part of the normal pattern of use of the land	playing fields, farmland (unless commercially-sensitive horticultural), footpaths, short term car parks and roads
Sensitivities of People to the Health Effects of PM_{10}		
High	locations where members of the public may be exposed for eight hours or more in a day	residential properties, hospitals, schools and residential care homes
Medium	locations where the people exposed are workers, and where individuals may be exposed for eight hours or more in a day.	may include office and shop workers, but will generally not include workers occupationally exposed to PM_{10}
Low	locations where human exposure is transient	public footpaths, playing fields, parks and shopping streets
Sensitivities of Receptors to Ecological Effects		
High	locations with an international or national designation and the designated features may be affected by dust soiling; or locations where there is a community of a particularly dust sensitive species	Special Areas of Conservation with dust sensitive features
Medium	locations where there is a particularly important plant species, where its dust sensitivity is uncertain or unknown; or locations with a national designation where the features may be affected by dust deposition	Sites of Special Scientific Interest with dust sensitive features
Low	locations with a local designation where the features may be affected by dust deposition	Local Nature Reserves with dust sensitive features

Table A2.3: Sensitivity of the Area to Dust Soiling Effects on People and Property [1]

Receptor Sensitivity	Number of Receptors	Distance from the Source (m)			
		<20	<50	<100	<350
High	>100	High	High	Medium	Low
	10-100	High	Medium	Low	Low
	1-10	Medium	Low	Low	Low
Medium	>1	Medium	Low	Low	Low
Low	>1	Low	Low	Low	Low

[1] For demolition, earthworks and construction, distances are taken either from the dust source or from the boundary of the site. For trackout, distances are measured from the sides of roads used by construction traffic. Without mitigation, trackout may occur from roads up to 500 m from sites with a *large* dust emission magnitude, 200 m from sites with a *medium* dust emission magnitude and 50 m from sites with a *small* dust emission magnitude, as measured from the site exit. The impact declines with distance from the site, and it is only necessary to consider trackout impacts up to 50 m from the edge of the road.

Table A2.4: Sensitivity of the Area to Human Health Effects [1]

Receptor Sensitivity	Annual Mean PM_{10}	Number of Receptors	Distance from the Source (m)				
			<20	<50	<100	<200	<350
High	>32 µg/m^3	>100	High	High	High	Medium	Low
		10-100	High	High	Medium	Low	Low
		1-10	High	Medium	Low	Low	Low
	28-32 µg/m^3	>100	High	High	Medium	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	High	Medium	Low	Low	Low
	24-28 µg/m^3	>100	High	Medium	Low	Low	Low
		10-100	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	<24 µg/m^3	>100	Medium	Low	Low	Low	Low
		10-100	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Medium	>32 µg/m^3	>10	High	Medium	Low	Low	Low
		1-10	Medium	Low	Low	Low	Low
	28-32 µg/m^3	>10	Medium	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	24-28 µg/m^3	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
	<24 µg/m^3	>10	Low	Low	Low	Low	Low
		1-10	Low	Low	Low	Low	Low
Low	-	>1	Low	Low	Low	Low	Low

Table A2.5: Sensitivity of the Area to Ecological Effects [1]

Receptor Sensitivity	Distance from the Source (m)	
	<20	<50
High	High	Medium
Medium	Medium	Low
Low	Low	Low

Table A2.6: Defining the Risk of Dust Impacts

Sensitivity of the Area	Dust Emission Magnitude		
	Large	Medium	Small
Demolition			
High	High Risk	Medium Risk	Medium Risk
Medium	High Risk	Medium Risk	Low Risk
Low	Medium Risk	Low Risk	Negligible
Earthworks			
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Medium Risk	Low Risk
Low	Low Risk	Low Risk	Negligible
Construction			
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Medium Risk	Low Risk
Low	Low Risk	Low Risk	Negligible
Trackout			
High	High Risk	Medium Risk	Low Risk
Medium	Medium Risk	Low Risk	Negligible
Low	Low Risk	Low Risk	Negligible

A3 Meteorological Data

Table A3.1: Summary of Meteorological Input Parameters

Parameter	Value	
	Dispersion site	Liverpool Airport
Surface roughness	1.0	0.2
Surface albedo	Default	Default
Minimum Monin-Obukhov length (m)	30	10
Priestley-Taylor parameter	Default	Default
Met data in sectors (degrees)	10	
Met data are hourly sequential	Yes	

