AIR DISPERSION MODELLING REPORT

GAS UTILISATION COMPOUND
WHINNEY HILL LANDFILL
WHINNEY HILL ROAD
ACCRINGTON
LANCASHIRE
BB5 5EN

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AIR DISPERSION MODELLING REPORT – GAS UTILISATION COMPOUND, WHINNEY HILL LANDFILL, WHINNEY HILL ROAD, ACCRINGTON, LANCASHIRE

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1 INTRODUCTION

1.1 Scope

1.1.1 Sirius Environmental Limited (Sirius) have been commissioned by Suez Recycling and Recovery UK Limited ('Suez') to prepare an Air Dispersion Monitoring Report (ADM) to support the addition of a backup gas engine and enclosed flare to the Gas Utilisation Compound (GUC) associated with Whinney Hill Landfill Site, Accrington, Lancashire.

1.1.2 Currently there are six existing Jenbacher 320 gas engines operational within the GUC and a 3,000m^3/hr High Temperature (HT) Enclosed Flare. An additional Jenbacher 320 gas engine is proposed for use exclusively when maintenance work is being carried out on any of the existing engines. An additional 2,000m^3/hr enclosed flare unit will also be installed to provide sufficient backup capacity for the landfill gas currently being managed at the compound.

1.1.3 The objective of this ADM report is to assess the potential impact on local air quality of the emissions from the combustion of landfill gas in the existing and proposed engines and flares systems under a variety of potential operating scenarios. The ADM results are compared with the Air Quality Standards (AQS) and Environmental Assessment Levels (EALs) set to protect human health, vegetation and ecosystems.

1.2 Model Specification

1.2.1 The air dispersion modelling was performed in accordance with Environment Agency's guidance "Environmental Permitting: Air dispersion modelling reports" (last updated on 19 January 2021). The detailed exhaust emissions dispersion modelling was carried out using the computer model software ADMS5.2, developed by Cambridge Environmental Research Consultants (CERC). This is a new generation dispersion model, which characterises the atmospheric boundary layer in terms of the Monin-Pbukhov length and the boundary layer depth. In addition, the model uses a skewed Gaussian distribution for dispersion under convective conditions, to take into account of the effect of complex terrain and nearby buildings. This model software can be used to assess ambient pollutant concentrations arising form a wide variety of emissions sources associated with an industrial process. It can be used for initial screening or more refined determination of ground level pollutant concentrations on either a short-term basis (up to 24 hour means) or longer term (monthly, quarterly or annual means).

1.2.2 The model outputs have been compared to appropriate long-term and short-term AQS (i.e. statutory national air quality objectives) and EALs (i.e. set guidance values) set to protect human health, and vegetation and ecosystems in order to assess compliance. The findings of the modelling study and conclusions reached are presented in terms of predicted impact on local air quality sensitive receptors (i.e. residential receptors, locations where the general public may be present for sufficient periods of time and ecological designated sites) located within the surrounding area of the site.

1.2.3 The impact assessment includes potential future worst-case emissions from the site, therefore, it is considered that the assessment and findings presented in this report are conservative and that in reality the potential impacts of air emissions are likely to be lower than predicted within the models.

1.3 Report Layout

1.3.1 This report consists of the following:

- Details of the key legislation and policy;
- Details and assumptions used for the model input configuration.
- Results of sensitivity analysis;
- Results and assessment of detailed modelling of ground level concentrations and deposition rates as a result of gas engine and flare exhaust emissions.

2 LEGISLATION & POLICY

2.1 UK Air Quality Strategy

2.1.1 In 2001 the UK Government and developed administrations for Scotland, Wales and Northern Ireland published the Air Quality Strategy. This strategy set air quality standards and objectives for the following key air pollutants that should have been achieved between 2003 and 2010:

- Benzene
- 1,3 – Butadiene
- Carbon Monoxide (CO)
- Lead (Pb)
- Nitrogen Dioxide (NO_2)
- Oxides of Nitrogen (NOx)
- Ozone (O_3)
- Particles (PM_{10})
- Sulphur Dioxide (SO_2)

2.1.2 Local authorities are charged with the task of working towards the objectives for seven of these pollutants. The standards and objectives are subject to regular review taking into account the latest information on the health effects of air pollution as well as technical and policy developments.

2.1.3 The air quality standards and objectives defined within the original 2001 AQS (as amended) are presented in **Table 1**. These standards and objectives, summarised overleaf, were used as the benchmark against which air quality predictions were made.

2.1.4 The objectives are based on the Air Quality (England) Regulations 2000 and Air Quality Limit Values Regulations 2001, and their subsequent amendments, for the purpose of Local Air Quality Management. These Air Quality Regulations incorporate into UK law the limit values required by EU Daughter Directives on Air Quality.

2.1.5 The Air Quality (Standards) Regulations 2010 implement the EC Daughter Directives for sulphur dioxide, nitrogen dioxide, oxides of nitrogen, and particulates (1999/30/EC); benzene and carbon monoxide (2000/69/EC); ozone (2002/3/EC); and, arsenic, cadmium, mercury, nickel and polynuclear aromatic hydrocarbons (2004/107/EC).

2.1.6 For those objectives that are included in regulations for the purposes of local air quality management (LAQM), each local authority is required to work towards the achievement of the objectives within their area.

2.1.7 There are no specified assessment levels for total VOCs, only for specific compounds within this group, such as benzene. However, benzene is only likely to form a small fraction of the total VOC emission. Accordingly, the assessment for VOCs was based solely on the Process Contribution to background concentrations.

Table 1: National Qir Quality Standards and Objectives

Pollutant	Justification	Objective		Measured as	To be achieved by
Benzene	All Authorities	16.25 µg/m^3		Running Annual Mean	31 December 2003
	Authorities in England and Wales only	5 µg/m^3		Annual Mean	31 December 2010
	Authorities in Scotland and Northern Ireland only [a]	3.25 µg/m^3		Running Annual Mean	31 December 2010
1,3- Butadiene	All Authorities	2.25 µg/m^3		Running Annual Mean	31 December 2003
Carbon monoxide	Authorities in England, Wales and Northern Ireland only [a]	10.0 mg/m^3		Maximum daily running 8 hour mean	31 December 2003
	Authorities in Scotland only	10.0 mg/m^3		Running 8 hour mean [b]	31 December 2003
Lead	All Authorities	0.5 µg/m^3		Annual Mean	31 December 2004
		0.25 µg/m^3		Annual Mean	31 December 2008
Nitrogen Dioxide [c]		200 µg/m^3	Not to be exceeded more than 18 times per year	1 Hour Mean	31 December 2005
		40 µg/m^3		Annual Mean	31 December 2005
Oxides of Nitrogen**		(V) 30 µg/m^3		Annual Mean	31 December 2000
Particles (PM_{10}) (gravimetric) [d]	All authorities	50 µg/m^3	Not to be exceeded more than 35 times per year	24 hour mean	31 December 2004
		40 µg/m^3		Annual mean	31 December 2004
	Authorities in Scotland only [e]	50 µg/m^3	Not the be exceeded more than 7 times per year	24 hour mean	31 December 2010
		18 µg/m^3		Annual mean	31 December 2010
Particles ($PM_{2.5}$) Exposure Reduction	UK (Except Scotland)	25 µg/m^3		Annual mean	2020
	Scotland	10 µg/m^3		Annual mean	31 December 2020
	UK Urban Areas	Target of 15% reduction in concentrations at urban background		Annual mean	Between 2010 and 2020
Polynuclear Aromatic Hydrocarbons		1 ng/m^3 B[a]P total content within the PM10 fraction		Annual Mean	31 December 2012
Sulphur Dioxide		266 µg/m^3	Not the be exceeded more than 35 times per year	15 minute mean	31 December 2005
		350 µg/m^3	Not to be exceeded more than 24 times per year	1 hour mean	31 December 2004
		125 µg/m^3	Not to be exceeded more than 3 times per year	24 hour mean	31 December 2004
		(V) 20 µg/m^3		Annual mean	31 December 2000
		(V) 20 µg/m^3		Winter Mean (01 October – 31 March)	31 December 2000

Notes:

- a. *In Northern Ireland none of the objectives are currently in regulation. Air Quality (Northern Ireland) Regulations are scheduled for consultation early in 2003.*
- b. *The Quality Objective in Scotland has been defined in Regulations as the running 8 Hour mean, in practice this is equivalent to the maximum daily running 8 Hour mean.*
- c. *The objectives for nitrogen dioxide are provisional.*
- d. *Measured using the European gravimetric transfer sampler or equivalent.*
- e. *These 2010 Air Quality Objectives for PM 10 apply in Scotland only, as set out in the Air Quality (Scotland) Amendment Regulations 2002.*

μg/m³ – micrograms per cubic metre
mg/m³ – milligrams per cubic metre
*** Assuming NOx is expressed as* NO_2
(v) These standards are adopted for the protection of vegetation and ecosystems. All of the remainder are for the protection of human health.

2.2 Hyndburn Borough Council Air Quality Status Report (ASR)

2.2.1 The requirements of the Local Air Quality Management (LAQM) as set out in Part IV of the Environment Act 1995 and the relevant Policy and Technical Guidance documents place an obligation on all local authorities to regularly review and assess air quality in their areas with the aim to determine whether or not air quality objectives are likely to be achieved. Where an exceedance is considered likely, the local authority must declare an Air Quality Management Area (AQMA) and prepare an Air Quality Action Plan (AQAP) setting out the measures it intends to put in place in pursuit of the objectives. Hyndburn Borough Council is required to produce an annual report outlining the strategies employed to improve air quality and document any progress that has been made.

2.2.2 Currently, there are no AQMAs declared in Hyndburn Borough, where the Whinney Hill Landfill Site is located, therefore, there has been no requirement for an Air Quality Action Plan (AQAP).