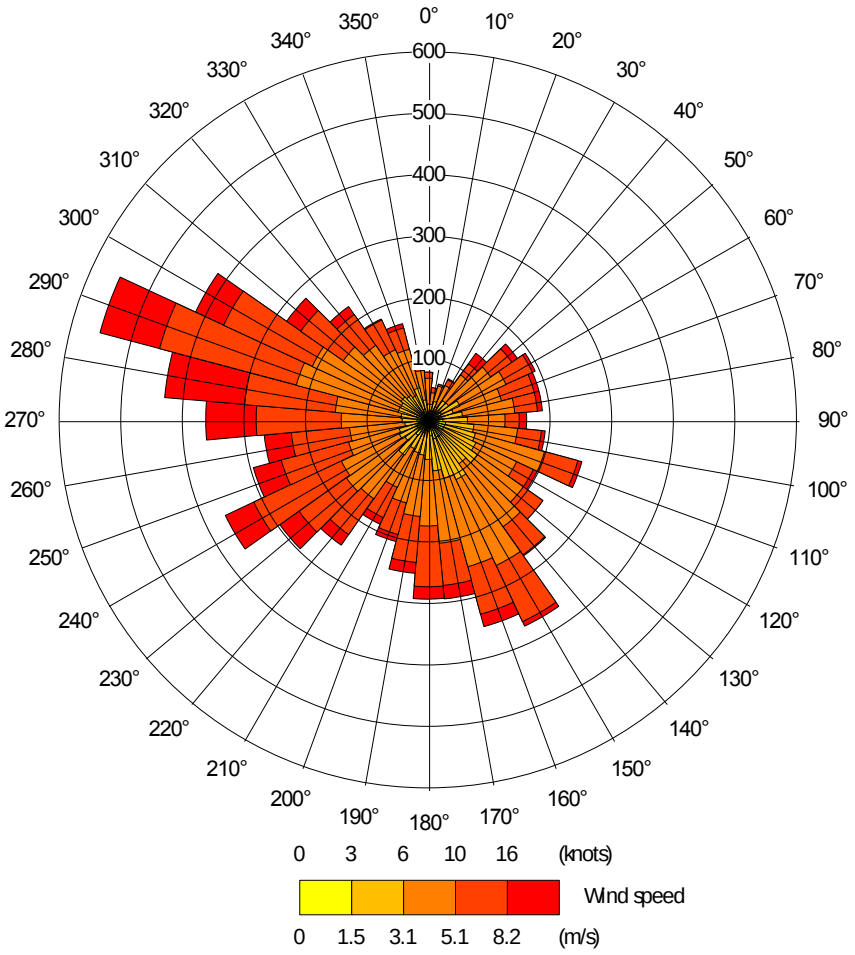

Figure A3.1: Liverpool Airport Wind Rose for 2012

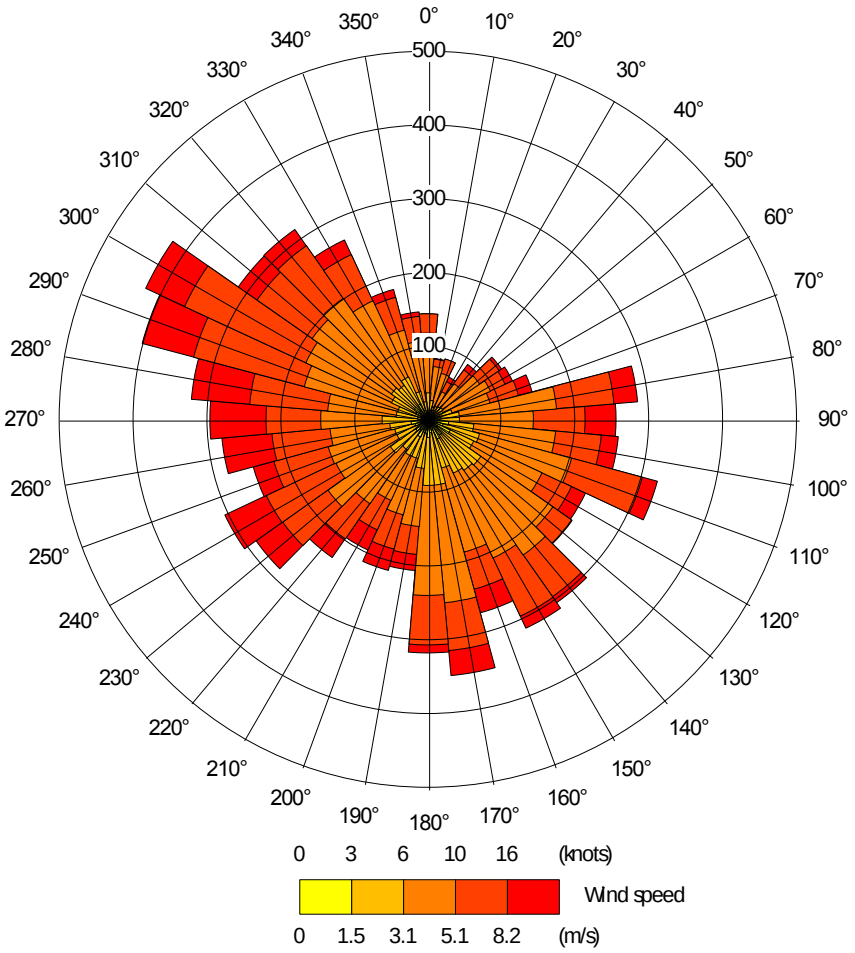

Figure A3.2: Liverpool Airport Wind Rose for 2013

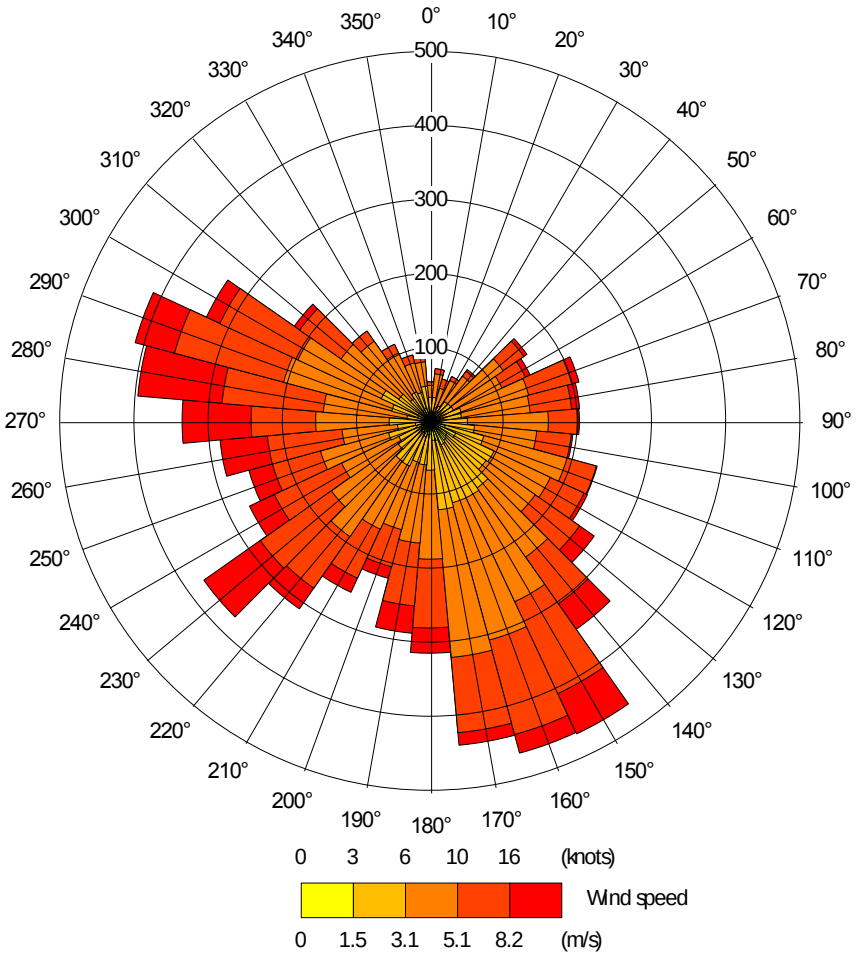

Figure A3.3: Liverpool Airport Wind Rose for 2014

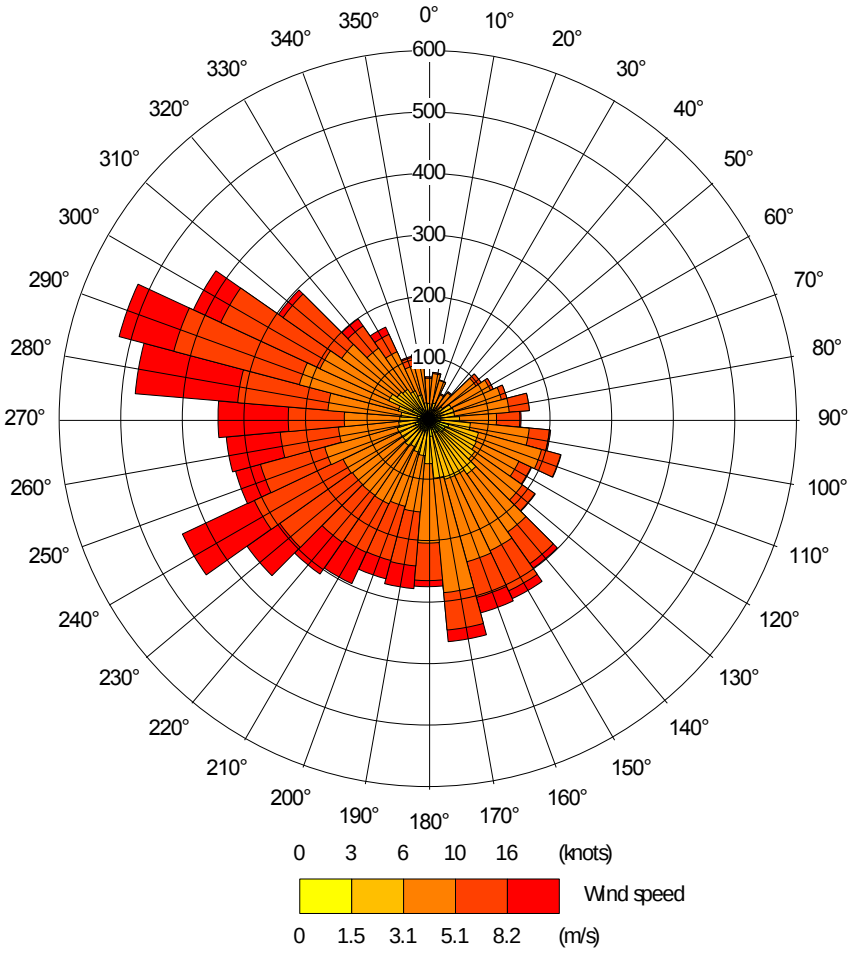

Figure A3.4: Liverpool Airport Wind Rose for 2015

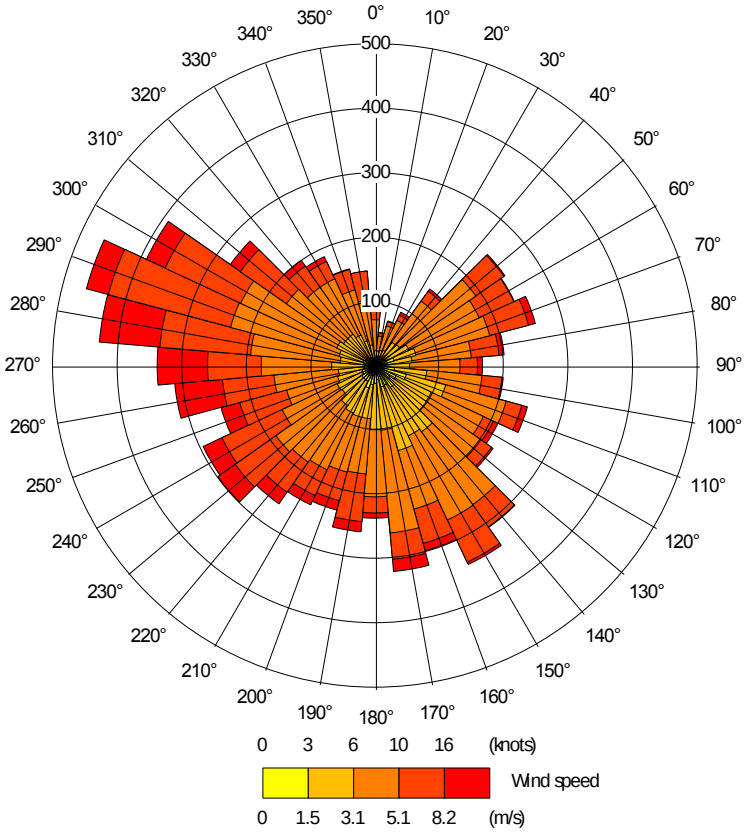

Figure A3.5: Liverpool Airport Wind Rose for 2016

A4 Modelling Methodology

Model Inputs

Main Stack Emissions

A4.1 The emissions parameters and model inputs for the main stack serving the proposed development are set out in Table A4.1 and Table A4.2. emission rates in Table A4.2 for averaging periods of 24 hours or more have been calculated using the Average Operation values from Table A4.1, while short-term emission rates have been calculated using the Peak Operation values.

Table A4.1: Emission Parameters for the Proposed Development

Stack Parameter	Average Operation [a]	Peak Operation [a]
Exit Velocity (m/s)	14.9	20.2
Normalised[2] Volume Flow Rate (Nm^3/s)	59.8	80.7
Actual Volume Flow Rate (m^3/s)	88.6	119.7
Exhaust Temperature (˚C)	130	
Stack Internal Diameter (m)	2.75	
Stack Height Above Ground-Level (m)	80.0	
Stack Location (O.S. x,y)	350907, 394194	

[a] rounded numbers are presented here but unrounded numbers were input into the model.

Table A4.2: Modelled Emission Rates

Pollutant	Concentration Averaging Period [a]	Emissions (g/s) [b]
Nitrogen oxides	1-hour mean	32
	annual mean	12 [c]
PM_{10}	24-hour mean	0.60
	annual mean	0.60
SO_2	1-hour and 15-minute means	16
	annual mean	3.0
CO	rolling 8-hour mean	8.1

[2] Throughout these appendices and the air quality chapter, 'normal' ('N') is used to refer to conditions recorded in the absence of moisture, at 11% oxygen, and at 0 degrees Celsius. These are the reference conditions at which the relevant IED emissions limits are expressed.

Pollutant	Concentration Averaging Period [a]	Emissions (g/s) [b]
TOC	1-hour mean	1.6
	annual mean	0.60
HCl	1-hour mean	4.8
	annual mean	0.60
HF	1-hour mean	0.32
	annual mean	0.060
Cd and Tl	annual mean	0.0030
Hg	1-hour mean	0.0040
	annual mean	0.0030
Group III metals	1-hour mean	0.030
	annual mean	
NH_3	1-hour mean	0.60
	annual mean	
Dioxins and furans	annual mean	0.0000000060

[a] i.e. the averaging periods set in the air quality objectives and EALs over which concentrations have been predicted.

[b] rounded numbers (to two significant figures) are presented here but unrounded numbers were input into the model.

[c] This is based on the 200 mg/Nm^3 IED limit.

A4.2 For most of the group III metals shown in Table A4.2, when assessing against each of the EALs for each metal in turn, it has been assumed that the total group III metals emission rate is made up entirely of that metal. This is a worst-case approach. For some pollutants, in particular chromium VI, it is not possible to screen out the potential for significant impacts using this method. Therefore the more detailed approach set out by the Environment Agency in its Interim Guidance Note for Metals (Environment Agency, 2016b) has been used. This includes two steps. The first step is what has initially been assumed in this assessment; that the total group III metals emission rate is made up entirely of each metal in turn. The second step involves using typical emission concentrations for energy from waste plant as set out in Table A4.3.

Table A4.3: Typical Emission Concentrations for Energy from Waste Plant (mg/Nm^3)

Pollutant	Maximum	Mean	Minimum
Arsenic	0.0250	0.0010	0.0002
Chromium VI	0.00013	0.000035	0.0000023

A4.3 It is considered that, given the similarity of the proposed facility and its fuel source to those included in the Environment Agency guidance, it is appropriate to use the emission concentrations set out above for chromium VI. The amended mass emission rates are shown in Table A4.4. These amended emission rates have been used in the assessment.

Table A4.4: Mass Emission Rates (g/s)

Pollutant	Maximum	Mean	Minimum
Arsenic	0.001495	0.000060	0.000012
Chromium VI	0.0000078	0.0000021	0.00000014

A4.4 Entrainment of the plume into the wake of the buildings (the so-called building downwash effect) has been taken into account in the model. The building included in the model is shown in Figure A4.1.

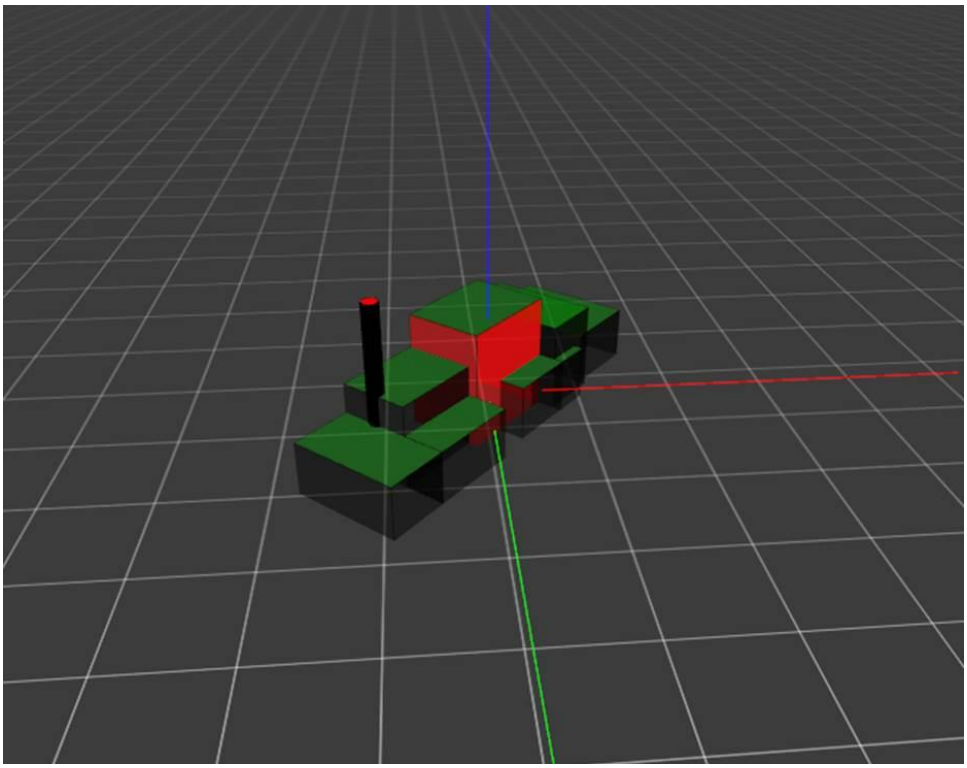

Figure A4.1: Modelled Buildings

Backup Diesel Generator

A4.5 The assumed emission parameters for the backup diesel generator are set out in Table A4.5.

Table A4.5: Diesel Generator Emission Parameters

Parameter	Value
Estimated Flue Internal Diameter (m)	0.35
Calculated Actual Exhaust Volume Flow	3.61
Calculated Exit Velocity (m/s)	37.5
Estimated NOx Emission Rate (mg/kWh)	19,000
Calculated Gross Fuel Input (kW)	2,668
Calculated NOx Emission Rate (g/s)	5.63
Estimated Exhaust Temperature (°C)	450
Stack Height Above Ground-Level (m)	2.5
Stack Location (O.S. x, y)	351031, 394302

A4.6 The backup generator plant will operate for maintenance and testing for 25 hours per year in accordance with the maintenance schedule. The exhaust volume flow rate for the diesel generator has been calculated based on the complete combustion of the assumed diesel oil composition in Table A4.6.

Table A4.6: Typical Diesel Fuel Composition

Elemental Component	Diesel Oil
Carbon	86.5%
Hydrogen	13.2%
Oxygen	0.3%
Net Calorific Value (LHV) (MJ/kg)	42.82
Gross Calorific Value (HHV) (MJ/kg)	45.70
HHV/LHV	1.07
Liquid Density @ 15°C (kg/m^3)	835

A4.7 Entrainment of the plume into the wake of the buildings has been taken into account in the model; the modelled buildings are shown in Figure A4.1. The generator flue has been modelled at a height of 2.5 m and its assumed location is shown in Figure A4.2.

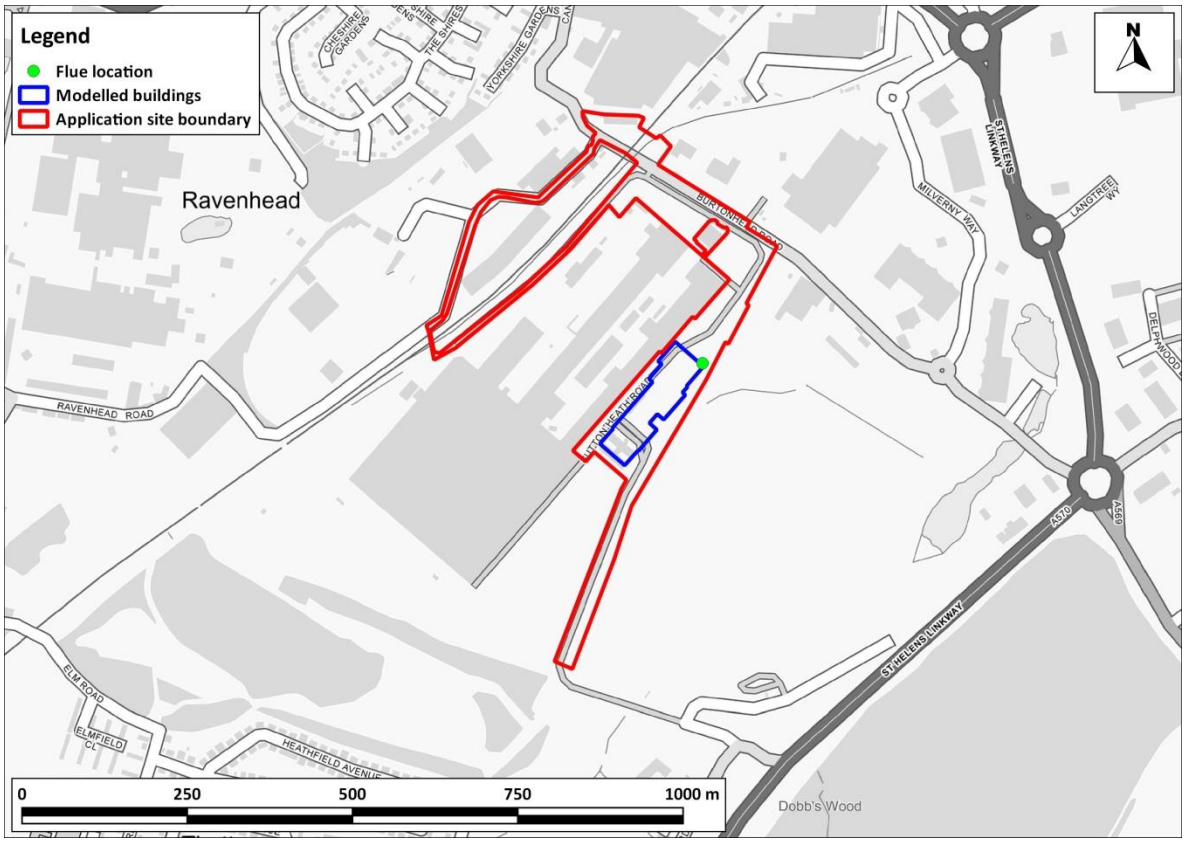

Figure A4.2: Generator Flue Location

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Road Traffic

A4.8 Predictions have been carried out using the ADMS-Roads dispersion model (v4.1). The model requires the user to provide various input data, including emissions from each section of road and the road characteristics (including road width, street canyon width, street canyon height and porosity, where applicable). Vehicle emissions have been calculated based on vehicle flow, composition and speed data using the EFT (Version 8.0.1) published by Defra (2018d).