2.2.3 The most recent Air Quality Status Report (ASR) available for Hyndburn Borough Council's (HBC) was published in 2020 and outlined actions to be taken forward to improve local air quality, including:

- Sustainable procurement built into the corporate procurement policy
- Green council policy (promoting travel alternatives)
- Eco-driving training for council employees
- Workplace travel plans
- Continuous upgrading of council fleet
- Free rapid electric vehicle recharging point at the town centre
- Installation of 20mph zones
- Projects to actively seek out permitted processes under the Environmental permitting regulations
- Projects to actively identify contraventions of the Clean Air Act
- Use of Planning regime to control emissions from development sites
- Use of the planning regime to assess and where appropriate mitigate air pollution from end developments

2.2.4 As detailed in Policy Guidance LAQM.PG17 (Chapter 7), local authorities are expected to work towards reducing emissions and/or concentrations of $PM_{2.5}$ (particulate matter with an aerodynamic diameter of 2.5µm or less). There is clear evidence that $PM_{2.5}$ has a significant impact on human health, including premature mortality, allergic reactions and cardiovascular diseases.

2.2.5 Owing to financial constraints, $PM_{2.5}$ is not monitored as it is recognised that there is no safe limit, therefore, HBC aims to reduce this pollutant via the following measures:

<u>Planning</u>

- Control of emissions from construction sites likely to contribute to PM2.5 concentrations by establishing Dust Management Plans and Construction Management Plans.
- Developments anticipated to be a source of PM2.5 will have air quality assessments conditioned to enable any attenuation measures to be secured prior to operation.
- No disposal of waste via burning is permitted on development/demolition sites in the borough.

Local Air Pollution Prevention and Control

- Permit applications for installations likely to be a source of $PM_{2.5}$ would require an assessment and attenuation measures if indicated.
- Permitted installations will be inspected in timely fashion and emission monitoring audited to facilitate the maintenance of $PM_{2.5}$ at appropriate levels.

Other Control Sources of $PM_{2.5}$

- Smoke Control Orders – The whole of Hyndburn Borough is subject to smoke control orders, contravention of the requirements of the orders from all sources will be investigated and appropriate action taken to remedy the contravention which could include advice, written warnings and legal action e.g. advice to homeowners on the correct use and maintenance of solid fuel stoves.
- Clean Air Act – The emission of dark smoke from industrial/commercial premises will be investigated and remedied through the powers available under the Act.
- Vehicles Emissions & Education - Awareness raising amongst carers collecting children from school, about the detrimental emissions from car engines left running whilst they wait, with the aim of reducing this practise;
- Statutory Nuisance – Nuisance arising from smoke, fumes and or dust will, if appropriate, be dealt with through abatement notice.
- Allotment Waste Burning – consideration of a ban on the burning of vegetation and other waste on Council controlled sites;

2.2.6 HBC have undertaken passive monitoring of NO_2 at 14 sites. Between 2012 and 2020, with declining trends at all monitoring points, with the exception of one which is stated to be as a result of its proximity to the M65. At present, there is no monitoring of Particulate Matter ($PM_{2.5}$ and PM_{10}), sulphur dioxide (SO_2) or other pollutants (such as carbon monoxide, benzene, lead and 1,3-butadiene).

2.2.7 In 2017, HBC commissioned Ricardo Energy & Environment (of Ricardo-AEA Ltd) to undertake air quality monitoring between March and June. This air quality monitoring was carried out in response to an issue with the burning of an unknown waste in the Meadow Street area of Great Harwood, ~3km northwest of the GUC. Assessment of compliance with relevant national air quality objectives was carried out. The monitoring location was 3km northwest of the Whinney Hill Landfill GUC. The automatic monitoring recorded Particulate Matter, Total Suspended Particles TSP, PM_{10}, $PM_{2.5}$ and PM_1.

2.2.8 The 2017 Air Quality Monitoring Report found the hourly PM_{10} mean limits specified by DEFRA were exceeded three times during the monitoring period, while all other analysed pollutants were within the limits. The AQS objective for PM_{10} is a maximum of 50µg m^{-3} for 24-hour mean periods and cannot be exceeded more than 35 times a year. As only three exceedances occurred during the period March – June, the area is well within the AQS objective. The annual mean for PM_{10} was compliant with the AQS objective of 40 µg m^{-3}.

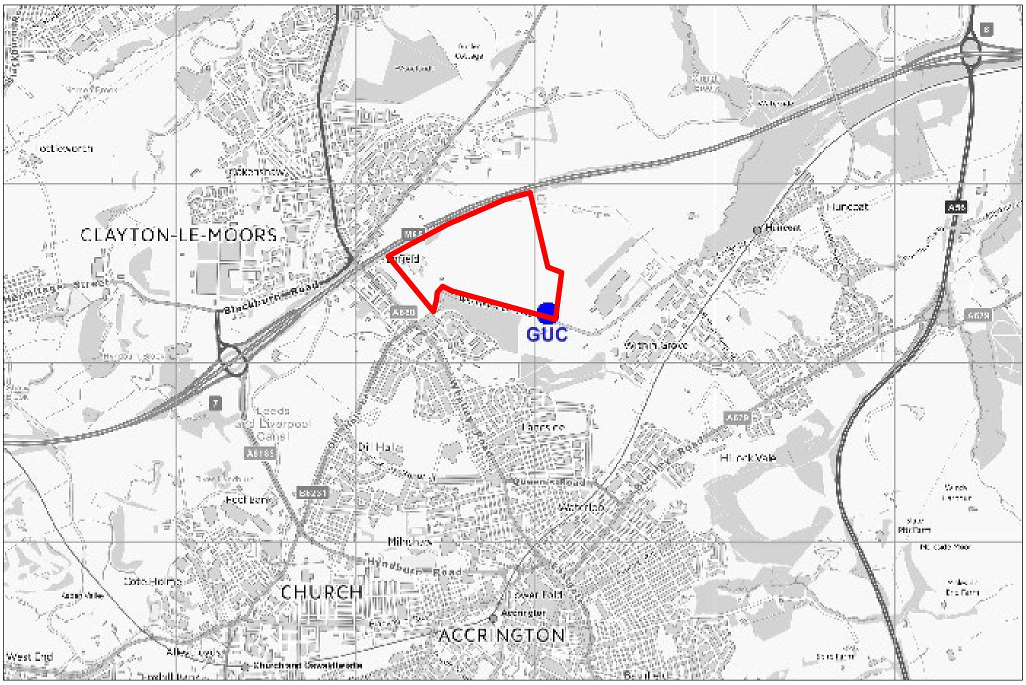
2.2.9 As mentioned above, there are no AQMAs within the Hyndburn Borough. The nearest AQMAs to the site are all within the Blackburn with Darwen Borough Council area and are located 5km, 6.3km and 7.3 km south-west to west of the Whinney Hill Landfill site boundary. All three of these AQMAs list the “Pollutants Declared” as “NO_2 - Annual Mean”.

3 MODEL PARAMETERS

3.1 Site Location & Local Setting

3.1.1 As shown in **Figure 1** Whinney Hill Landfill Site lies south of the M65 and is located approximately 600m southeast of the residential area of Clayton-Le-Moors, 1.5km north of Accrington town centre, 8.5km west of Burnley and 7.5km east of Blackburn. The landfill is bounded by the M65 to the north beyond which are open pasture and woodlands; residential areas and the A680 to the west; Whinney Hill Road, woodland and agricultural land to the south, beyond which are the residential suburbs of Accrington; and a HWRC, woodland and industrial properties to the east. The Gas Utilisation Compound (GUC) is located in the south-eastern corner of the wider landfill complex, adjacent to Whinney Hill Road.

Figure 1: Site Location



3.2 Plant Details

3.2.1 The ADMS model requires emission sources to be defined in terms of dimensions, location and physical characteristics of temperature and velocity. This modelling study has been carried out to assess the potential impact on local air quality due to releases of atmospheric pollutants from the emission release points associated with the GUC.

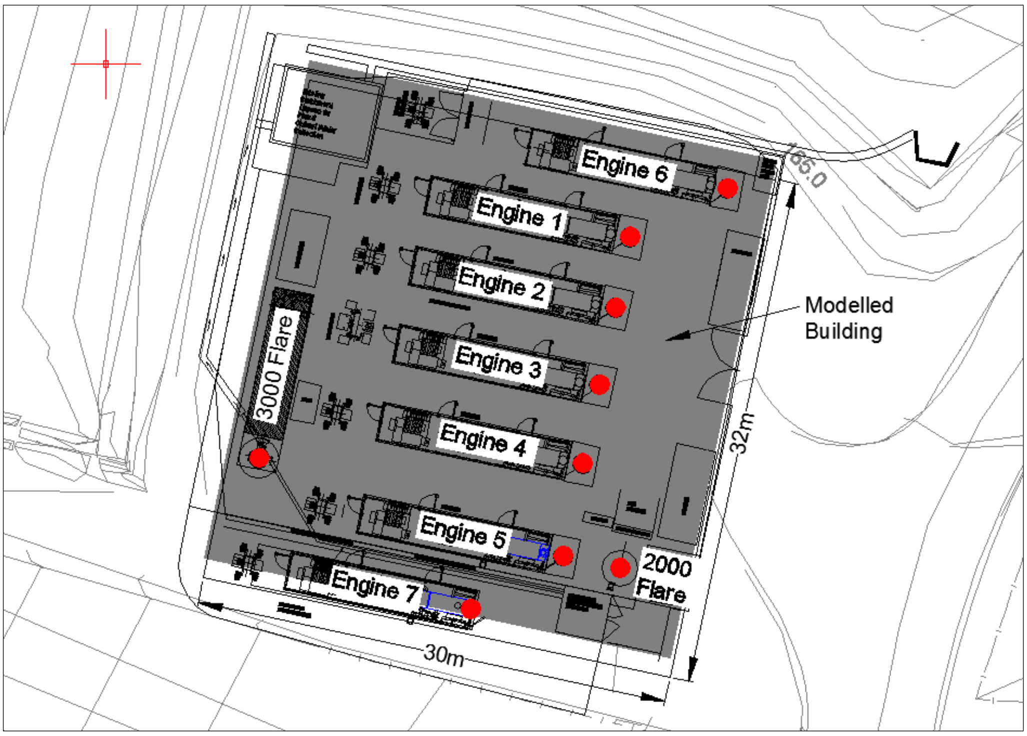
3.2.2 The GUC currently consists of six Jenbacher 320 (1MWe) gas engines and a High Temperature Enclosed Flare (3,000 m^3/hr capacity) that are used to treat the landfill gas generated within the adjacent landfill. Engines 1 and 2 were installed before 31st December 2005. All other engines were installed after this date, with the last two engines installed in 2013. All engines are currently fitted with 20m high exhaust stacks to support the level of dispersion required to account for the background concentrations of nitrogen dioxide present in the vicinity of the landfill when the assessment to support the installation of the Engines 5 and 6 was carried out in 2012 (Golders, 2012).