A4.9 Hourly sequential meteorological data from Liverpool Airport for 2016 have been used in all of the road traffic modelling.

A4.10 For the purposes of modelling, it has been assumed that the buildings on Prescot Road and Borough Road form street canyons. These roads have a number of canyon-like features, which reduce dispersion of traffic emissions, and can lead to concentrations of pollutants being higher here than they would be in areas with greater dispersion. They have, therefore, been modelled as street canyons using ADMS-Roads' advanced canyon module, with appropriate input parameters determined from plans, on-site measurements, local mapping and photographs.

A4.11 AADT flows, and the proportions of HDVs, for roads to the south and east of the proposed development site have been provided by Sweco, who have undertaken the transport assessment work for the proposed development. AADT flows, and the proportions of HDVs, for roads to the north and west of the proposed development site have been determined from the interactive web-based map provided by DfT (2018). The 2016 AADT flows have been factored forwards to the assessment year of 2023 using growth factors derived using the TEMPro System v7.2 (DfT, 2017a). Traffic speeds have been estimated based on professional judgement, taking account of the road layout, speed limits and the proximity to a junction. The traffic data used in this assessment are summarised in Table A4.7. Diurnal and monthly flow profiles for the traffic have been derived from the national profiles published by DfT (2017b).

Table A4.7: Summary of Traffic Data used in the Assessment (AADT Flows)

Road Link	2016		2023 (Without Scheme)		2023 (With Scheme)	
	AADT	%HDV	AADT	%HDV	AADT	%HDV
Prescot Road west of Borough Road	24,202	3.5	26,235	3.5	26,235	3.5
Prescot Road adjacent to Borough Road	9,463	4.2	9,463	4.2	9,463	4.2
Borough Road	9,812	6.5	9,812	6.5	9,812	6.5
Westfield Street	23,507	5.1	23,507	5.1	23,507	5.1
Dunriding Lane	12,101	3.5	12,101	3.5	12,101	3.5
Boundary Road	12,101	3.5	12,101	3.5	12,101	3.5
Eccleston Street	12,101	3.5	12,101	3.5	12,101	3.5
Kirkland Street	14,406	4.7	14,406	4.7	14,406	4.7
King Street	19,078	2.5	19,078	2.5	19,078	2.5
Westfield Street	19,078	2.5	19,078	2.5	19,078	2.5
Linkway West	32,255	2.6	32,255	2.6	32,255	2.6
Peasley Cross Lane	-	-	11,474	2.0	11,474	2.0
Sherdley Road east of St Helens Linkway	-	-	11,474	2.0	11,474	2.0
Sutton Road	-	-	11,474	2.0	11,474	2.0
Marshalls Cross Road	-	-	11,474	2.0	11,474	2.0
Sutton Heath Road west of Sherdley Road	777	5.0	1,120	12.6	1,296	21.4
Sutton Heath Road east of Sherdley Road	6,699	1.8	8,192	2.8	8,354	4.4
Sherdley Road	5,922	1.4	7,202	1.2	7,216	1.2
St Helens Linkway north of Sutton Heath Road	29,244	3.5	32,837	3.7	32,951	4.0
St Helens Linkway south of Sutton Heath Road	23,802	4.5	26,282	4.7	26,378	4.9

A4.12 Figure A4.3 shows the road network included within the model, along with the speed at which each link was modelled.

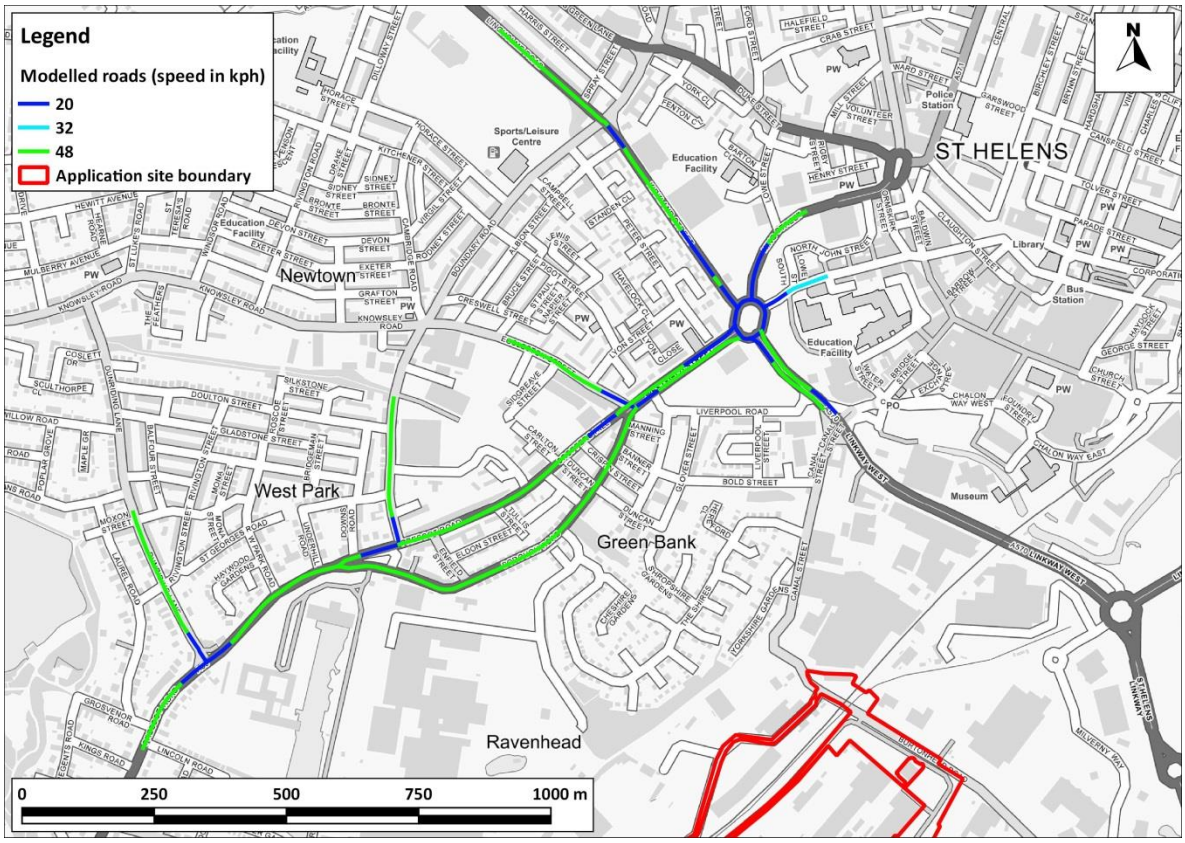

Figure A4.3: Modelled Road Network & Speeds to the North and West of the Proposed Development

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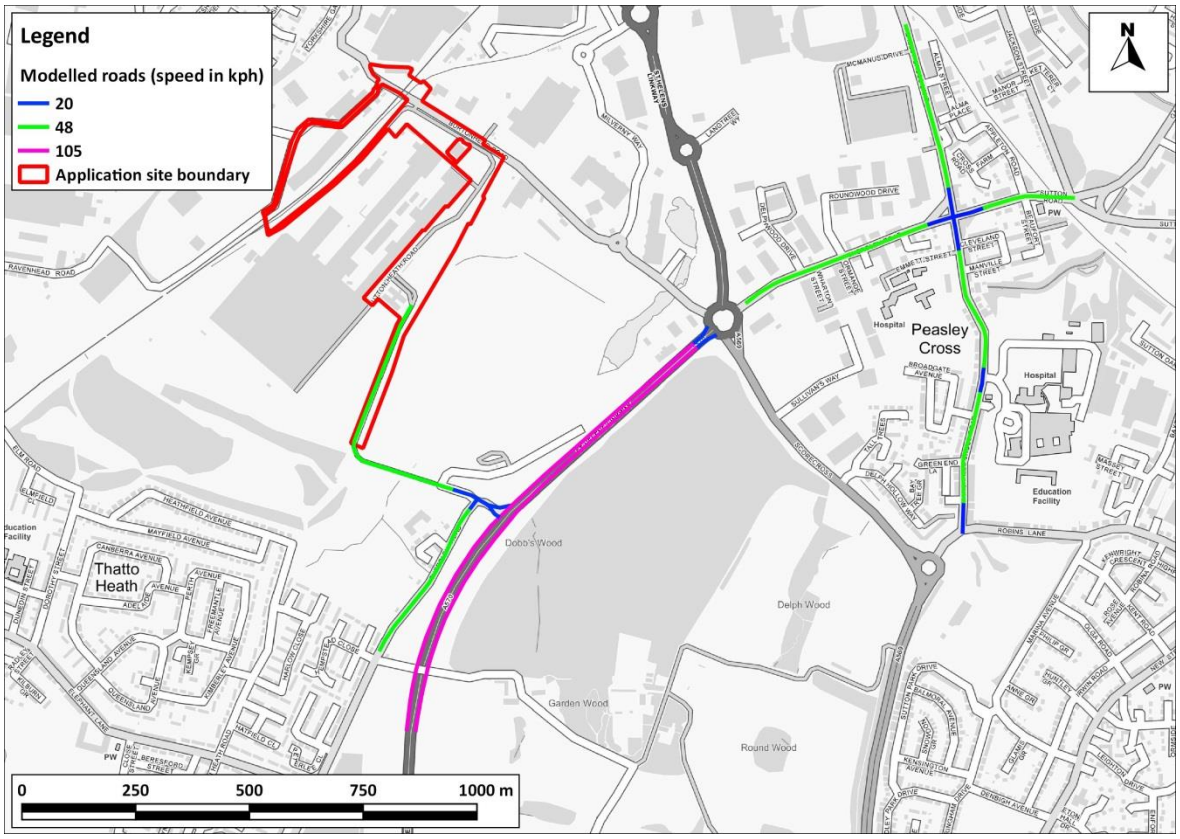

Figure A4.4: Modelled Road Network & Speeds to the South and East of the Proposed Development

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Sensitivity Test for Nitrogen Oxides and Nitrogen Dioxide

A4.13 AQC has carried out a detailed analysis which showed that, whereas previous standards had had limited on-road success in reducing nitrogen oxides emissions from diesel vehicles, the 'Euro VI' and 'Euro 6' standards are delivering real on-road improvements (AQC, 2016). Defra's EFT v8.0.1 takes account of these observed improvements, but also makes additional assumptions regarding the performance of diesel cars and vans that will be produced in the future. In particular, it assumes that diesel cars and vans registered for type approval after 2020 will, on average, emit significantly less NOx than earlier models. A sensitivity test has been carried out using AQC's CURED v3A model (AQC, 2017), which assumes that this post-2020 technology does not deliver any benefits (as a worst-case assumption). Further details of CURED v3A are provided in the supporting report prepared by AQC (2018a).

Background NOx, NO_2, PM_{10} and $PM_{2.5}$ Concentrations

A4.14 The background annual mean nitrogen oxides, nitrogen dioxide, PM_{10} and $PM_{2.5}$ concentrations across the study area have been defined using the national pollution maps published by Defra (2018d). These cover the whole of the UK on a 1x1 km grid and are published for each year from 2015 until 2030. The background nitrogen oxides and nitrogen dioxide maps for 2016 have been calibrated against concurrent measurements from national monitoring sites (AQC, 2018b). The calibration factor calculated has also been applied to future year backgrounds. This has resulted in slightly higher predicted nitrogen oxides and nitrogen dioxide concentrations for the future assessment year than those derived from the Defra maps.

Background NO_2 and NOx Concentrations for Sensitivity Test

A4.15 The road-traffic components of nitrogen oxides and nitrogen dioxide in the background maps have been uplifted in order to derive future year background nitrogen dioxide and nitrogen oxides concentrations for use in the sensitivity test. Details of the approach are provided in the report prepared by AQC (2018c).

Model Verification

A4.16 In order to ensure that ADMS-Roads accurately predicts local concentrations, it is necessary to verify the model against local measurements. It is not practical, nor usual, to verify the ADMS-5 model, and, because ADMS-5 does not rely on estimated road-vehicle emission factors, the adjustment used for ADMS-Roads cannot be applied to ADMS-5. Predictions made using ADMS-5 have thus not been verified.

Nitrogen Dioxide

A4.17 Most nitrogen dioxide (NO_2) is produced in the atmosphere by reaction of nitric oxide (NO) with ozone. It is therefore most appropriate to verify the model in terms of primary pollutant emissions of nitrogen oxides (NOx = NO + NO_2). The model has been run to predict the annual mean NOx concentrations during 2016 at the Linkway, Borough Road and Prescot Road monitoring sites. Concentrations have been modelled at the individual heights of the monitors.

A4.18 The model output of road-NOx (i.e. the component of total NOx coming from road traffic) has been compared with the 'measured' road-NOx. Measured road-NOx has been calculated from the measured NO_2 concentrations and the predicted background NO_2 concentration using the NOx from NO_2 calculator (Version 6.1) available on the Defra LAQM Support website (Defra, 2018d).

A4.19 An adjustment factor based on the Linkway and Borough Road monitors has been determined as the slope of the best-fit line between the 'measured' road contribution and the model derived road contribution, forced through zero (Figure A4.5). The calculated adjustment factor of 2.461 has

been applied to the modelled road-NOx concentration for each receptor to provide adjusted modelled road-NOx concentrations.

A4.20 The total nitrogen dioxide concentrations have then been determined by combining the adjusted modelled road-NOx concentrations with the predicted background NO_2 concentration within the NOx to NO_2 calculator. Figure A4.6 compares final adjusted modelled total NO_2 at each of the monitoring sites on Linkway and Borough Road to measured total NO_2, and shows a close agreement.

A4.21 The factor implies that the unadjusted model is under-predicting the road-NOx contribution. This is a common experience with this and most other road traffic emissions dispersion models.