3.2.3 The GUC connects to the national electricity grid via two separate connections, with engines 1-4 linked to one connection and engines 5 & 6 connected to the other. The probability of both connections suffering issues simultaneously and affecting the export to the grid is much lower.

3.2.4 The latest GasSim model has calculated that the landfill will achieve peak gas generation of ~5,000m³/hr (95th percentile) in 2022. The combined gas treatment capacity of the GUC is currently ~6,600m³/hr. However, to ensure that suitable flare capacity is available at the site a second high temperature enclosed flare with the capacity to treat up to a further 2,000 m³/hr is proposed to be installed. Additionally, a seventh Jenbacher 320 (1MWe) gas engine is also proposed to be installed as a backup unit for when any of the other six engines need to be shut down for maintenance requirements. Due to the intermittent operation of this backup engine, it is proposed to fit the engine with a standard 7.4m high exhaust system.

3.2.5 The proposed layout of the GUC is presented in **Figure 2.**

Figure 2: Modelled building layout



3.3 Emissions Parameters

3.3.1 The operation of the existing six engines and HT flare are regulated by Environmental Permit EPR/BL9500IJ. Whilst two of the engines were installed before 2006, the ELVs for NOx for all engines are specified at the reduced value of 500mg/Nm³ due to the elevated background concentrations of NO_2 present in the vicinity of the site when the last assessment was performed in 2012 (Golders, 2012).

3.3.2 All the existing engines are not currently subject to the requirements of the Medium Combustion Plant Directive (MCPD). It is understood that the seventh engine will be supplied to be compliant with the MCPD ELVs, regardless if the operating hours are less than 500 hr/year.

3.3.3 Stack flow parameters for each engine and flare unit has been derived from technical datasheets published by the manufacturer. Flow parameters for each flare unit has been calculated in line with the sample calculations and assumptions presented in EA (2002).

3.3.4 The physical characteristics and flow parameters of each emission point modelled is summarised in **Table 2.**

Table 2: Stack physical and flow characteristics

Parameter	Engines 1-6	Engine 7	3000 m³/hr HT Flare	2000 m³/hr HT Flare
Stack Height (m)	20	7.4	11	9.5
Stack Internal Diameter (m)	0.4	0.4	2.12	1.6
Efflux Temperature (ºC)	510	510	1,000	1,000
Efflux Velocity (m/s)	28.09	28.09	12.14	14.21
Location (x,y)	(1) 376073,430277 (2) 376072,430273 (3) 376071,430268 (4) 376070,430263 (5) 376069,430257 (6) 376079,430280	376063,430254	376050,430263	376073,430256

3.3.5 The mass emission rate for each emission point is summarised in **Table 3**. Engine emission rates are derived using mean oxygen and water content of 6.4% and 11% respectively, as derived from stack emission monitoring carried out in 2020.

Table 3: Emission flow rates

Parameter	Mass Emission Rate (g/s)			
	Engines 1-6	Engine 7	3,000 m³/hr HT Flare	2,000 m³/hr HT Flare
Nitrogen Oxides (as NO_2)	0.5	0.51	1.38	0.92
Sulphur Dioxide	0.2	0.11	2.21	1.47
Carbon Monoxide	1.4	1.4	0.46	0.31
Particulates	0.012	0.012	0.09	0.06
NMVOCs	0.037	0.037	0.09	0.06

3.3.6 For the existing engines the emission rates for NOx (as NO_2) and carbon monoxide are derived from ELVs specified in the permit of 500 mg/Nm³ and 1,400 mg/Nm³ respectively *(reference conditions are: 0ºC; 101.3kPA, 5% O2, dry gas).*

3.3.7 Particulates are based on the maximum recommended emission concentration of 12.5mg/Nm³ for gas engines specified in the GasSim manual. Sulphur dioxide releases from the existing engines are calculated at a concentration set at approximately half (~200 mg/Nm³) the maximum recommended concentration for gas engines specified in GasSim manual. Test reports indicate that the concentration of sulphurous compounds in the inflow gas to the GUC is less then 150mg/m³. Allowing for combustion conversions and the dilution available from combustion air flow a SO_2 emission concentration of 200mg/Nm³ is therefore considered to be a conservative representation of potential emissions from the engines.

3.3.8 VOCs emissions rates from the engines are based on 50% of the former ELV for non-methane VOCs of 75mg/Nm³. This ELV is no longer allocated for landfill gas engines following a review in 2010 (EA, 2010b) that showed that the ELV was not exceeded. Historic site-based monitoring has also confirmed that NMVOCs concentrations are less than 1% of the ELVs (Golders, 2012), with a benzene and 1,3-butadiene making up a fraction of the total NOVOCs monitored.

3.3.9 The additional backup engine will be MCPD compliant. The emission rate for NO_x and SO_2 are based on the ELVs for engines fuelled by biogas specified in Table 2 of Part 2 to Annex II of the MCPD i.e. NO_x = 190mg/Nm³; SO_2 = 40 mg/Nm³ *(reference conditions: 0ºC; 101.3kPA, 15% O_2, dry gas)*. Emission rates for other parameters are derived as per Engines 1-6.

3.3.10 For each flare the emission rates are also based on the ELVs for NOx, (150mg/Nm^3), CO (50mg/Nm^3) and total VOCs (10mg/Nm^3) (*reference conditions are: 0ºC; 101.3kPA, 3% O_2, dry gas*). Particulates are based on maximum recommended value of 10mg/Nm^3 specified in the GasSim manual. SO_2 emission rates for the flares are derived at 50% of the maximum emission concentration of 480mg/Nm^3 recommended in the GasSim manual.

3.4 Atmospheric Chemistry

3.4.1 The atmospheric chemistry module of ADMS was not used for calculating predicted ground level concentrations of NO_2. Instead, as per the EAs guidelines the following conversion ratios have been applied:-

- 35% for short-term average concentrations; and
- 70% for long-term average concentrations.

3.5 Meteorological Data

3.5.1 The most important meteorological parameters governing the atmospheric dispersion of pollutants are wind speed, wind direction and atmospheric stability:

- Wind direction determines the direction of travel of the plume;
- Wind speed affects dispersion by increasing the initial dilution of pollutants and inhibiting plume rise for elevated sources; and
- Atmospheric stability is a measure of the turbulence of the air, which will affect the degree of dilution in the atmosphere or dispersion.

3.5.2 Following consultation with the Met Office the nearest weather station to the site is located at Stonyhurst, ~10.5km northwest of the site. However, this station only records air temperature, rainfall and relative humidity.

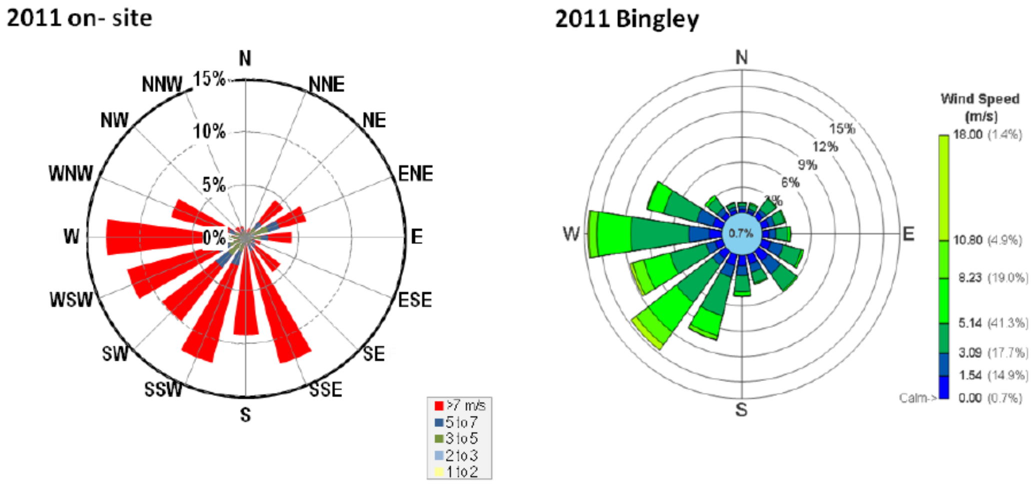
3.5.3 The nearest weather station that records all meteorological parameters necessary to support modelling with ADMS 5.2 is located ~33.5km southeast of the site (Bingley No. 2). Other sites considered included Blackpool (~44km) and Manchester (~46km). Both sites are located further from Whinney Hill, whilst Blackpool is also representative of a coastal location and Manchester of a more urban landscape.

3.5.4 Previous comparisons of site derived meteorological data to Bingley indicate similarities with their wind roses **(Figure 3).** Windroses for each of the five years of met data used in this assessment are presented in **Appendix 2**. Note, appropriate datasets are not available from the site recording station to support modelling requirements.

3.5.5 Due to proximity of the Stonyhurst weather station to the site the available data was merged with the other required parameters available from the Bingley No.