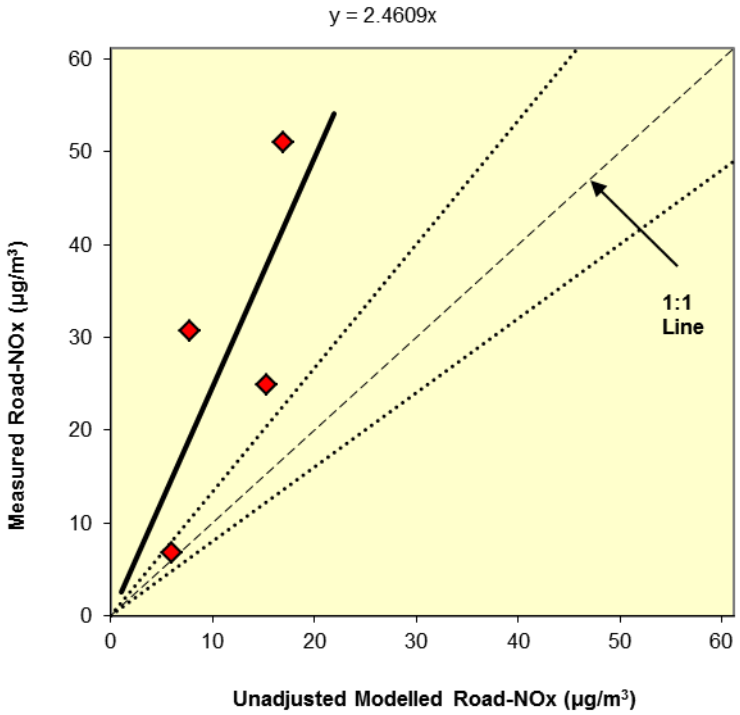

Figure A4.5: Comparison of Measured Road NOx to Unadjusted Modelled Road NOx Concentrations. The dashed lines show ± 25%.

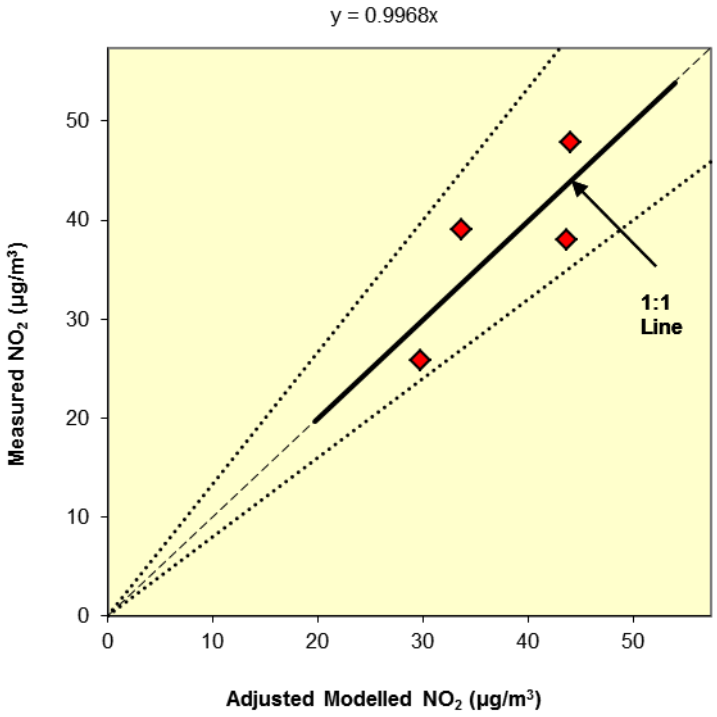

Figure A4.6: Comparison of Measured Total NO_2 to Final Adjusted Modelled Total NO_2 Concentrations. The dashed lines show ± 25%.

A4.22 When adjusted using the factor described above, the model over-predicts significantly along a short section of Croppers Hill, running alongside Jubilee Barracks. This is known because the Prescott Road monitoring site, which is located opposite the Barracks, has consistently, over a number of years, measured much lower concentrations than are predicted by the model. Because monitoring is carried out along this section of road, it is considered appropriate to ensure that these measurements are matched by the model; even though this means applying a bespoke model adjustment just for those receptors within the street canyon formed by the Barracks building itself. The data used to calculate the Prescot Road adjustment factor are provided below:

- Measured NO_2 : 26.5 µg/m^3
- Background NO_2 : 25.0 µg/m^3
- 'Measured' road-NOx (using NOx from NO_2 calculator): 2.9 µg/m^3
- Modelled road-NOx = 24.1 µg/m^3
- Road-NOx adjustment factor: 2.9/24.1 = **0.120**[3]

[3] Based on un-rounded values.

A4.23 The Prescot Road monitoring site has not been included within the verification and adjustment applied to other receptors (i.e. all receptors outside of the canyon formed by Jubilee Barracks). This is because including this site would have resulted in lower predicted concentrations and omitting it is thus worst-case. This will, however, mean that concentrations will have been over-predicted in any other areas that are similar to Prescot Road but which do not contain any monitoring sites.

PM_{10} and $PM_{2.5}$

A4.24 The model has also been run to predict annual mean road-PM_{10} concentrations during 2016. In order to calculate a verification factor for PM_{10} a similar process to calculating the road-NOx adjustment factor has been followed.

A4.25 The measured road-PM_{10} and modelled road-PM_{10} concentrations are compared to provide the factor for PM_{10}. The data used to calculate the adjustment factor are provided below:

- Measured PM_{10}: 19 µg/m^3
- Background PM_{10} : 13.6 µg/m^3
- 'Measured' road-PM_{10} (measured – background): 19 –13.6 = 5.4 µg/m^3
- Modelled road-PM_{10} = 1.26 µg/m^3
- Road-PM_{10} adjustment factor: 5.4/1.26 = **4.29**

A4.26 There are no nearby $PM_{2.5}$ monitors. It has therefore not been possible to verify the model for $PM_{2.5}$. The model outputs of road-$PM_{2.5}$ have therefore been adjusted by applying the adjustment factor calculated for road PM_{10}.

Model Post-processing

Point Sources

A4.27 Details of the post-processing for the stack emissions and diesel generator are provided in the main air quality chapter.

Road Traffic

A4.28 The model predicts road-NOx concentrations at each receptor location. These concentrations have been adjusted using the adjustment factor set out above, which, along with the background NO_2, has been processed through the NOx to NO_2 calculator available on the Defra LAQM Support website (Defra, 2018d). The traffic mix within the calculator has been set to "All other urban UK traffic", which is considered suitable for the study area. The calculator predicts the component of NO_2 based on the adjusted road-NOx and the background NO_2.

Deposition Rates

A4.29 Deposition has not been included within the dispersion model because the principal depositing component of concern is nitrogen dioxide and this is calculated from nitrogen oxides outside of the model. Instead, deposition has been calculated from the predicted ambient concentrations using the deposition velocities set out in Table A4.8. Deposition velocities refer to a height above ground, typically 1 or 2 m, although in practice the precise height makes little difference and here they have been applied to concentrations predicted at a height of 1.5 m above ground. The velocities are applied simply by multiplying a concentration ($\mu g/m^3$) by the velocity (m/s) to predict a deposition flux ($\mu g/m^2/s$).

Table A4.8: Deposition Velocities Used in This Assessment

Pollutant	Deposition Velocity (m/s)	Reference
Nitrogen Dioxide	0.0015 m/s (Grassland)	AQTAG06 (Environment Agency, 2011)
Sulphur Dioxide	0.012 m/s (Grassland)	AQTAG06 (Environment Agency, 2011)
Hydrogen Chloride	0.025 m/s (Grassland)	AQTAG06 (Environment Agency, 2011)
Ammonia	0.02 m/s (Grassland)	AQTAG06 (Environment Agency, 2011)

A4.30 Wet deposition has been discounted. Wet deposition of the emitted pollutants this close to the emission source will be restricted to wash-out, or below cloud scavenging. For this to occur, rain droplets must come into contact with the gas molecules before they hit the ground. Falling raindrops displace the air around them, effectively pushing gasses away. The low solubility of nitrogen dioxide means that any scavenging of this gas will be a negligible factor. While wash-out of sulphur dioxide might be more significant, the very low sulphur oxide emission rates mean that discounting wet deposition is highly unlikely to affect the outcomes of the assessment.

A5 EPUK & IAQM Planning for Air Quality Guidance

A5.1 The guidance issued by EPUK and IAQM (Moorcroft and Barrowcliffe et al, 2017) is comprehensive in its explanation of the place of air quality in the planning regime. Key sections of the guidance not already mentioned above are set out below.

Air Quality as a Material Consideration

"Any air quality issue that relates to land use and its development is capable of being a material planning consideration. The weight, however, given to air quality in making a planning application decision, in addition to the policies in the local plan, will depend on such factors as:

- *the severity of the impacts on air quality;*
- *the air quality in the area surrounding the proposed development;*
- *the likely use of the development, i.e. the length of time people are likely to be exposed at that location; and*
- *the positive benefits provided through other material considerations".*

Recommended Best Practice

A5.2 The guidance goes into detail on how all development proposals can and should adopt good design principles that reduce emissions and contribute to better air quality management. It states:

"The basic concept is that good practice to reduce emissions and exposure is incorporated into all developments at the outset, at a scale commensurate with the emissions".

A5.3 The guidance sets out a number of good practice principles that should be applied to all developments that:

- include 10 or more dwellings;
- where the number of dwellings is not known, residential development is carried out on a site of more than 0.5 ha;
- provide more than 1,000 m^2 of commercial floorspace;
- are carried out on land of 1 ha or more.

A5.4 The good practice principles are that:

- New developments should not contravene the Council's Air Quality Action Plan, or render any of the measures unworkable;

- Wherever possible, new developments should not create a new “street canyon”, as this inhibits pollution dispersion;
- Delivering sustainable development should be the key theme of any application;
- New development should be designed to minimise public exposure to pollution sources, e.g. by locating habitable rooms away from busy roads;
- The provision of at least 1 Electric Vehicle (EV) “rapid charge” point per 10 residential dwellings and/or 1000 m^2 of commercial floorspace. Where on-site parking is provided for residential dwellings, EV charging points for each parking space should be made available;
- Where development generates significant additional traffic, provision of a detailed travel plan (with provision to measure its implementation and effect) which sets out measures to encourage sustainable means of transport (public, cycling and walking) via subsidised or free-ticketing, improved links to bus stops, improved infrastructure and layouts to improve accessibility and safety;
- All gas-fired boilers to meet a minimum standard of <40 mgNOx/kWh;
- Where emissions are likely to impact on an AQMA, all gas-fired CHP plant to meet a minimum emissions standard of:
    - Spark ignition engine: 250 mgNOx/Nm^3;
    - Compression ignition engine: 400 mgNOx/Nm^3;
    - Gas turbine: 50 mgNOx/Nm^3.
- A presumption should be to use natural gas-fired installations. Where biomass is proposed within an urban area it is to meet minimum emissions standards of 275 mgNOx/Nm^3 and 25 mgPM/Nm^3.

A5.5 The guidance also outlines that offsetting emissions might be used as a mitigation measure for a proposed development. However, it states that:

“It is important that obligations to include offsetting are proportional to the nature and scale of development proposed and the level of concern about air quality; such offsetting can be based on a quantification of the emissions associated with the development. These emissions can be assigned a value, based on the “damage cost approach” used by Defra, and then applied as an indicator of the level of offsetting required, or as a financial obligation on the developer. Unless some form of benchmarking is applied, it is impractical to include building emissions in this approach, but if the boiler and CHP emissions are consistent with the standards as described above then this is not essential”.

A5.6 The guidance offers a widely used approach for quantifying costs associated with pollutant emissions from transport. It also outlines the following typical measures that may be considered to

offset emissions, stating that measures to offset emissions may also be applied as post assessment mitigation:

- Support and promotion of car clubs;
- Contributions to low emission vehicle refuelling infrastructure;
- Provision of incentives for the uptake of low emission vehicles;
- Financial support to low emission public transport options; and
- Improvements to cycling and walking infrastructures.

Screening

Impacts of the Local Area on the Development

"There may be a requirement to carry out an air quality assessment for the impacts of the local area's emissions on the proposed development itself, to assess the exposure that residents or users might experience. This will need to be a matter of judgement and should take into account:

- *the background and future baseline air quality and whether this will be likely to approach or exceed the values set by air quality objectives;*
- *the presence and location of Air Quality Management Areas as an indicator of local hotspots where the air quality objectives may be exceeded;*
- *the presence of a heavily trafficked road, with emissions that could give rise to sufficiently high concentrations of pollutants (in particular nitrogen dioxide), that would cause unacceptably high exposure for users of the new development; and*
- *the presence of a source of odour and/or dust that may affect amenity for future occupants of the development".*

Impacts of the Development on the Local Area

A5.7 The guidance sets out two stages of screening criteria that can be used to identify whether a detailed air quality assessment is required, in terms of the impact of the development on the local area. The first stage is that you should proceed to the second stage if any of the following apply:

- 10 or more residential units or a site area of more than 0.5 ha residential use; and/or
- more than 1,000 m^2 of floor space for all other uses or a site area greater than 1 ha.

A5.8 Coupled with any of the following:

- the development has more than 10 parking spaces; and/or

- the development will have a centralised energy facility or other centralised combustion process.

A5.9 If the above do not apply then the development can be screened out as not requiring a detailed air quality assessment of the impact of the development on the local area. If they do apply then you proceed to stage 2, which sets out indicative criteria for requiring an air quality assessment. The stage 2 criteria relating to vehicle emissions are set out below:

- the development will lead to a change in LDV flows of more than 100 AADT within or adjacent to an AQMA or more than 500 AADT elsewhere;
- the development will lead to a change in HDV flows of more than 25 AADT within or adjacent to an AQMA or more than 100 AADT elsewhere;
- the development will lead to a realigning of roads (i.e. changing the proximity of receptors to traffic lanes) where the change is 5m or more and the road is within an AQMA;
- the development will introduce a new junction or remove an existing junction near to relevant receptors, and the junction will cause traffic to significantly change vehicle acceleration/deceleration, e.g. traffic lights or roundabouts;
- the development will introduce or change a bus station where bus flows will change by more than 25 AADT within or adjacent to an AQMA or more than 100 AADT elsewhere; and
- the development will have an underground car park with more than 100 movements per day (total in and out) with an extraction system that exhausts within 20 m of a relevant receptor.

A5.10 The criteria are more stringent where the traffic impacts may arise on roads where concentrations are close to the objective. The presence of an AQMA is taken to indicate the possibility of being close to the objective, but where whole authority AQMAs are present and it is known that the affected roads have concentrations below 90% of the objective, the less stringent criteria are likely to be more appropriate.