2 recording station. Whilst both the Stonyhurst and Bingley No2 recording stations are in rural areas, Stonyhurst is located at a similar elevation ~110mAOD to that of Whinney Hill, whilst Bingley is located at an altitude of ~250mAOD. The parameters available for Stonyhurst are therefore considered to be more representative of the meteorological conditions in the vicinity of Accrington.

Figure 3: Comparison of wind roses plotted from site-based data and Bingley No2. recording station



3.6 Local Environmental Conditions

3.6.1 Local environmental conditions describe the factors that might influence the dispersion process (such as nearby structures, sharply rising terrain, etc.) and also describe the locations at which pollutant concentrations are to be predicted. These include:

<u>Surface Roughness</u>

3.6.2 Surface roughness defines the amount of near-ground turbulence that occurs as a consequence of surface features, such as land use (i.e. agriculture, water bodies, urbanisation, open parkland, etc). A value of 0.5m is typical of open parkland and suburbia. Agricultural areas may have a surface roughness of approximately 0.2m to 0.3m whereas large cities may have a roughness of 1 to 1.5m.

3.6.3 A surface roughness factor of 0.5m was considered to most representative roughness values accounting for the prevailing wind direction and the suburban landscape surrounding Whinney Hill Landfill site. This is discussed in greater detail in **Appendix 1.**

<u>Nearby Buildings and Structures</u>

3.6.4 The proximity of solid structures, such as buildings, to an emission source can affect the dispersion of a plume, particularly in the vicinity of that emission points. The GUC is remote from other structures and buildings, but itself contains a number of engine, storage and welfare units. Due to the similarity in height and proximity of each unit to each all these structures have been combined as a single structure for modelling purposes. Summary details of the building input parameters modelled are presented in **Table 4**. The generally rule of thumb that buildings that are at least 1/3rd of the height of the stack are likely to have an impact on dispersion. The height of the modelled building unit is specified at 2.6m, which is marginally greater than 1/3rd of the exhaust stack height of the additional engine.

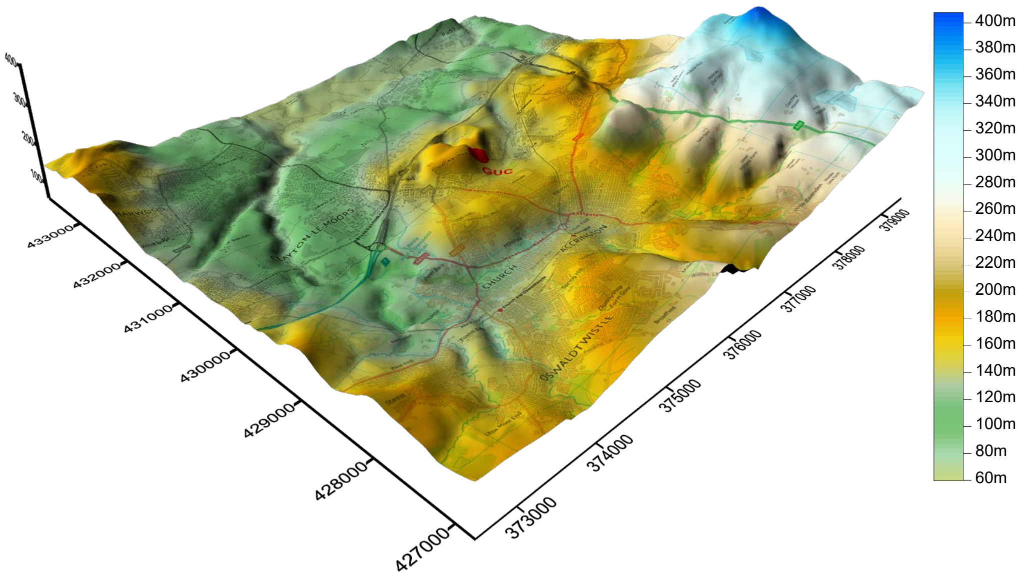
Table 4: Modelled building parameters

Building	Height (m)	Length (m)	Width (m)	Angle (º)
Gas Compound	2.6	30	32	102

<u>Topography</u>

3.6.5 Local terrain can affect wind flow patterns and, consequently, can affect the dispersion of atmospheric pollutants. The presence of elevated terrain can significantly affect the dispersion of pollutants and the resulting ground level concentration in a number of ways. Elevated terrain reduced the distance between the plume centre line and the ground level, thereby increasing ground level concentrations. Elevated terrain can also increase turbulence and, hence, plume mixing with the effect of increasing concentration near to a source and reducing concentrations further away. The effects of terrain are not normally noticeable where the gradient is less than 1:10. The terrain model for the locality is presented in **Figure 4** and shows an area measuring 6 km x 6 km.

Figure 4: 3D representation of modelled terrain



3.6.6 Whinney Hill landfill site is located at a topographical high point along the northern edge of Accrington. Along the southern edge of the landfill ground levels peak at ~180mAOD falling towards the south at gradients of up to ~1:10. Ground levels also fall away from the site along the western, northern and eastern edges of the landfill, although at shallower gradients.

<u>Output Grid</u>

3.6.7 When setting up a receptor grid it is important to ensure that there are sufficient receptor points to be able to predict the magnitude and location of the maximum Process Contribution. If the grid of receptor points is too widely spaced, the maximum concentration may be missed. The 2012 assessment was carried out using a 50m grid spacing combined with specified receptor points. This grid spacing has been reduced to 25m to account for the stack heights of the additional engine and flares being modelled.

3.6.8 Discrete receptors have also been included in the model. Discrete receptors were identified as the areas of population surrounding the modelled site boundary and locations where there is likely to be relevant public exposure to the emissions. A total of 21 discrete receptors have been included in the modelling, as listed in **Table 5** and illustrated **Figure 5.**

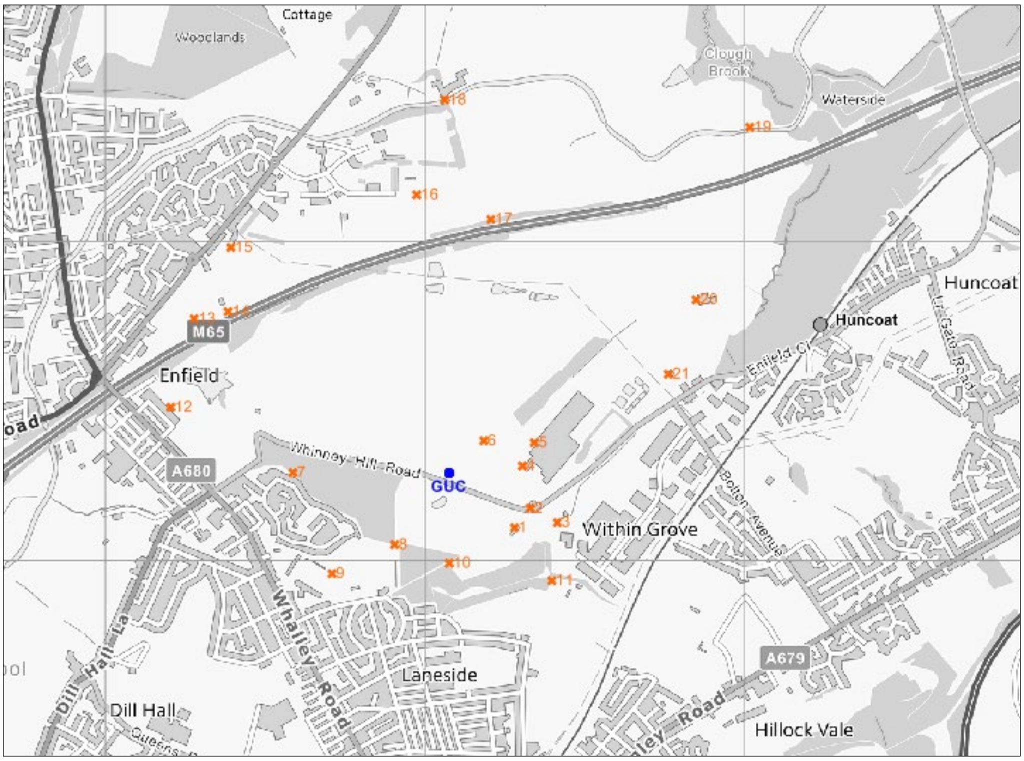
Table 5: Specified receptors included in the Model

No.	Receptor Name	X Coordinate (m)	Y Coordinate (m)	Approx. Distance from GUC (m)
1	Sankey House Farm	376278	430105	250
2	Caravan Park	376327	430166	270
3	Huntcoat Industrial Estate	376412	430121	360
4	Brickworks S	376303	430298	220
5	Brickworks N	376340	430371	425
6	HWDC 1	376182	430377	60
7	Tunstall Drive	375585	430277	300
8	Playing Field S	375903	430052	310
9	Football Ground S	375707	429961	450
10	Footpath S	376074	429994	275
11	Tennis / Cricket Ground	376395	429939	450
12	William Street	375203	430482	875
13	Football Ground W	375276	430759	900
14	Bold Venture Farm	375382	430781	890
15	Hawthorne Bank	375391	430982	975
16	Moorfield Industrial Estate	375972	431147	875
17	Footpath N	376204	431071	750
18	Moorside Farm	376060	431444	1,175
19	Clough Bank Bridge & Altham Clough Wood (DAW)	377014	431358	1,400
20	Nearer Holker House	376846	430818	925
21	Oak Bank	376759	430585	750

3.6.9 In terms of ecological receptors, upon a search on DEFRA's Magic Map Application (www.magic.gov.uk, 2020) it was confirmed that there are no SPAs, SACs, or RAMSAR sites located within 10km of the site. There are also no SSSIs within 2km of the site.

3.6.10 The only locally designated conservation area with 2km of the GUC is Altham Clough Wood, which is located ~1.4km to the northeast (see Receptor '19') and this has been included in the dispersion modelling assessment. There are other open spaces which the local borough council like to 'encourage' wildlife e.g. Mercer Park, but these are not designated local wildlife sites.