A5.11 On combustion processes (including standby emergency generators and shipping) where there is a risk of impacts at relevant receptors, the guidance states that:

"Typically, any combustion plant where the single or combined NOx emission rate is less than 5 mg/sec is unlikely to give rise to impacts, provided that the emissions are released from a vent or stack in a location and at a height that provides adequate dispersion. As a guide, the 5 mg/s criterion equates to a 450 kW ultra-low NOx gas boiler or a 30kW CHP unit operating at <95mg/Nm^3.

In situations where the emissions are released close to buildings with relevant receptors, or where the dispersion of the plume may be adversely affected by the size and/or height of adjacent buildings (including situations where the stack height is lower than the receptor) then consideration will need to be given to potential impacts at much lower emission rates.

Conversely, where existing nitrogen dioxide concentrations are low, and where the dispersion conditions are favourable, a much higher emission rate may be acceptable".

A5.12 Should none of the above apply then the development can be screened out as not requiring a detailed air quality assessment of the impact of the development on the local area, provided that professional judgement is applied; the guidance importantly states the following:

"The criteria provided are precautionary and should be treated as indicative. They are intended to function as a sensitive 'trigger' for initiating an assessment in cases where there is a possibility of significant effects arising on local air quality. This possibility will, self-evidently, not be realised in many cases. The criteria should not be applied rigidly; in some instances, it may be appropriate to amend them on the basis of professional judgement, bearing in mind that the objective is to identify situations where there is a possibility of a significant effect on local air quality".

A5.13 Even if a development cannot be screened out, the guidance is clear that a detailed assessment is not necessarily required:

"The use of a Simple Assessment may be appropriate, where it will clearly suffice for the purposes of reaching a conclusion on the significance of effects on local air quality. The principle underlying this guidance is that any assessment should provide enough evidence that will lead to a sound conclusion on the presence, or otherwise, of a significant effect on local air quality. A Simple Assessment will be appropriate, if it can provide this evidence. Similarly, it may be possible to conduct a quantitative assessment that does not require the use of a dispersion model run on a computer".

A5.14 The guidance also outlines what the content of the air quality assessment should include, and this has been adhered to in the production of this chapter.

Impact Descriptors and Assessment of Significance

A5.15 There is no official guidance in the UK in relation to development control on how to describe the nature of air quality impacts, nor how to assess their significance. The approach within the EPUK/IAQM guidance has, therefore, been used in this assessment. This approach involves a two stage process:

- a qualitative or quantitative description of the impacts on local air quality arising from the development; and
- a judgement on the overall significance of the effects of any impacts.

Impact Descriptors

A5.16 Impact description involves expressing the magnitude of incremental change as a proportion of a relevant assessment level and then examining this change in the context of the new total concentration and its relationship with the assessment criterion. Table A5.1 sets out the method for determining the impact descriptor for annual mean concentrations at individual receptors, having been adapted from the table presented in the guidance document. For the assessment criterion the term Air Quality Assessment Level or AQAL has been adopted, as it covers all pollutants, i.e. those with and without formal standards. Typically, as is the case for this assessment, the AQAL will be the air quality objective value. Note that impacts may be adverse or beneficial, depending on whether the change in concentration is positive or negative.

Table A5.1: Air Quality Impact Descriptors for Individual Receptors for All Pollutants [a]

Long-Term Average Concentration At Receptor In Assessment Year [b]	Change in concentration relative to AQAL [c]				
	0%	1%	2-5%	6-10%	>10%
75% or less of AQAL	Negligible	Negligible	Negligible	Slight	Moderate
76-94% of AQAL	Negligible	Negligible	Slight	Moderate	Moderate
95-102% of AQAL	Negligible	Slight	Moderate	Moderate	Substantial
103-109% of AQAL	Negligible	Moderate	Moderate	Substantial	Substantial
110% or more of AQAL	Negligible	Moderate	Substantial	Substantial	Substantial

[a] Values are rounded to the nearest whole number.

[b] This is the "Without Scheme" concentration where there is a decrease in pollutant concentration and the "With Scheme" concentration where there is an increase.

[c] AQAL = Air Quality Assessment Level, which may be an air quality objective, EU limit or target value, or an Environment Agency 'Environmental Assessment Level (EAL)'.

Assessment of Significance

A5.17 The guidance recommends that the assessment of significance should be based on professional judgement, with the overall air quality impact of the development described as either 'significant' or 'not significant'. In drawing this conclusion, the following factors should be taken into account:

- the existing and future air quality in the absence of the development;
- the extent of current and future population exposure to the impacts;
- the influence and validity of any assumptions adopted when undertaking the prediction of impacts;
- the potential for cumulative impacts and, in such circumstances, several impacts that are described as '*slight*' individually could, taken together, be regarded as having a significant effect for the purposes of air quality management in an area, especially where it is proving difficult to reduce concentrations of a pollutant. Conversely, a '*moderate*' or '*substantial*'

impact may not have a significant effect if it is confined to a very small area and where it is not obviously the cause of harm to human health; and

- the judgement on significance relates to the consequences of the impacts; will they have an effect on human health that could be considered as significant? In the majority of cases, the impacts from an individual development will be insufficiently large to result in measurable changes in health outcomes that could be regarded as significant by health care professionals.

A5.18 The guidance is clear that other factors may be relevant in individual cases. It also states that the effect on the residents of any new development where the air quality is such that an air quality objective is not met will be judged as significant. For people working at new developments in this situation, the same will not be true as occupational exposure standards are different, although any assessment may wish to draw attention to the undesirability of the exposure.

A5.19 A judgement of the significance should be made by a competent professional who is suitably qualified. A summary of the professional experience of the staff contributing to this assessment is provided in Appendix A4.

A6 Professional Experience

Ricky Gellatly, BSc (Hons) MIEnvSc MIAQM

Mr Gellatly is a Principal Consultant with AQC with over seven years' relevant experience. He has undertaken air quality assessments for a wide range of projects, assessing many different pollution sources using both qualitative and quantitative methodologies, with most assessments having included dispersion modelling (using a variety of models). He has assessed road schemes, airports, energy from waste facilities, anaerobic digesters, poultry farms, urban extensions, rail freight interchanges, energy centres, waste handling sites, sewage works and shopping and sports centres, amongst others. He also has experience in ambient air quality monitoring, the analysis and interpretation of air quality monitoring data, the monitoring and assessment of nuisance odours and the monitoring and assessment of construction dust. He is a Member of the Institute of Air Quality Management

Dr Ben Marner, BSc (Hons) PhD CSci MIEnvSc MIAQM

Dr Marner is a Technical Director with AQC and has twenty years' experience in the field of air quality. He has been responsible for air quality and greenhouse gas assessments of road schemes, rail schemes, airports, power stations, waste incinerators, commercial developments and residential developments in the UK and abroad. He has been an expert witness at several public inquiries, where he has presented evidence on health-related air quality impacts, the impacts of air quality on sensitive ecosystems, and greenhouse gas impacts. He has extensive experience of using detailed dispersion models, as well as contributing to the development of modelling best practices. Dr Marner has arranged and overseen air quality monitoring surveys, as well as contributing to Defra guidance on harmonising monitoring methods. He has been responsible for air quality review and assessments on behalf of numerous local authorities. He has also developed methods to predict nitrogen deposition fluxes on behalf of the Environment Agency, provided support and advice to the UK Government's air quality review and assessment helpdesk, Transport Scotland, Transport for London, and numerous local authorities. He is a Member of the Institute of Air Quality Management and a Chartered Scientist. Dr Marner is a member of Defra's Network of Evidence Experts and a member of Defra's Air Quality Expert Group.

Dr Imogen Heard, BSc (Hons) MSc PhD MInstPhys

Dr Heard is a Senior Consultant with AQC, having joined the company in 2013. Prior to joining she worked as a scientist in the Atmospheric Dispersion and Air Quality area at the UK Met Office for four years, modelling the dispersion of a range of pollutants over varying spatial and temporal scales. She now works in the field of air quality assessment and has been involved in numerous development projects including road schemes, energy from waste facilities, urban extensions and

energy centres. These have included the use of ADMS-5 and ADMS-Roads dispersion models to study the impacts of a variety of pollutants, including nitrogen dioxide, PM_{10} and $PM_{2.5}$, and the preparation of air quality assessment reports and air quality chapters for Environmental Statements. She also has experience in undertaking construction dust risk assessments and Air Quality Neutral assessments, as well as in preparing local authority reports.

Full CVs are available at www.aqconsultants.co.uk.

A7 Construction Mitigation

A7.1 The following is a set of best-practice measures from the IAQM guidance (IAQM, 2016) that should be incorporated into the specification for the works. These measures should ideally be written into a Dust Management Plan. Some of the measures may only be necessary during specific phases of work, or during activities with a high potential to produce dust, and the list should be refined and expanded upon in liaison with the construction contractor when producing the Dust Management Plan

Communications

- Develop and implement a stakeholder communications plan that includes community engagement before and during work on site;
- display the name and contact details of person(s) accountable for air quality and dust issues on the site boundary. This may be the environmental manager/engineer or the site manager; and
- display the head or regional office contact information.

Dust Management Plan

- Develop and implement a Dust Management Plan (DMP) approved by the Local Authority which documents the mitigation measures to be applied, and the procedures for their implementation and management.

Site Management

- Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken;
- make the complaints log available to the local authority when asked; and
- record any exceptional incidents that cause dust and/or air emissions, either on- or off-site, and the action taken to resolve the situation in the log book.

Monitoring

- Undertake daily on-site and off-site inspections where receptors (including roads) are nearby, to monitor dust. Record inspection results, and make the log available to the Local Authority when asked. This should include regular dust soiling checks of surfaces such as street furniture, cars and window sills within 100 m of the site boundary, with cleaning to be provided if necessary;

- carry out regular site inspections to monitor compliance with the DMP, record inspection results, and make an inspection log available to the Local Authority when asked;
- increase the frequency of site inspections by the person accountable for air quality and dust issues on site when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions; and
- agree dust deposition, dust flux, or real-time PM_{10} continuous monitoring locations with the Local Authority. Where possible commence baseline monitoring at least three months before work commences on site or, if it is a large site, before work on a phase commences. Further guidance is provided by IAQM on monitoring during demolition, earthworks and construction (IAQM, 2012).

Preparing and Maintaining the Site

- Plan the site layout so that machinery and dust-causing activities are located away from receptors, as far as is possible;
- erect solid screens or barriers around dusty activities or the site boundary that are at least as high as any stockpiles on site;
- fully enclose site or specific operations where there is a high potential for dust production and the site is active for an extensive period;
- avoid site runoff of water or mud;
- keep site fencing, barriers and scaffolding clean using wet methods;
- remove materials that have a potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site cover as described below; and
- cover, seed, or fence stockpiles to prevent wind whipping.

Operating Vehicle/Machinery and Sustainable Travel

- Ensure all vehicles switch off their engines when stationary – no idling vehicles;
- avoid the use of diesel- or petrol-powered generators and use mains electricity or battery-powered equipment where practicable;
- impose and signpost a maximum-speed-limit of 15 mph on surfaced and 10 mph on un-surfaced haul roads and work areas (if long haul routes are required these speeds may be increased with suitable additional control measures provided, subject to the approval of the nominated undertaker and with the agreement of the local authority, where appropriate);
- produce a Construction Logistics Plan to manage the sustainable delivery of goods and materials; and

- implement a Travel Plan that supports and encourages sustainable staff travel (public transport, cycling, walking, and car-sharing).

Operations

- Only use cutting, grinding or sawing equipment fitted or in conjunction with suitable dust suppression techniques such as water sprays or local extraction, e.g. suitable local exhaust ventilation systems;
- ensure an adequate water supply on the site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate;
- use enclosed chutes, conveyors and covered skips;
- minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate; and
- ensure equipment is readily available on site to clean any dry spillages, and clean up spillages as soon as reasonably practicable after the event using wet cleaning methods.

Waste Management

- Avoid bonfires and burning of waste materials.

Measures Specific to Demolition

- Soft strip inside buildings before demolition (retaining walls and windows in the rest of the building where possible, to provide a screen against dust);
- ensure effective water suppression is used during demolition operations. Hand held sprays are more effective than hoses attached to equipment as the water can be directed to where it is needed. In addition high volume water suppression systems, manually controlled, can produce fine water droplets that effectively bring the dust particles to the ground;
- avoid explosive blasting, using appropriate manual or mechanical alternatives; and
- bag and remove any biological debris or damp down such material before demolition.

Measures Specific to Earthworks

- Re-vegetate earthworks and exposed areas/soil stockpiles to stabilise surfaces as soon as practicable;
- use Hessian, mulches or trackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable; and
- only remove the cover from small areas during work, not all at once.

Measures Specific to Construction

- Avoid scabbling (roughening of concrete surfaces), if possible;
- ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place;
- ensure bulk cement and other fine powder materials are delivered in enclosed tankers and stored in silos with suitable emission control systems to prevent escape of material and overfilling during delivery; and
- for smaller supplies of fine powder materials ensure bags are sealed after use and stored appropriately to prevent dust.

Measures Specific to Trackout

- Use water-assisted dust sweeper(s) on the access and local roads, to remove, as necessary, any material tracked out of the site. This may require the sweeper being continuously in use;
- avoid dry sweeping of large areas;
- ensure vehicles entering and leaving sites are covered to prevent escape of materials during transport;
- implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the site where reasonably practicable);
- ensure there is an adequate area of hard surfaced road between the wheel wash facility and the site exit, wherever site size and layout permits; and
- access gates should be located at least 10 m from receptors, where possible.

A8 Human Health Risk Assessment

A8.1 A detailed human health risk assessment (HHRA) has been carried out in order to identify any potential health risks associated with emissions from the proposed development.

A8.2 The pollutants of concern to this assessment (as defined in paragraph A8.4) are termed 'persistent', which means that they have the potential to remain and accumulate in the local environment over the operational life of the proposed development, including bioaccumulation through the food chain. The assessment is based on the United States Environmental Protection Agency (USEPA) Human Health Risk Assessment Protocol (HHRAP). This approach is current best-practice in the UK and is often recommended by the UK Environment Agency. The assessment has used the Industrial Risk Assessment Program-Human Health (IRAP) model, which is based on the HHRAP

A8.3 The HHRAP method was developed to assess risks in areas where much of the population derives a substantial portion of its diet from local produce. Because of the potential for accumulation in the food chain, animal husbandry (particularly the raising of pigs and cattle) forms a key part of HHRAP. In practice, many areas near to the proposed development are urban and thus the HHRAP method will provide an extremely conservative (i.e. worst-case) assessment.