Figure 5: Discrete receptor locations



3.7 Background Air Quality

<u>Nitrogen Dioxide</u>

3.7.1 In order to determine appropriate background levels of nitrogen dioxide within the assessment area, a number of information sources have been reviewed, including;

- DEFRA 2018 background estimate maps
- Local authority monitoring data
- Air Pollution Information System (APIS)

3.7.2 The estimated annual mean NO_2 concentrations based on the 2018 DEFRA background model data have been for 2018, 2019, 2020, 2021 and 2022 for the 1km x 1km grid within the vicinity of the site (X 376500, Y 430500) are summarised in **Table 6.** The estimated NOx concentration for 2022 is also presented.

Table 6: Background NOx and NO_2 Concentration Estimates within the vicinity of the site

Determinand	Projection Year				
	2018	2019	2020	2021	2022
NOx	-	-	-	-	16.51
NO_2	14.07	13.59	13.06	12.66	12.27

3.7.3 The background maps predict reductions in NO_2 concentrations of ~0.4-0.5µg/m³ each year on year from 2018.

3.7.4 Nitrogen dioxide is monitored at a total of 14 non-automated, diffusion tube locations across the Hyndburn borough. The nearest (Site 14) to Whinney Hill Landfill GUC is ~750m to the west, along the A680 (Whalley Road). Another 5 diffusion tubes sites (Sites 2 & 16-19) are also located further north along the

A680, in the vicinity of the M65. Each of these monitoring sites are listed as monitoring 'urban background' or 'kerbside' air quality.

3.7.5 A further 6 diffusion tubes (Sites 1, 7, 10-12 & 20) are located over ~1.5km from the site, within the centre and immediately surrounding suburban areas of Accrington. The remaining 2 are located in the conurbation of Broadfield (Site 4) to the south of Accrington and the village of Rishton (Site 3). Both these monitoring sites are located over 3km from Whinney Hill GUC.

3.7.6 Details of the annual mean NO_2 concentrations recorded at around the A680 and in and immediately surrounding the centre of Accrington are present in **Table 7**. Their locations are illustrated in **Figure 6.** Between 2012 and 2019 significant reductions of between **~4 μg/m³** and **~10 μg/m³** have been achieved at most sites, but also indicate that kerbside and urban background concentration are around twice that of the background estimates for the area. NO_2 concentrations in the vicinity of Whalley Road (Sites 2, 14 & 16-19) located to the west of the landfill typically range between **23 μg/m³** and **30.4 μg/m³**, with a mean of **~26.3 μg/m³.** For assessment purposes the background concentration has therefore been selected at the mean background concentration of **26.3 μg/m³**. It should be noted, that given the current operation of the GUC, these monitored background concentrations are likely to include a contribution from its operation. Modelling results of the current operating scenario at the GUC (Scenario 1) would that this is likely to contribute to up to **0.9 μg/m³** in the vicinity of these monitoring sites, although a level of conservatism is included in these modelled scenarios.

3.7.7 A search on the APIS database has returned a 3-year annual mean (2016-2018) background NOx (as NO_2) concentration of **21.54** μg/m³ for the 1km x1 km modelled grid square within which Altham Clough Wood is located. This is based on the Pollution Climate Mapping Model background maps that has been calibrated using data from the national roadside contribution networks, with locations close to busy roads including an additional roadside contribution to account for contribution from road traffic source. This concentration is considered to more representative of background NOx concentrations at areas located further from the urban areas of Accrington.

Figure 6: Hyndburn BC NOx monitoring locations

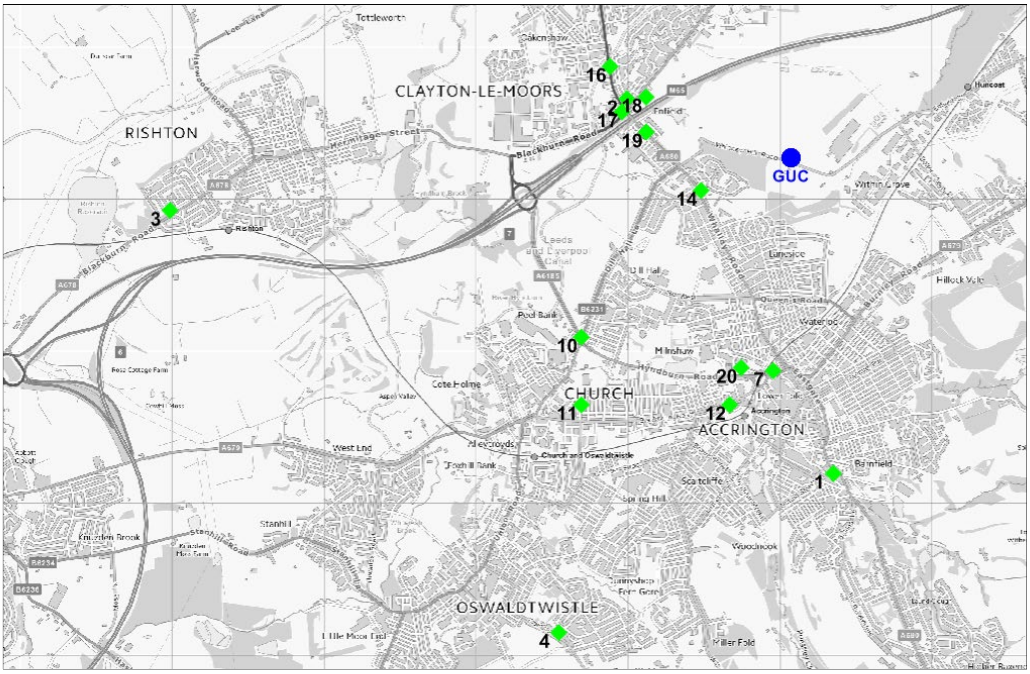


Table 7: Hyndburn Borough Council Annual Mean NO_2 Monitoring Results (2012-2019)

Site ID	Site Name	Site Type	Monitoring Type	NO_2 Annual Mean Concentration (µg/m3) (1) (2)							
				2012	2013	2014	2015	2016	2017	2018	2019
1	Manchester Road	Urban Background	Diffusion Tube	34	28.8	30.4	28.5	28.5	29.4	28.2	25.8
2	Hare and Hounds, Whalley Road	Kerbside	Diffusion Tube	31	26.9	28.5	25.8	26.7	25.8	25.9	25.8
3	Rishton Esplanade	Urban Background	Diffusion Tube	22.3	19.2	20.9	15.6	15.6	15	15.3	15.6
4	Fielding Lane	Urban Background	Diffusion Tube	22.3	19.2	20.9	18.4	18.4	18.7	18	17.5
7	Eastgate	Urban Centre	Diffusion Tube	35.9	31.7	31.4	29.4	30.4	31	29.9	29.4
10	Henry Street	Urban Background	Diffusion Tube	28	24	27.6	23.9	24.8	25.8	25.2	24.8
11	Blackburn Road	Urban Background	Diffusion Tube	23.3	21.1	21.9	19.3	19.3	18.7	19.9	19.3
12	King Street	Urban Background	Diffusion Tube	36.9	33.6	34.2	29.4	30.4	33	29	33.1
14	71 Whalley Rd	Urban Background	Diffusion Tube	33	29.7	29	27.6	29.4	28.5	27.1	23.9
16	274 Whalley Rd	Kerbside	Diffusion Tube	37.8	33.6	33.3	31.3	31.3	30.3	27.6	30.4
17	20 St Marys Court	Kerbside	Diffusion Tube	32	28.8	29.5	26.7	27.6	26.7	26.9	26.7
18	27 Wellfield	Urban Background	Diffusion Tube	23.3	24	22.8	22	22.1	24	22.5	23
19	116 Whalley Road	Urban Background	Diffusion Tube	35.9	30.7	30.4	28.5	33.1	29.4	28.9	27.6
20	Tesco, Eagle Street	Urban Background	Diffusion Tube	35.9	32.6	29.4	29.4	30.4	29.4	28.7	30.4

Notes:
(1) Means for diffusion tubes have been corrected for bias. All means have been “annualised”.
(2) Concentrations are those at the location of monitoring and not those following any fall-off with distance adjustment.

Other Pollutants

3.7.8 The estimate background concentrations for other pollutants considered in this assessment are summarised in **Table 8**. PM_{10} and $PM_{2.5}$ are based on the 2018 updated background maps, whilst sulphur dioxide, benzene, 1,3-butadienne and carbon monoxide have been derived from the 2001 background maps, with adjustment factors used to calculate the predicted concentrations for the year 2022.

Table 8: Predicted annual mean background pollutant concentration (Year: 2022)

Pollutant	Predicted Annual Mean Background Concentration for 2022 (µg/m³)
PM_{10}	13.1
$PM_{2.5}$	8.71
Sulphur Dioxide	4.22
Carbon Monoxide	143
Benzene	0.322
1,3-butadienne	0.087

Short-Term Averaging Period Adjustments

3.7.9 The background concentrations presented above are representative of annual average long-term concentrations. For short-term averaging periods the following conversations have been utilised in line with EA guidance: -

- Hourly mean – annual mean x 2;
- Daily mean – hourly mean x 0.59;
- 8 hour mean – hourly mean x 0.7; and
- 15-minute mean – hourly mean x 1.34.

Nutrient Deposition

3.7.10 The critical load function for nitrogen deposition at the Altham Clough Wood Designated Ancient Woodland (DAW) along with the most recent estimates of nitrogen deposition at this DAW has been derived the Air Pollution Information System (APIS) database, the details of which are summarised in **Table 9.**

Table 9: Baseline and Critical Loads for nitrogen deposition at Altham Clough Wood DAW

Conservation Area	Critical Load (Kg/Ha/yr)		Baseline Conditions (kg/Ha/yr)	"Headroom" (kg/Ha/yr)	
Altham Clough Wood (DAW)[1]	10	20	40.74	-30.74	-20.74

[1] - Critical load based on range specified for broadleaved woodland habitats

3.7.11 As can be seen, the data from the APIS website indicates that the Critical Load for nutrient nitrogen deposition is currently exceeded in terms of the lower and higher critical loadings.

Acid Deposition

3.7.12 An assessment of acid deposition in relation to Critical Loads has also been undertaken based upon Critical Load data from the APIS website. The Critical Loads and baseline for acid deposition at the DAW are summarised in **Table 10.**

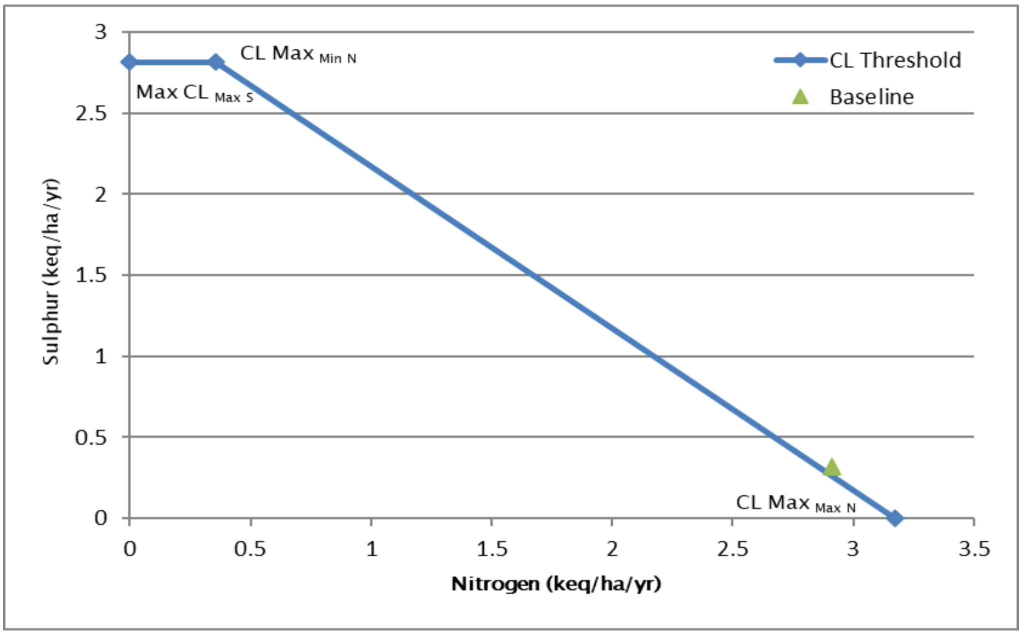
Table 10: Baseline and Critical Loads for acid deposition at Altham Clough Wood DAW

Conservation Area	Critical Load (Keq/Ha/yr)		Baseline Conditions (keq/Ha/yr)
	$CL_{Min/Max}$ N	CL_{Max} S	
Altham Clough Wood (DAW)[1]	0.357/3.176	2.819	2.68 (N:2.91 / S0.34)

[1] - Critical load based on range specified for broadleaved woodland habitats

3.7.13 The three critical loads values represent a combined threshold for which exceedance may result in damage to a particular habitat. As shown in **Figure 7** the baseline acid deposition for Altham Clough Wood is currently marginally exceeding the critical load threshold.

Figure 7: Baseline and Critical Load threshold graph for acid deposition at Altham Clough Woods DAW



3.7.14 It should be noted that exceedance of a Critical Load is not a quantitative estimate of damage to a particular habitat but represents the potential for damage to occur. There is no evidence in the available literature to indicate that Altham Clough Wood DAW is suffering as a consequence of nutrient nitrogen and acid deposition from nearby sources, even though background deposition rates marginally exceed the Critical Loads thresholds.

3.8 Sensitivity Analysis

3.8.1 The model was run to determine the parameters that have a significant impact on the predicted ground-level concentrations (Process Contributions). The parameters assessed were:

- Surface Roughness;
- Terrain;
- Building Effects; and,
- Meteorological Data.

3.8.2 The results are presented and discussed in **Section 4.2 to 4.4.**

3.9 Model Scenarios & Assumptions

3.9.1 In consideration of the proposed changes to the Gas Utilisation Compound a total of four scenarios have been modelled to consider the potential emissions from various operational options:-

- ***Scenario 1*** – Six existing engines together with the 3,000m³/hr capacity flare (existing operating scenario);
- ***Scenario 2*** – 5 existing engines, engine 7 and 3,000m³/hr capacity HT flare;
- ***Scenario 3*** - 5 existing engines, engine 7 and 2,000m³/hr capacity HT flare; and
- ***Scenario 4*** – Both HT flares only.

3.9.2 In order to undertake the preliminary sensitivity analysis it has been necessary to make several assumptions. These have been described above, however a comprehensive list follows:-

- All engine and flare emissions are continuous each day throughout the year;
- Emission scenarios assume all combustion source are operating at full capacity regardless of the landfill gas flow to the GUC;
- Pollutant emission concentrations and discharge parameters (efflux temperature, efflux velocity, moisture content etc) were based on data provided by Suez;
- The effects of terrain were taken into account in the modelling procedures;
- Hourly averaged meteorological data has been used to model dispersion. The data has been derived by combining the relevant available parameters recorded at the Stonyhurst recording station with the remaining parameter requirements recorded at the Bingley No.2 record station;
- Environmental Assessment Levels were based on the Air Quality Regulations and Limit Values, and Environmental Assessment Levels (EALs) specified by the Environment Agency;
- Pollutant precipitation wash out was ignored i.e. wet deposition.

4 SENSITIVITY ANALYSIS

4.1 Introduction

4.1.1 Sensitivity analysis was undertaken on the basis of maximum emissions of NOx (as NO2) and the potential impact on ground level concentrations. This is the most significant pollutant in terms of Local Air Quality Management within the Borough of Hyndburn, particularly in relation to the long-term annual average objective value of **40 µg/m³**. Sensitivity analysis was undertaken based on **Scenario 2** using the existing stack heights for the existing engines and flare, with exhaust stack heights for the additional engines and flares modelled at the standard heights with which the units are supplied.

4.2 Surface Roughness

4.2.1 Previous modelling carried out in 2012 (Golders, 2012) was carried using a surface roughness of 0.3m, which is representative of agricultural landuse. Taking into consideration the presence of outer developed areas of Accrington to the south and west of the landfill, together with areas of open fields and woodlands, consideration has been given to the significance of using an increased surface roughness value of 0.5m (parkland and open suburbia). The results of the dispersion modelling sensitivity analysis for surface roughness are presented in **Table 11.** The sensitivity analysis indicates that a surface roughness value of 0.5m increases the annual mean and hourly mean ground level concentrations by ~15% and ~6% respectively. A surface roughness value of 0.5m was therefore used in the modelling.

Table 11: Results from surface roughness sensitivity analysis - PC NOx

Run Name	Surface Roughness Value	
	0.3	0.5
Annual Average	11.6	13.3
Hourly Average	102	108
Based on: Surface Roughness – variable; Buildings Effects Module – Inactive; Terrain Module – Inactive; Meteorological Data - 2017		

4.3 Buildings

4.3.1 Modelling of building downwash effects was undertaken using, the results of which are presented in **Table 12**. The results that the building modules has no significant influence on ground levels concentrations.

Table 12: Results from building sensitivity analysis - PC NOx

Run Name	Buildings Module	
	No	Yes
Annual Average	13.3	13.3
Hourly Average	108	108
Based on: Surface Roughness – 0.5m; Buildings Effects Module – variable; Terrain Module – Inactive; Meteorological Data - 2017		

4.4 Terrain

4.4.1 The results of the dispersion modelling sensitivity analysis for terrain using ADMS 5.2 are presented in **Table 13.** Inclusion of terrain effects into the model resulted in a ~15% increase in both short- and long-term ground level concentrations of pollutants. Subsequent inclusion of the buildings module alongside the terrain module resulted in a very marginal reduction in the short-term ground level concentration.

Table 13: Results from terrain sensitivity analysis - PC NOx

Run Name	Terrains Module		Terrain & Buildings
	No	Yes	
Annual Average	13.3	15.3	15.3
Hourly Average	108	124	123
Based on: Surface Roughness – 0.5m; Buildings Effects Module – variable; Terrain Module – variable; Meteorological Data - 2017			

5 DETAILED MODELLING – AIR QUALITY ASSESSMENT

5.1 Modelled Parameters

5.1.1 Detailed atmospheric dispersion modelling was undertaken on the basis of the conclusions of the sensitivity analysis as follows:

- Building module: active
- Terrain effects: active
- Surface roughness: 0.5 metres

5.1.2 Emissions of NOx, SO_2, CO, Particles (PM_{10} & $PM_{2.5}$), and VOCs were assessed in line with the Air Quality Regulations and their objective limits (where applicable), or against specific pollutant Environmental Assessment Limits (EALs) detailed in the Environment Agency's guidance.