Assessment Scope

A8.4 Following standard Environment Agency practice for studies of this nature, the health risk assessment focuses on the uptake of polychlorinated dibenzo-para-dioxins and polychlorinated dibenzofurans, often abbreviated to 'dioxins and furans'. While other substances such as metals, acid gases, and particulate matter would be emitted from the proposed development, these can be adequately assessed by comparing the predicted ambient concentrations against relevant assessment criteria.

A8.5 Exposure to emissions of dioxins and furans can be through a number of pathways, with inhalation and the food chain being most critical. This assessment covers exposure through the direct inhalation of dioxins and furans as gases and fine airborne particles, as well as indirect exposure following the deposition of contaminants to land and subsequent transfer by biogeochemical processes through soils and vegetation into the food chain.

A8.6 The assessment has not considered the potential for significant impacts associated with ingestion of drinking water, or dermal contact with soil or water. Other studies have shown that absorption through dermal contact with soil is significantly less efficient than absorption by inhalation and can thus safely be discounted (Pasternach, 1989). Dermal contact with standing water in the area will also be sporadic and unlikely to lead to significant exposure. Exposure via drinking water requires contamination of drinking water sources local to the point of consumption. Mains water for the

local area comes from the River Dee, approximately 29 km to the south-west of the application site. This is sufficiently far from the application site that mains water will not be significantly affected by emissions from the proposed development. The Prescot Water Treatment Works, approximately 3.5 km west of the proposed development, may provide mains water in emergency situations. However, water from this source will only constitute a minor proportion of that consumed by the local population. This pathway has thus not been included in the assessment.

A8.7 The assessment has also discounted the potential for local residents to derive a large proportion of their diet from locally-caught fish. Although the Cleg fishing lake is located approximately 1 km south west of the proposed development, any fish caught there unlikely to provide a substantial part of people's diets, therefore this pathway has not been included in this assessment.

Assessment Methodology

Baseline Conditions

A8.8 Background exposure to dioxins and furans is dependent on a wide range of complex individual factors and will vary from one individual to another. Key issues include individual lifestyle, diet, baseline land quality, and background levels of dioxins and furans. This study has thus focused on the potential impact of the proposed development, rather than on the combined effect of the proposed development and other potential sources of exposure. If it is possible to demonstrate that the impacts of the proposed development will be insignificant, then it is not necessary to calculate the total exposure.

Emissions of Dioxins and Furans

A8.9 The general term 'dioxins and furans' describes a large number of compounds, which are individually known as 'congeners'. Each congener has a different toxicity and physical properties with regard to atmospheric behaviour.

A8.10 The IED (2010/75/EU, 2010) allows a maximum emission rate for total dioxins and furans of 0.1 ng/Nm^3 (averaged over a sampling period between 6 and 8 hours). The IED also provides a range of congener-specific international toxic equivalence (TEQ) factors by which the mass concentrations of specific congeners should be multiplied before summing. In other words, 0.1 ng/Nm^3 refers not to the total mass emission, but to the toxic-equivalent emission. In practice, the proposed development is unlikely to emit anywhere near 0.1 ng/Nm^3, but it has nevertheless been assumed that 0.1 ng TEQ/Nm^3 would be emitted during every hour of every year. This provides a worst-case assessment.

A8.11 Her Majesty's Inspectorate of Pollution (HMIP) previously published a dioxin and furan congener profile based on measurements at municipal waste incinerators (HMIP, 1996). This provides the

most robust dataset to describe the proposed development at this time and has thus been used to define the relative quantities of each congener that would be emitted.

A8.12 The congener profile from HMIP has been combined with the IED toxic equivalence factor and the volumetric emission rate from the proposed development to calculate g/s mass emissions of the individual congeners. These calculations are shown in Table A8.1.

Table A8.1: Assumed Dioxin and Furan Emissions from the Proposed Development

Congener	Sum of Emissions (ng-TEQ/Nm^3)	% of Total Toxic-Equivalent Conc from Each Congener	Toxic Eq Factor (ng TEQ / ng)	Mass Emission Conc (ng/Nm^3) [a]	Mass Emission Rate (g/s) [b]
2,3,7,8-TCDD	-	3.1%	1	0.0031	1.85×10^{-10}
1,2,3,7,8-PeCDD	-	12.4%	0.5	0.025	1.50×10^{-9}
1,2,3,4,7,8-HxCDD	-	2.9%	0.1	0.029	1.73 x 10-^{9}
1,2,3,7,8,9-HxCDD	-	2.1%	0.1	0.021	1.26×10^{-9}
1,2,3,6,7,8-HxCDD	-	2.6%	0.1	0.026	1.55×10^{-9}
1,2,3,4,6,7,8-HpCDD	-	1.7%	0.01	0.17	1.02×10^{-8}
OCDD	-	0.4%	0.001	0.4	2.39×10^{-8}
2,3,7,8-TCDF	-	2.7%	0.1	0.027	1.61×10^{-9}
2,3,4,7,8-PeCDF	-	26.8%	0.5	0.054	3.23×10^{-9}
1,2,3,7,8-PeCDF	-	1.4%	0.05	0.028	1.67×10^{-9}
1,2,3,4,7,8-HxCDF	-	21.8%	0.1	0.22	1.32×10^{-8}
1,2,3,7,8,9-HxCDF	-	0.4%	0.1	0.0042	2.51×10^{-10}
1,2,3,6,7,8-HxCDF	-	8.0%	0.1	0.081	4.84×10^{-9}
2,3,4,6,7,8-HxCDF	-	8.6%	0.1	0.087	5.20×10^{-9}
1,2,3,4,6,7,8-HpCDF	-	4.4%	0.01	0.44	2.63×10^{-8}
1,2,3,4,7,8,9-HpCDF	-	0.4%	0.01	0.043	2.57×10^{-9}
OCDF	-	0.4%	0.001	0.36	2.15×10^{-8}
Sum	**0.1**	**100%**	**-**	**2.1**	**1.21×10^{-7}**

[a] i.e. 0.1 ng TEQ/Nm^3 divided by the toxic equivalence factor and multiplied by the percentage of total toxic-equivalent concentration from each congener. Calculated from unrounded numbers.

[b] i.e. mass emission concentration (ng/Nm^3) divided by 1 billion, multiplied by the volume flow rate (169,992 Nm^3/hr – see Chapter 9 of the ES) divided by 3,600.

Dispersion Modelling

A8.13 The transport of emissions though air, and dry and wet deposition of particle-bound and vapour-phase congeners, have been simulated within the ADMS-5 model. In terms of the dry deposition of particles, because large particles will be filtered out from the stack emissions, particulate emissions are expected to be predominantly in the 1-2 µm diameter range. For particles of this size, deposition velocities are likely to be in the range of 0.001 m/s to 0.1 m/s. For dry deposition of particle-bound congeners, a fixed worst-case deposition velocity of 0.01 m/s has thus been assumed. The dry deposition of vapour-phase congeners has been modelled using the ADMS default parameters for non-reactive gases.

A8.14 The ADMS model has been run using five separate yearly meteorological datasets (2012 to 2016 inclusive) from Liverpool Airport. For each receptor, the maximum predicted concentration, dry deposition flux, and wet deposition flux during any year was taken and used for the health risk assessment. Where these maxima come from different years, the approach is worst-case since, in practice, one form of deposition depletes the potential for the other.

Receptors for Dispersion Modelling

A8.15 Modelling has been carried out over the same Cartesian grid of receptors as was used for the main air quality assessment, extending approximately 10 km from the proposed development in each direction.

Human Health Risk Assessment

A8.16 The assessment has used the IRAP model, which is based on HHRAP.

Receptors for IRAP Model

A8.17 Within the IRAP model, there are four receptor types of relevance to this assessment:

- Resident adult;
- Resident child;
- Farmer adult; and
- Farmer child.

A8.18 Resident receptors are assumed to have the potential to intake pollutants via inhalation, by eating above-ground home-grown vegetables and by eating soil[4].

A8.19 Farmer receptors are assumed to intake pollutants by these same pathways, but also from eating home-reared beef, chicken and pork, drinking milk from cows kept at home, and eating home-produced eggs. It is important to recognise that, when a receptor is included as a farmer, the assumption is made that the location is an active farm at which only beef, pork, poultry, eggs, milk and vegetables produced at that farm are consumed. It is unlikely that there are any such locations in the vicinity of the application site.

A8.20 Occasionally, residents keep animals in domestic gardens. Where this occurs, it is highly unlikely that these animals would provide the dominant source of consumed food. While it is possible that, for example, chickens kept at home could provide the only source of eggs consumed, it is relatively unlikely that a dominant proportion of the chickens' food would be grown within the study area.

[4] This is usually accidental and associated with home-grown vegetables.

A8.21 Because of the absence of significant farming activities in the vicinity of the proposed facility, allotments have been included as farm receptors. It should, though, be stressed that allotments are used for growing vegetables and not for animal husbandry and so are not really appropriate. Including them provides a worst-case assessment.

A8.22 The results from the ADMS-dispersion model runs for the Cartesian grid of receptors have been plotted on a map and used to select the worst-case receptors for the human health risk assessment (i.e. the human health risk assessment receptors were chosen to represent locations where the gridded concentrations and deposition fluxes were highest). The receptors used for the health risk assessment are described in Table A8.2 and shown in Figure A8.1.

Table A8.2: Receptors Used in the HHRA

Receptor	Description	Type
H1	Allotments on Alder Hey Road	Farm
H2	Allotments on Recreation Street	Farm
H3	Allotments on Bedford Street	Farm
H4	Allotments on Sherdley Road	Farm
H5	Allotments on Main Avenue	Farm
H6	Allotments on Old Eccleston Lane	Farm
H7	The Mansion House	Residential
H8	Property on Heathfield Avenue	Residential
H9	Reeve Court Village	Residential
H10	Arable land adjacent to Elton Head Road	Farm
H11	Arable land adjacent to St Helens Road	Farm
H12	Arable land adjacent to Eccleston Gardens	Farm
H13	Arable land adjacent to Reginald Road	Farm
H14	Arable land adjacent to St Helens Canal	Farm
H15	Property on Yorkshire Gardens	Residential
H16	Property on Berkshire Gardens	Residential
H17	Property on Heathfield Avenue	Residential
H18	Property on Sherdley Road	Residential
H19	Property on Sherdley Road	Residential
H20	Property on Tall Trees	Residential
H21	Property on Shropshire Gardens	Residential

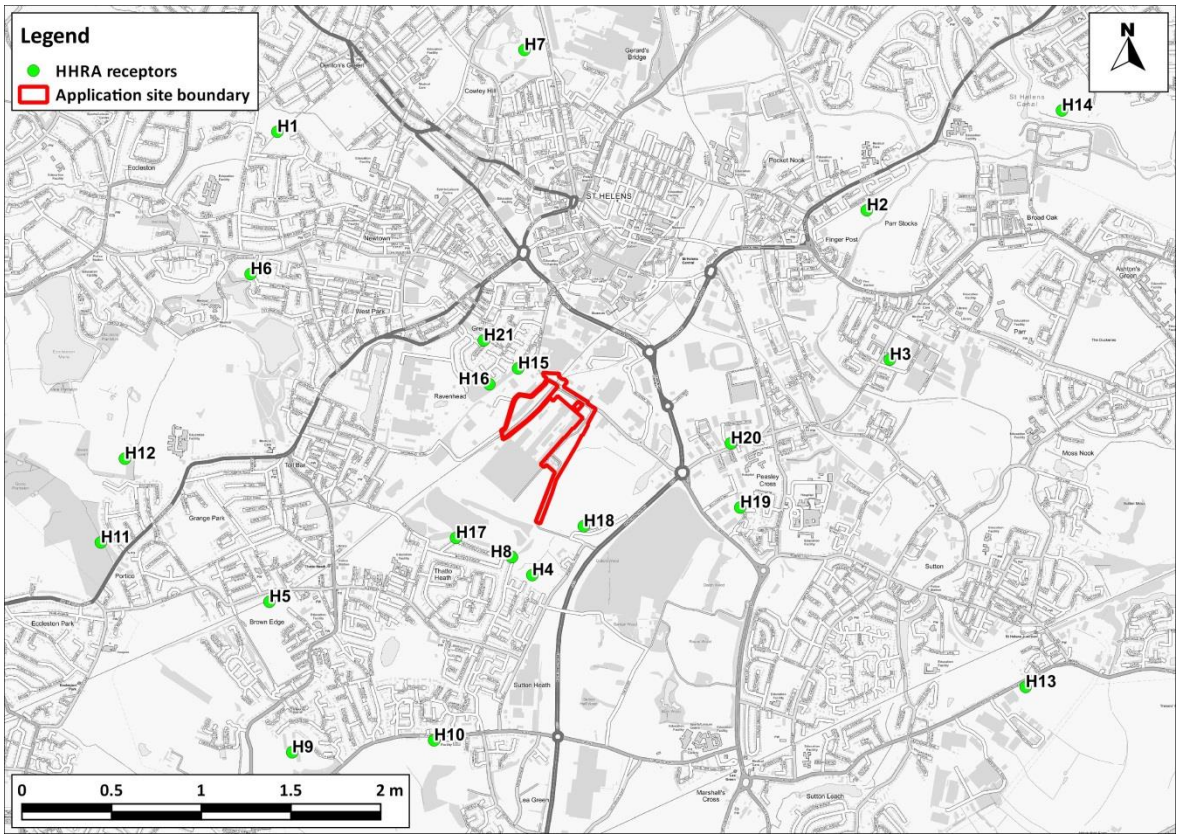

Figure A8.1: Receptors for the HHRA

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IRAP Model Inputs

A8.23 The outputs from the ADMS-5 dispersion model have been used as inputs to the IRAP model. From these, IRAP calculated the concentrations of the various congeners in the environmental media, foodstuffs, and the human population.

A8.24 The IRAP model requires a wide range of input data to be defined as set out below. In many cases the default parameters have been used, as is common practice for such assessments.

Physical and Chemical Properties of the Pollutants

A8.25 These parameters determine how the pollutants behave in the environment and their presence and accumulation in various food sources. The HHRAP and IRAP default values have been used in this assessment.

Site-specific Information

A8.26 The IRAP model requires information about the location and its surroundings including:

- the fraction of animal feed grown on local soils and the amount of animal feed and soil consumed by various species;
- the interception fraction for above ground vegetation, forage and silage and lengths of vegetation exposure to deposition;
- data for assessing the risks with exposure to breast milk, such as infant bodyweight, fraction of mother's body weight that is fat etc.; and
- other physical parameters such as soil and air density etc.

The HHRAP and IRAP default parameters have been used for all of this information.

A8.27 Other parameters need to be taken from site-specific data. These are set out in Table A8.3.

Table A8.3: Site-specific Parameters Used

Parameter	Value
Annual Mean Precipitation	64.4 cm/yr [a]
Annual Mean Wind Velocity	4.8 m/s [b]
Annual Mean Evapotranspiration	45.1 cm/yr [c]
Annual Mean Irrigation	0 cm/yr
Annual Mean Runoff	6.4 cm/yr [d]
Time period over which deposition occurs	30 yrs

[a] The average of two year's meteorological data, as precipitation was not recorded in three of the meteorological datasets used in the modelling assessment.

[b] The average of five year's meteorological data.

[c] Assumed to be 70% of precipitation.

[d] Assumed to be 10% of precipitation.

Receptor Information

A8.28 For each receptor type, IRAP requires information on receptor behaviour including absolute and relative food consumption rates, body weight, inhalation rates, and exposure frequency etc. The HHRAP and IRAP default values have been used in this assessment.

IRAP Model Outputs

Cancer Risk

A8.29 The HHRAP approach is to calculate the probability of affected receptors developing cancer over their lifetime as a result of emissions from the proposed development. This risk is presented as an absolute number which represents a probability. For example, a value of 1 x 10^{-6} (or 0.000001) represents a one in one million chance of an effect over a lifetime's exposure.

Hazard Risk

A8.30 IRAP has also been used to calculate the 'Hazard Quotient' for each receptor. The 'Hazard Quotient' is a way of expressing the ratio of the predicted exposure level and a 'reference dose' which represents the level at which no adverse effects are expected. Hazard Quotients are pollutant and pathway specific and can then be summed to calculate a 'Hazard Index'. Of the congeners considered in this assessment, a reference dose has only been set for the most toxic congener (2,3,7,8-TCDD) via the ingestion pathway. Thus, for this assessment, the Hazard Quotient and the Hazard Index are the same. The Hazard Quotient is simply the exposure level divided by the reference dose and is thus unitless.

Oral Intake of All Congeners

A8.31 While the Hazard Quotient only takes account of intake of the most toxic congener (2,3,7,8-TCDD), the total oral intake of all modelled congeners has been derived from the IRAP model and compared against defined TDIs. The units for this assessment are toxic-equivalent-picogrammes[5] per kg of bodyweight per day (pg-TEQ/kg/d).

Infant Exposure through Breast Milk

A8.32 Dioxins and furans are extremely fat soluble and hence prone to accumulation in breast milk. The accumulated compounds can then be passed to the infant. Exposure through breast milk is measured by the ADD on the basis of an averaging time of one year. The units for this assessment are also pg-TEQ/kg/d.

Concentrations in Soils

A8.33 The final set of outputs derived from the IRAP model is the concentrations of dioxins and furans in soils. These are expressed as the sum of all congeners in μg per kg (μg/kg) of soil (dry weight).

Assessment Criteria

A8.34 The HHRA is based on the United States Environmental Protection Agency (USEPA) Human Health Risk Assessment Protocol (HHRAP). This approach is current best-practice in the UK and is often recommended by the UK Environment Agency. The assessment has used the Industrial Risk Assessment Program-Human Health (IRAP) model, which is based on the HHRAP

A8.35 The HHRAP method was developed to assess risks in areas where much of the population derives a substantial portion of its diet from local produce. Because of the potential for accumulation in the food chain, animal husbandry (particularly the raising of pigs and cattle) forms a key part of

[5] One picogramme is equal to 0.000000000001 grammes.

HHRAP. In practice, many areas near to the application site are urban and thus the HHRAP method will provide an extremely conservative (i.e. worst-case) assessment.

Cancer Risk

A8.36 One definition of 'acceptable risk' that has been widely used in the UK, is if exposure to a substance increases a person's chance of dying in any one year by one chance in a million (1:1,000,000 or 1 x 10^{-6}) or less[6] (Hunter and Fewtrell, 2010). The one in one million figure used in the UK is an annual figure. Since risk is cumulative, assuming a 70 year lifetime, the equivalent lifetime risk is one in fourteen thousand (1:14,300 or 7 x 10^{-5}).

A8.37 HHRAP uses a value of one in one hundred thousand (1:100,000 or 1 x 10^{-5}) for lifetime cancer risk. This is effectively more stringent than the 1 in 1 million annual risk figure and has thus been used for this study. The assessment criterion for cancer risk is thus 1 x 10^{-5}.

Hazard Risk

A8.38 The 'Hazard Quotient' is a way of expressing the ratio of the predicted exposure level and a 'reference dose' which represents the level at which no adverse effects are expected. Hazard Quotients are pollutant and pathway specific and can then be summed to calculate a 'Hazard Index'. Of the congeners considered in this assessment, a reference dose has only been set for the most toxic congener (2,3,7,8-TCDD) via the ingestion pathway. This reference dose is given in Table A8.4. If the Hazard Quotient is less than 1 (i.e. the predicted exposure is less than the reference dose), then no adverse health effects are expected. If the Hazard Quotient is greater than 1, then adverse health effects are possible. The Hazard Quotient is different from the cancer risk estimates; in that it cannot be translated into a probability that adverse health effects will occur and it is unlikely to be proportional to risk. It is important to note that a Hazard Quotient exceeding 1 does not necessarily mean that adverse effects will occur; it simply indicates the potential for an effect.

[6] By way of comparison, the likelihood of dying in a road traffic accident is approximately 1 in 17,500 per year http://www.medicine.ox.ac.uk/bandolier/booth/Risk/trasnsportpop.html

Table A8.4: Reference Dose and Hazard Quotient

Description	Value
Reference Dose (of 2,3,7,8-TCDD per kg body weight) (mg/kg/d)	1 x 10^{-9}
Hazard Quotient	1

Oral Intake of All Congeners

A8.39 The World Health Organisation (WHO) has recommended a range of Tolerable Daily Intakes (TDIs)s (Table A8.5). These represent a lifetime's exposure and short-term exceedences of the TDI are not of concern if the long-term average is not exceeded (WHO, 1998).

A8.40 In the UK, the Health Protection Agency and the Department of Health are advised by the Committee on the Toxicity of Chemicals in Food, Consumer Products and the Environment (COT). The COT has also provided recommendations on TDIs, which are based on adverse effects on a developing foetus (since this represents the most sensitive exposure pathway) (COT, 2001). The TDIs used in this study are set out in Table A8.5.

Table A8.5: Tolerable Daily Intake (TDI values)

Reference Source	TDI (pg-TEQ/kg/d)
(WHO, 1998)	1 – 4
(COT, 2001)	2

Infant Exposure through Breast Milk

A8.41 There is no official UK or USEPA assessment criterion for acceptable infant exposure. One approach that is often taken is to compare the Average Daily Dose (ADD) against average background exposure levels, while other studies have cited a threshold value of 50 pg-TEQ/kg/d of the congener 2,3,7,8-TCDD as being potentially harmful.

A8.42 Two separate approaches have been taken here. The first is to compare the ADD for all congeners against an assumed nominal baseline dose of 100 pg-TEQ/kg/day [7]. The second is to compare the ADD for the congener 2,3,7,8-TCDD against the threshold value of 50 pg-TEQ/kg/day.

[7] A compilation of European dioxin exposure data (DETR, 1999) found that, in 1993, the dioxin intake of firstborn infants, up to 2 months of age, might be around 106 pg-TEQ/kg/day in rural areas of the EU and 144 pg TEQ/kg/day in industrial areas. These intake levels fall rapidly after the first few months. These are well in excess of the TDIs, but, as explained in Paragraph 3.5, the TDIs refer to an average lifetime's exposure. Exposure is likely to have fallen since 1993 but these values nevertheless provide a basis for assessment.

Concentrations in Soils

A8.43 The Environment Agency has developed Soil Guideline Values (SGVs) for dioxins, furans, and dioxin-like PCBs (Environment Agency, 2009). These are assessment criteria that can be used to evaluate the risk to human health from long-term exposure to chemicals in soil.

A8.44 For residential and allotment land uses, the SGVs are based on estimates representative of exposure of young children because they are generally more likely to have higher exposures to soil contaminants. The toxic equivalence of the various congeners has been taking into account in the derivation of the SGVs. Thus, the mass sum of all congeners in the soil may be compared directly with the SGVs.

A8.45 The SGVs used in this assessment are set out in Table A8.6. These are based on a generic profile of congeners which is representative of general diffuse pollution, but within the context of this assessment are considered to be sufficiently accurate.

Table A8.6: Soil Guideline Values (SGVs) for dioxins, furans and dioxin-like PCBs [a]

Land use	Sum of Congeners (µg/kg)
Residential	8
Allotment	8
Commercial	240

[a] Based on an assumed soil profile for urban soils and on a sandy loam soil.

Results

Cancer Risk

A8.46 The total lifetime cancer risks associated with emissions from the facility for each of the receptors are presented in Table A8.7.

A8.47 The data in Table A8.7 shows that the highest residential risk is predicted at receptor H19 (residential property on Sherdley Road), where the predicted lifetime risk of developing cancer as a result of emissions from the Proposal is 4.0×10^{-9} (1 in 250 million). The highest risks at any of the receptors that have been treated as farms are at receptors H2 and H3 (allotments adjacent to Recreation Street and Bedford Street) where the risk is 5.0×10^{-7} (1 in two million). All of the results are well below the assessment criterion of 1×10^{-5} (1 in one hundred thousand). Such risks are conventionally considered to be acceptable in the UK.

Table A8.7: Total Lifetime Cancer Risk for all Receptors [a]

Receptor	Description	Type [b]	Child	Adult
H1	Allotments on Alder Hey Road	F	8.6×10^{-8}	4.0×10^{-7}
H2	Allotments on Recreation Street	F	**1.1×10^{-7}**	**5.0×10^{-7}**
H3	Allotments on Bedford Street	F	**1.1×10^{-7}**	**5.0×10^{-7}**
H4	Allotments on Sherdley Road	F	4.1×10^{-8}	1.9×10^{-7}
H5	Allotments on Main Avenue	F	7.7×10^{-8}	3.6×10^{-7}
H6	Allotments on Old Eccleston Lane	F	7.3×10^{-8}	3.4×10^{-7}
H7	The Mansion House	R	6.6×10^{-10}	1.2×10^{-9}
H8	Property on Heathfield Avenue	R	6.5×10^{-10}	1.2×10^{-9}
H9	Reeve Court Village	R	3.9×10^{-10}	7.0×10^{-10}
H10	Arable land adjacent to Elton Head Road	F	2.7×10^{-8}	1.3×10^{-7}
H11	Arable land adjacent to St Helens Road	F	4.9×10^{-8}	2.3×10^{-7}
H12	Arable land adjacent to Eccleston Gardens	F	5.2×10^{-8}	2.4×10^{-7}
H13	Arable land adjacent to Reginald Road	F	7.1×10^{-8}	3.3×10^{-7}
H14	Arable land adjacent to St Helens Canal	F	6.3×10^{-8}	3.0×10^{-7}
H15	Property on Yorkshire Gardens	R	1.9×10^{-9}	3.4×10^{-9}
H16	Property on Berkshire Gardens	R	1.7×10^{-9}	3.0×10^{-9}
H17	Property on Heathfield Avenue	R	1.4×10^{-9}	2.5×10^{-9}
H18	Property on Sherdley Road	R	7.3×10^{-10}	1.2×10^{-9}
H19	Property on Sherdley Road	R	**2.2×10^{-9}**	**4.0×10^{-9}**
H20	Property on Tall Trees	R	2.0×10^{-9}	3.5×10^{-9}
H21	Property on Shropshire Gardens	R	1.9×10^{-9}	3.4×10^{-9}
Assessment Criterion			**1×10^{-5}**	

1×10^{-5} = 1 in one hundred thousand chance of an effect over a lifetime's exposure

1×10^{-6} = 1 in one million chance of an effect over a lifetime's exposure

1×10^{-8} = 1 in one hundred million chance of an effect over a lifetime's exposure

1×10^{-10} = 1 in one billion chance of an effect over a lifetime's exposure

[a] The highest relevant values are shown in bold.

[b] R = residential, F = farm.

A8.48 Table A8.8 shows the pathways of exposure for receptors H2, H3 and H19. The most significant pathway for the residential receptors is eating home-grown vegetables, while the most significant pathway for farm receptors is drinking home-produced milk. As explained in Paragraph A8.19, by including receptors as farms, it is assumed that the location is an active farm at which only beef, pork, poultry, eggs, milk and vegetables produced at that farm are consumed. As there are

unlikely to be any such locations in the vicinity of the Proposal (i.e. all local residents who consume these foodstuffs are likely to purchase at least some of their food), the assessment is thus worst-case.

Table A8.8: Total Lifetime Carcinogenic Risk by Pathway at Worst-case Receptors [a]

Pathway	Receptor H2 (Farm)		Receptor H3 (Farm)		Receptor H19 (Residential)	
	Child	Adult	Child	Adult	Child	Adult
Eating above ground vegetables	9.9×10^{-10}	2.8×10^{-9}	1.0×10^{-9}	2.9×10^{-9}	**1.8×10^{-9}**	**3.7×10^{-9}**
Eating soil	1.7×10^{-10}	1.4×10^{-10}	1.8×10^{-10}	1.4×10^{-10}	4.5×10^{-10}	2.4×10^{-10}
Inhalation	1.0×10^{-11}	6.7×10^{-11}	1.0×10^{-11}	6.8×10^{-11}	2.5×10^{-11}	1.2×10^{-10}
Eating home-reared beef	9.9×10^{-9}	1.1×10^{-7}	1.0×10^{-8}	1.1×10^{-7}	0	0
Eating home-reared chicken	2.4×10^{-12}	2.7×10^{-11}	2.6×10^{-12}	2.8×10^{-11}	0	0
Eating home-produced eggs	1.7×10^{-12}	1.7×10^{-11}	1.8×10^{-12}	1.8×10^{-11}	0	0
Drinking home-produced milk	**9.5×10^{-8}**	**3.8×10^{-7}**	**9.6×10^{-8}**	**3.9×10^{-7}**	0	0
Eating home-reared pork	5.2×10^{-10}	4.6×10^{-9}	5.2×10^{-10}	4.6×10^{-9}	0	0
Total Lifetime Risk	1.1×10^{-7}	5.0×10^{-7}	1.1×10^{-7}	5.0×10^{-7}	2.2×10^{-9}	4.1×10^{-9}

1×10^{-5} = 1 in one hundred thousand chance of an effect over a lifetime's exposure

1×10^{-6} = 1 in one million chance of an effect over a lifetime's exposure

1×10^{-8} = 1 in one hundred million chance of an effect over a lifetime's exposure

1×10^{-10} = 1 in one billion chance of an effect over a lifetime's exposure

[a] Highest relevant values in each column are shown in bold.