5.2 Assessment Criteria

<u>Environment Agency Significance Screening</u>

5.2.1 The screening assessment criteria utilised has been derived from current Environment Agency guidance on air emissions risk assessment and air dispersion modelling report. This criterion is specifically used for screening the significance of air quality impacts associated with the operation of industrial processes. The criteria includes:

- Process contributions can be screened as insignificant if:
  - *The long-term process contribution is <1% of the long-term environmental standard; and*
  - *The short-term process contribution is <10% of the short-term environmental standard.*
- The long-term process contribution threshold is based on the judgements that:
  - *It is unlikely that an emission at this level will make a significant contribution to air quality since process contribution will be small in comparison to background levels, even if a standard is exceeded; and*
  - *The proposed 1% threshold is also two orders of magnitude below the standard and provided a substantial safety margin to protect human health and the environment.*
- The short-term 10% process contribution threshold is based on the judgements that:
  - *Spatial and temporal conditions means that process contributions are more likely to dominate ambient environmental concentrations; and*
  - *The proposed 10% threshold is an order of magnitude below the standard and provides a substantial safety margin to protect health and the environment.*

5.2.2 If the PC is more than 1% or 10% of the long- and short-term environmental standards respectively, the significance of the PC or Predicted Environmental Concentration (PEC) is based on the site-specific circumstances. However, the significance of predicted concentration can also assessed against the following screening criteria:-

- the short-term PC is less than 20% of the short-term environmental standards minus twice the long-term background concentration
- the long-term PEC is less than 70% of the long-term environmental standards

5.2.3 For local nature sites the EA guidelines also assume that emissions are insignificant if they meet the following criteria:-

- the short-term PC is less than 100% of the short-term environmental standard
- the long-term PC is less than 100% of the long-term environmental standard

Nutrient Nitrogen and Acid Deposition

5.2.4 The EA significance screening guidance does not apply to the determination of the significance of the deposition of nutrient nitrogen and acidity.

5.2.5 Nitrogen and sulphur deposition rates associated with emissions from the proposed development were calculated in accordance with the methodology recommended by the Environment Agency technical guidance document AQTQG06 (AQAG, 2014). This methodology was also used by Laxen and Marner (2005) in a study carried out in support of the development of the Dorset and Poole Local Waste Plan. The method specifies calculation of the annual deposition rate by means of the annual mean PC to ground level concentrations and a given deposition velocity as per the following equation:

Deposition Rate (µg/m²/s) = Deposition velocity (m/s) x Concentration (µg/m³)

5.2.6 Laxen and Marner commented that NOx deposits to vegetation mainly via uptake of nitrogen dioxide through stomata, and that nitric oxide does not deposited at a significant rate. Accordingly, they assumed a worst-case scenario whereby 50% of the NOx (as NO_2) and used that as the basis for calculating the nitrogen deposition rate. Only dry deposition was considered by Laxen and Marner as wet deposition effects close to the point of release are considered to be much less significant than dry deposition mechanisms.

5.2.7 Using the predicted ground level concentrations modelled for the conservation areas deposition rates were calculated using the above-mentioned equation. The deposition velocities used in this assessment are taken from those recommended in AQTQG06, and are listed below.

- NO_2 – 1.5 mm/s
- SO_2 – 12 mm/s

5.2.8 The calculated dry nutrient deposition rates are subsequently converted to equivalent acid deposition equivalents using the following conversion factors taken from AQTQG06. Equivalent units (i.e. keq/ha/yr) are a measure of how acidifying the chemical species can be:-

- Nitrogen – 0.071428
- Sulphur – 0.0625

5.2.9 It should be noted that exceedance of a Critical Load is not a quantitative estimate of damage to a particular habitat but represents the potential for damage to occur. There is no evidence in the available literature to indicate that any of the local nature conservative areas are suffering as a consequence of nutrient or acid deposition from nearby sources.

5.3 Scenario 1

5.3.1 Scenario 1 considers the current operational arrangement at the GUC located at Whinney Hill landfill site, which incorporates six gas engines and a 3,000 m^3/hr HT flare. The model conservatively assumes that all engines and the flare operate at there maximum capacities, which exceeds the peak landfill gas generation rates predicted for the landfill facility of ~5,000m^3/hr in 2022.

5.3.2 The maximum predicted ground level concentrations of modelled pollutants under Scenario 1 (existing normal operating conditions) are summarised in **Table 14**. The maximum concentrations for each year of meteorological data modelled is present in **Appendix 3.**

Table 14: Maximum predicted ground level pollutants concentrations - Scenario 1 (µg/m³)

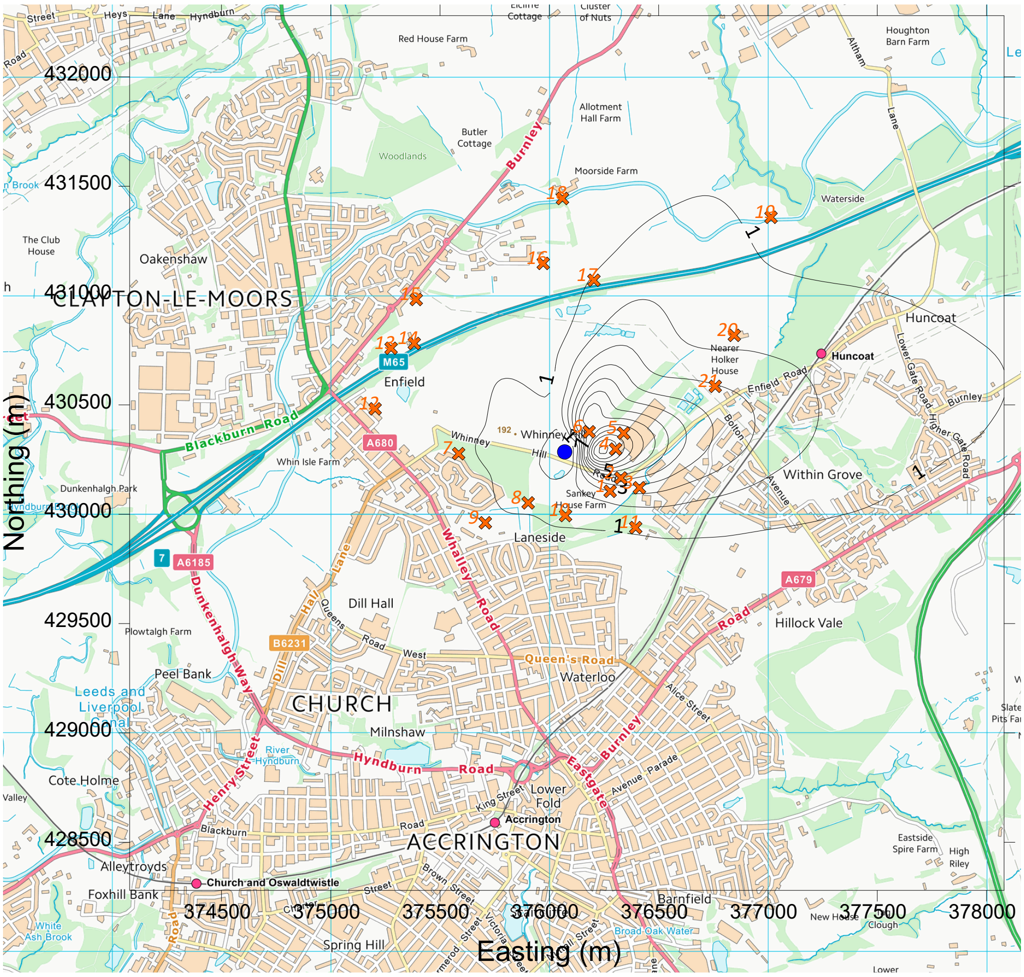
Parameter	Statistic	EAL	Max PC	PC %age of EAL	Back-ground	PEC	PEC %age of EAL
Long-Term							
NO_2[1]	Annual Mean	40	8.54	21.4%	26.3	34.84	87.1%
PM_{10}	Annual Mean	40	0.356	0.9%	13.1	13.47	33.6%
$PM_{2.5}$	Annual Mean	25	0.356	1.4%	8.71	9.07	36.3%
Benzene	Annual Mean	5	0.89	17.8%	0.322	1.21	24.2%
1,3-Butadiene	Annual Mean	2.25	0.89	39.6%	0.087	0.98	43.4%
Short-Term							
NO_2[2]	Hourly mean (99.79th %ile)	200	38.85	19.4%	52.6	91.45	45.7%
CO	8-hour running mean (100th %ile)	10,000	328	3.3%	200.2	528.2	5.3%
PM_{10}	Daily Mean (90.41st %ile)	50	1.13	2.3%	15.5	16.63	33.3%
SO2	15-minute mean (99.9th %ile)	266	94.6	35.6%	11.3	105.9	39.8%
SO2	hourly mean (99.73rd %ile)	350	83	23.7%	8.4	91.4	26.1%
SO2	Daily Mean (99.18th %ile)	125	47.2	37.8%	5	52.2	41.8%

[1] - assumes 70% conversation of total modelled NOx concentration
[2] - assumes 35% conversation of total modelled NOx concentration

<u>Nitrogen Dioxide</u>

5.3.3 The current installed gas utilisation and flare capacity within the GUC is predicted to contribute to a maximum annual mean NO_2 ground level concentration of **8.54 µg/m³**, which equates to **~21%** of the Air Quality Standard of **40 µg/m³.** A contour plot showing the distribution of the PC to the annual mean ground level concentrations of NOx (as NO_2) is presented in **Figure 8**. As shown, the peak concentration is predicted to occur ~140m ENE of the GUC on land that current comprises woodland. When the PC is added to the urban background concentration of **26.3 µg/m³** the PEC equates to **~87%** of the AQS. However, the location that the maximum predicted concentration is located away from the main urban areas of Accrington and the major highways networks, including the M65, where the background monitoring is carried out. This background concentration is also likely to include a contribution from the operation of the GUC during the period that the monitoring from which the background concentration has been derived was carried. Background concentration is therefore considered overly conservative for the location that peak concentration is predicted to occur. The model also assumes continuous emission of NOx at the ELV specified in the Environment Permit for each engine and the flare, whereas concentrations are likely to be vary, with the ELV being the maximum. An exceedance of the AQS is therefore unlikely.

Figure 8: Contour plot of predicted process contribution to annual mean ground level concentrations of NOx - Scenario 1



Units = µg/m³; Based on predicted concentration during the 2017 meteorological dataset; plotted concentrations exclude NO_2 conversion factors.