Hazard Risk

A8.49 The Hazard Quotient for each of the receptors is set out in Table A8.9. All of the values are less than 1 and the risk of significant health effects is thus discounted. The Hazard Risk pathway breakdown for receptors H2, H3 and H19 is given in Table A8.10. Again, this shows that eating home-grown vegetables is the dominant risk pathway for residents, while for farmers it is drinking home-produced milk.

Table A8.9: Hazard Quotient for All Receptors [a]

Receptor	Description	Type [b]	Child	Adult
H1	Allotments on Alder Hey Road	F	4.1×10^{-4}	2.8×10^{-4}
H2	Allotments on Recreation Street	F	**5.0×10^{-4}**	**3.5×10^{-4}**
H3	Allotments on Bedford Street	F	**5.0×10^{-4}**	**3.5×10^{-4}**
H4	Allotments on Sherdley Road	F	1.9×10^{-4}	1.3×10^{-4}
H5	Allotments on Main Avenue	F	3.6×10^{-4}	2.5×10^{-4}
H6	Allotments on Old Eccleston Lane	F	3.4×10^{-4}	2.4×10^{-4}
H7	The Mansion House	R	2.1×10^{-6}	7.6×10^{-7}
H8	Property on Heathfield Avenue	R	2.0×10^{-6}	7.3×10^{-7}
H9	Reeve Court Village	R	1.2×10^{-6}	4.7×10^{-7}
H10	Arable land adjacent to Elton Head Road	F	1.3×10^{-4}	8.9×10^{-5}
H11	Arable land adjacent to St Helens Road	F	2.3×10^{-4}	1.6×10^{-4}
H12	Arable land adjacent to Eccleston Gardens	F	2.4×10^{-4}	1.7×10^{-4}
H13	Arable land adjacent to Reginald Road	F	3.3×10^{-4}	2.3×10^{-4}
H14	Arable land adjacent to St Helens Canal	F	3.0×10^{-4}	2.1×10^{-4}
H15	Property on Yorkshire Gardens	R	5.9×10^{-6}	2.1×10^{-6}
H16	Property on Berkshire Gardens	R	5.2×10^{-6}	1.9×10^{-6}
H17	Property on Heathfield Avenue	R	4.2×10^{-6}	1.6×10^{-6}
H18	Property on Sherdley Road	R	2.1×10^{-6}	6.8×10^{-7}
H19	Property on Sherdley Road	R	**6.8×10^{-6}**	**2.5×10^{-6}**
H20	Property on Tall Trees	R	6.1×10^{-6}	2.2×10^{-6}
H21	Property on Shropshire Gardens	R	5.9×10^{-6}	2.2×10^{-6}
Assessment Criterion			**1**	

1×10^{-3} = 0.001

1×10^{-6} = 0.000001

[a] Highest relevant values are shown in bold.

[b] R = residential, F = farm.

Table A8.10: Hazard Quotient by Pathway at Worst-case Receptors [a]

Pathway	Receptor H2 (Farm)		Receptor H3 (Farm)		Receptor H19 (Residential)	
	Child	Adult	Child	Adult	Child	Adult
Eating above ground vegetables	3.3×10^{-6}	1.4×10^{-6}	3.4×10^{-6}	1.4×10^{-6}	**5.7×10^{-6}**	**2.4×10^{-6}**
Accidentally Eating soil	4.1×10^{-7}	4.3×10^{-8}	4.3×10^{-7}	4.6×10^{-8}	1.1×10^{-6}	1.2×10^{-7}
Eating home-reared beef	4.6×10^{-5}	7.5×10^{-5}	4.7×10^{-5}	7.6×10^{-5}	0	0
Eating home-reared chicken	6.0×10^{-9}	8.9×10^{-9}	6.4×10^{-9}	9.4×10^{-9}	0	0
Eating home-produced eggs	4.1×10^{-9}	5.8×10^{-9}	4.4×10^{-9}	6.1×10^{-9}	0	0
Drinking home-produced milk	**4.5×10^{-4}**	**2.7×10^{-4}**	**4.5×10^{-4}**	**2.7×10^{-4}**	0	0
Eating home-reared pork	2.3×10^{-6}	3.0×10^{-6}	2.3×10^{-6}	3.1×10^{-6}	0	0
Total Hazard Quotient	5.0×10^{-4}	3.5×10^{-4}	5.0×10^{-4}	3.5×10^{-4}	6.8×10^{-6}	2.5×10^{-6}

1×10^{-3} = 0.001

1×10^{-6} = 0.000001

1 x 10-9 = 0.000000001

[a] Highest relevant values in each column shown in bold.

Oral Intake of all Congeners

A8.50 Table A8.11 sets out the predicted oral intake of all congeners for Receptors H2, H3 and H19 which are the three receptors which have been identified as having the highest predicted impacts. The results are separately compared with the TDIs from both WHO and COT. The predicted intakes at all three receptors are well below 1% of the TDIs, thus the risk of significant health effects can be discounted.

Table A8.11: Predicted Oral Intake of Dioxins and Furans at Worst-case Receptors (pg-TEQ/kg/d)

Pathway	Receptor H2 (Farm)		Receptor H3 (Farm)		Receptor H19 (Residential)	
	Child	Adult	Child	Adult	Child	Adult
Eating above ground vegetables	8.0×10^{-5}	3.4×10^{-5}	8.2×10^{-5}	3.5×10^{-5}	1.5×10^{-4}	6.3×10^{-5}
Eating soil	2.2×10^{-5}	2.3×10^{-6}	2.3×10^{-5}	2.5×10^{-6}	5.8×10^{-5}	6.2×10^{-6}
Eating home-reared beef	6.7×0^{-4}	1.1×10^{-3}	6.8×10^{-4}	1.1×10^{-3}	0	0
Eating home-reared chicken	3.1×10^{-7}	4.5×10^{-7}	3.2×10^{-7}	4.7×10^{-7}	0	0
Eating home-produced eggs	2.1×10^{-7}	2.9×10^{-7}	2.2×10^{-7}	3.1×10^{-7}	0	0
Drinking home-produced milk	6.4×10^{-3}	3.9×10^{-3}	6.5×10^{-3}	3.9×10^{-3}	0	0
Eating home-reared pork	3.8×10^{-5}	5.0×10^{-5}	3.9×10^{-5}	5.1×10^{-5}	0	0
Total Intake	0.007	0.005	0.007	0.005	0.00021	0.00007
WHO Assessment Criteria (TDI)	1-4					
COT Assessment Criteria (TDI)	2					
Intake as % of 1 pg-TEQ/kg/d	0.73	0.51	0.73	0.51	0.021	0.007
Intake as % of 2 pg-TEQ/kg/d	0.36	0.25	0.37	0.26	0.010	0.003

1×10^{-3} = 0.001

1×10^{-6} = 0.000001

1 x 10-9 = 0.000000001

Infant Exposure through Breast Milk

A8.51 Table A8.12 sets out the estimated ADDs for infant exposure through breast milk at receptors H2, H3 and H19. The predicted ADDs have been compared with the assessment criteria described in Paragraph A8.42. All of the ADDs are less than 1% of the respective criteria and the impacts can thus be discounted as insignificant.

Table A8.12: Estimated Infant Average Daily Dose (ADD) of Dioxins and Furans (pg-TEQ'kg/d)

Pathway	Receptor H2 (Farm)	Receptor H3 (Farm)	Receptor H19 (Residential)
All Congeners			
ADD (pg TEQ/kg/day)	0.076	0.076	0.0014
Assessment Criterion (pg TEQ/kg/day)	100		
ADD as percentage of Criterion	0.076	0.076	0.0014
2,3,7,8-TCDD			
ADD (pg TEQ/kg/day)	0.0106	0.0107	0.0001
Assessment Criterion (pg TEQ/kg/day)	50		
ADD as percentage of Criterion	0.021	0.021	0.0003

Concentrations in Soils

A8.52 Table A8.13 sets out the maximum process contributions to dioxin and furan concentrations in soils at receptors H2, H3 and H19. The predicted concentrations have been compared with the residential SGV defined in Table A8.6. The predicted concentrations are well below 1% of the SGV. The impacts can thus be discounted as insignificant.

Table A8.13: Maximum Process Contribution to Dioxin and Furan Concentrations in Soils

Parameter	Receptor H2 (Farm)	Receptor H3 (Farm)	Receptor H19 (Residential)
Process Contribution to Maximum Soil Concentration (μg/kg)	0.000035	0.000037	0.00009
Soil Guideline Value (SGV) (μg/kg)	8		
Process Contribution as % of Guideline Value	0.0004	0.0005	0.001

Conclusions

A8.53 The human health risk assessment has shown that:

- **cancer risk** - all of the predicted process contributions are less than the assessment criterion. They are at levels which are conventionally considered to be acceptable and are thus discounted as **insignificant**;
- **hazard risk -** all of the predicted process contributions are less than 1 and the risk of effects can be discounted as **insignificant**;

- **oral intake of all congeners -** all of the predicted process contributions are less than 1% of the relevant assessment criteria and can thus be discounted as **insignificant**;
- **infant exposure through breast milk** - all of the predicted process contributions are less than 1% of the relevant assessment criteria and can thus be discounted as **insignificant**; and
- **concentrations in soils** - all of the predicted process contributions are less than 1% of the relevant assessment criterion and can thus be discounted as **insignificant**.

A8.54 These conclusions are on the basis that the proposed development will emit dioxins and furans constantly at the maximum level permitted by the European Directive (2010/75/EU, 2010). In practice, emissions are expected to be a small fraction of those assessed; meaning that the impacts will have been grossly over-stated.

A8.55 This assessment has found no requirement for specific mitigation measures.

A9 Stack Height Tests

A9.1 The proposed development was modelled with a stack at various heights, ranging from 60 m to 120 m, using the emission parameters set out in Table A4.1 and the annual mean NOx emission rate in Table A4.2. Figure A9.1 shows how the maximum predicted process contribution to annual mean NOx concentrations varies with increasing stack height. The maximum process contribution falls rapidly between stack heights of 60 m and 70 m; with a steadily-diminishing effect of raising the height beyond 70 m.

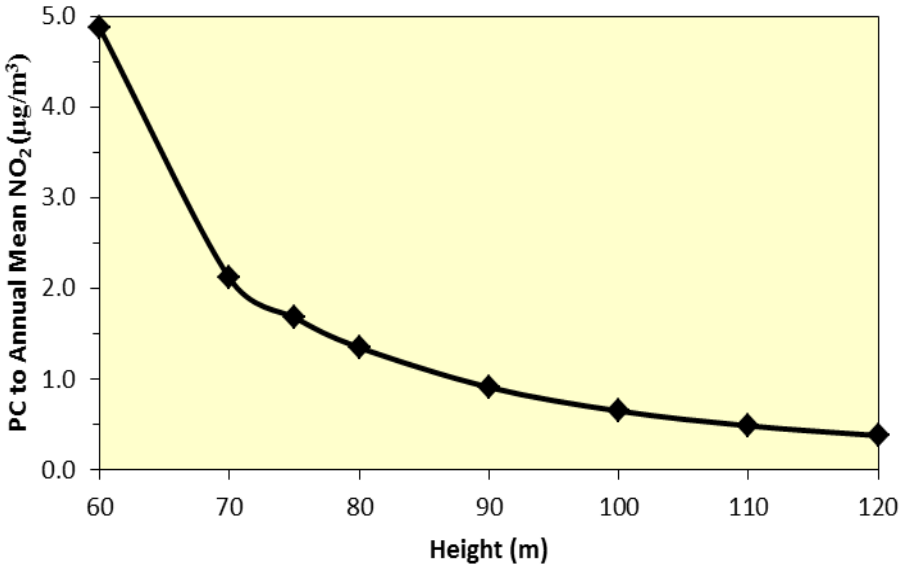

Figure A9.1: Relationship between Stack Height and Maximum PC to Annual Mean NO_2

A9.2 Of principal relevance to the assessment is how the predicted impacts at the worst-case receptors (which are defined as those where both existing concentrations are high and the process contribution will also be high) compare against the assessment criteria described within the air quality chapter of the ES. It was found that, at stack heights where impacts on annual mean NO_2 concentrations were described as 'negligible', impacts on other pollutants were all also described as either negligible or insignificant. The focus was thus on achieving the minimum stack height which would result in only negligible impacts on annual mean NO_2 concentrations. The modelled process contributions were thus combined with those from the road traffic model and assessed using the impact descriptors in Table A5.1. A summary of the impacts with various stack heights is provided in Table A9.1. An 80 m stack is the lowest stack for which the impacts are negligible at all sensitive receptor locations

Table A9.1: Impacts of the Proposed Development with Stack Heights from 60 m to 120 m

Stack Height (m)	Impact	Location
60	Moderate Adverse	Peter Street Sure Start Children's Centre
	Slight Adverse	Borough Road, Croppers Hill, Westfield Street, Peasley Cross Lane / Sutton Road
70	Slight Adverse	Borough Road, Croppers Hill, Westfield Street, Peter Street Sure Start Children's Centre
75	Slight Adverse	Borough Road, Peter Street Sure Start Children's Centre
80	Negligible	All sensitive receptor locations
90	Negligible	All sensitive receptor locations
100	Negligible	All sensitive receptor locations
110	Negligible	All sensitive receptor locations
120	Negligible	All sensitive receptor locations