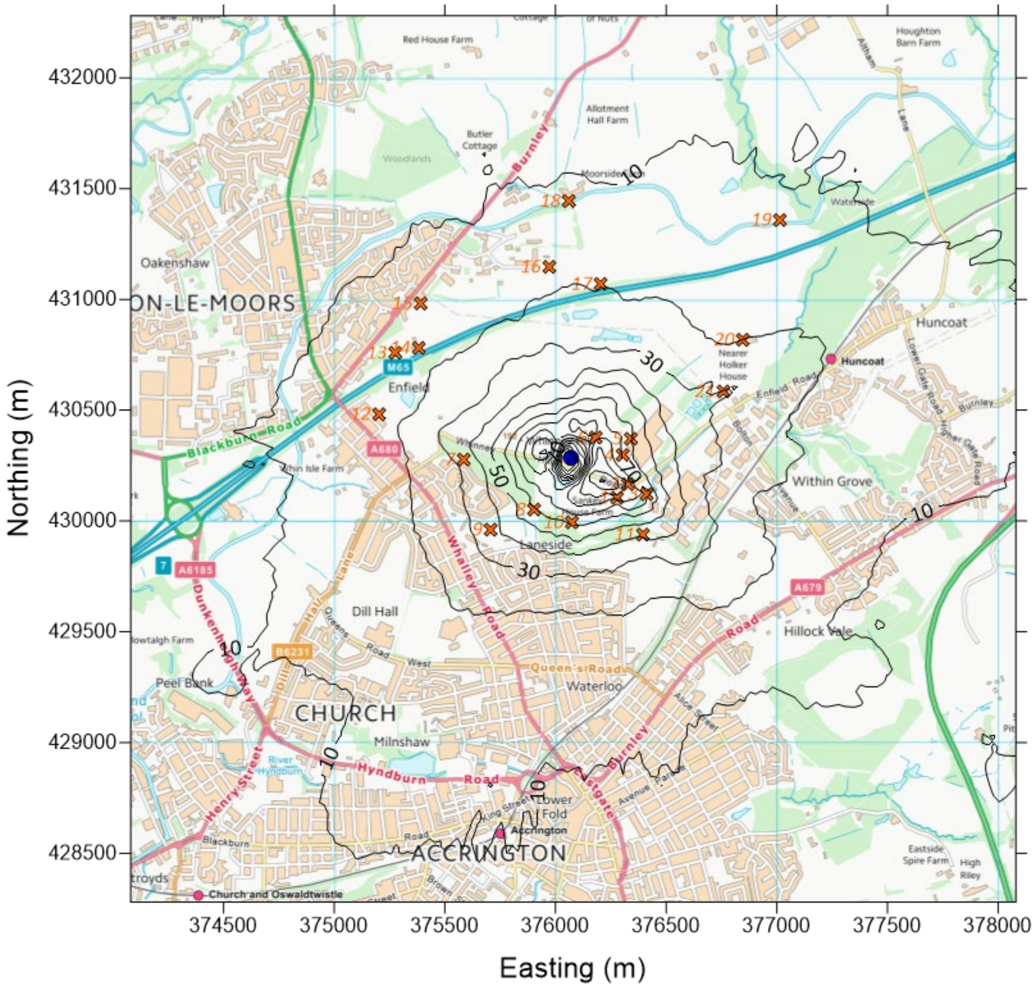
5.3.4 The predicted NO_2 concentrations at specified receptor points in the vicinity of the GUC are presented in **Appendix 4.** Of the specified receptors modelled, the highest annual mean ground level concentration is predicted to occur within the brickworks located adjacent to the woodland where the peak ground level concentration is predicted to occur. The annual mean PC and PEC within the brickworks site equates to **~19.6%** and **~85%** of the AQS and therefore unlikely to lead to an exceedance of the standard at this receptor.

5.3.5 At Sankey House Farm (Receptor '1') and the adjacent caravan park ('2'), which are located to the southeast of the GUC, the process contribution to the annual mean ground level concentration is predicted at **~2.5 µg/m³** and **~3.7 µg/m³** respectively, or **~6%** and **~9%** of the AQS. When combined with the urban background concentrations of **26.3 µg/m³** the PECs equate to **~72% and ~75%** of the AQS and therefore unlikely to result in an exceedance of the standard at these receptors.

5.3.6 In the residential areas of Turnstall Drive ('7') and William Street ('12') to the west of the landfill site the process contributions to the annual mean NO_2 ground level concentrations are predicted at **~0.9 µg/m³ and ~0.4 µg/m³** respectively, or **~2.5%** and **~1%** of the AQS**.** These concentrations are marginally significance screening threshold, but are very unlikely to lead to an exceedance of the AQS.

5.3.7 The maximum 99.79th percentile of hourly mean ground level concentrations is predicted at ~**38.9 µg/m³**, or ~**19%** of the AQS. A contour plot showing the distribution of the 99.79th percentile of hourly mean ground level concentrations of NOx is presented in **Figure 9**. When added to twice the annual mean urban background concentration the PEC equates to ~**47%** of the AQS and is it therefore considered that it is very unlikely to lead to an exceedance of the standard.

Figure 9: Contour plot of predicted process contributions to the 99.79th percentile of hourly mean ground level concentrations of NOx - Scenario 1



Units = µg/m³; Based on predicted concentration during the 2016 meteorological dataset; plotted concentrations exclude NO_2 conversion factors.

Particulates

5.3.8 The maximum annual mean process contribution from the GUC to ground level concentrations of particulates is predicted at ~**0.36 µg/m³.** This concentration equates to **<1%** of the AQS for PM_{10} and can therefore be screened as insignificant.

5.3.9 If all particulate emissions are conservatively considered to be released as $PM_{2.5}$ fraction the predicted ground level concentration equates to **~1.4%** of the AQS of **2.25 µg/m³.** Combined with a background concentration of **8.71 µg/m³** the PEC amount fo only **~36%** of the AQS. The PEC is less than 70% of the

AQS and can therefore be considered insignificant, on the basis that the likelihood of an exceedance of the AQS is therefore very low.

5.3.10 The maximum 90.41st percentile of daily mean ground level concentrations of particulates is predicted at **1.13 µg/m³,** which equates to only **~2%** of the AQS and is therefore insignificant.

Carbon Monoxide (CO)

5.3.11 The maximum 8-hour daily running mean ground level concentration is predicted at **328 µg/m³,** or **~3%** of the AQS of **10,000 µg/m³ and** is therefore considered insignificant.

Volatile Organic Compounds (VOCs)

5.3.12 The maximum annual mean process contribution from the GUC to ground level concentrations of VOCs is predicted at **0.837 µg/m³.** On the conservative assumption that this concentration is released as either benzene of 1,3-butadienne this concentration equates to **~18%** and **~40%** respectively of the corresponding annual mean AQS for these compounds. When added against the annual mean background concentrations the PECs equate to only **~25**% and **~43%** respectively of the AQS. Based on the conservative assumptions and that the predicted annual mean PECs will be less than 50% of the relevant AQSs the emissions can be screened out as insignificant on the basis that the likelihood of an exceedance of any VOC standard is very low.

Sulphur Dioxide

5.3.13 The modelled SO_2 releases from the GUC are predicted to return maximum 99.9th percentile 15-minute mean, 99,73rd percentile hourly mean and 99.18th percentile daily mean ground level concentrations of **94.6 µg/m³, 83 µg/m³** and **47.2 µg/m³** respectively, which equate to approximately **36%, 24% and 38% of** their respective AQSs**.** When combined with the background concentrations the respective PECs only increase marginally to approximately **40%, 26%** and **42%** of the AQSs.

5.3.14 Sulphur dioxide concentrations in the exhaust gases of the existing engines and flare unit have been assumed to be at an elevated concentrations of **200 mg/Nm³** and **240 mg/Nm³,** respectively. However, taking into account the concentration of sulphur containing compounds (principally H2S) recorded in the landfill gas being currently combusted at the GUC (i.e. <150mg/Nm³) the sulphur dioxide concentrations within the exhaust gases are unlikely to increase to those modelling. Moreover, if significantly increased concentrations of sulphur-based compounds are encountered within the landfill gas, gas clean-up technology is likely to need to be installed to minimise excess engine wear. Therefore, accounting for the conservative exhaust gas concentration at which the modelling is based, ground level concentrations of sulphur dioxide are very unlikely to exceed AQSs.

Designated Habitats

Nitrogen Dioxide

5.3.15 The maximum ground level concentration of NOx (as NO_2) at the Altham Clough Wood Designated Ancient Woodland is predicted at **~1.0 µg/m³ (Appendix 4),** which equates to **~3%** of the AQS of **30 µg/m³.** When combined with the APIS modelled background concentration of **21.54 µg/m³,** the PEC equates to **~75%**

of the AQS. It is therefore considered that exceedance of the AQS at the woodland habitat is unlikely.

Sulphur Dioxide

5.3.16 The maximum ground level concentration of SO_2 at the Altham Clough Wood Designated Ancient Woodland is predicted at **~0.63 µg/m³ (Appendix 4),** which equates to **~3%** of the AQS of **20 µg/m³.** When combined with the background concentration of **4.2 µg/m³,** the PEC equates to **~25%** of the AQS. It is therefore considered that an exceedance of the AQS at the woodland habitat is very unlikely.

Nitrogen Deposition

5.3.17 The results of the nutrient nitrogen deposition rate calculations for Altham Clough Wood DAW are summarised in **Table 15.**

Table 15: Process Contribution to nutrient nitrogen deposition at Athram Clough Wood DAW - Scenario 1

Deposition (kgN/ha/yr)	Critical Load (kgN/ha/yr)	% of Lower Critical Load	% of Higher Critical Load
0.072	10-20	0.72%	0.36%

5.3.18 The predicted nutrient nitrogen deposition attributable to emissions of NOx from the operation of the GUC is predicted to be ~0.072 kgN/ha/yr. This represents a small fraction (<1%) of the site-specific critical load range. The potential contribution of nutrient nitrogen from the operation of the GUC is therefore considered to be insignificant.

Acid Deposition

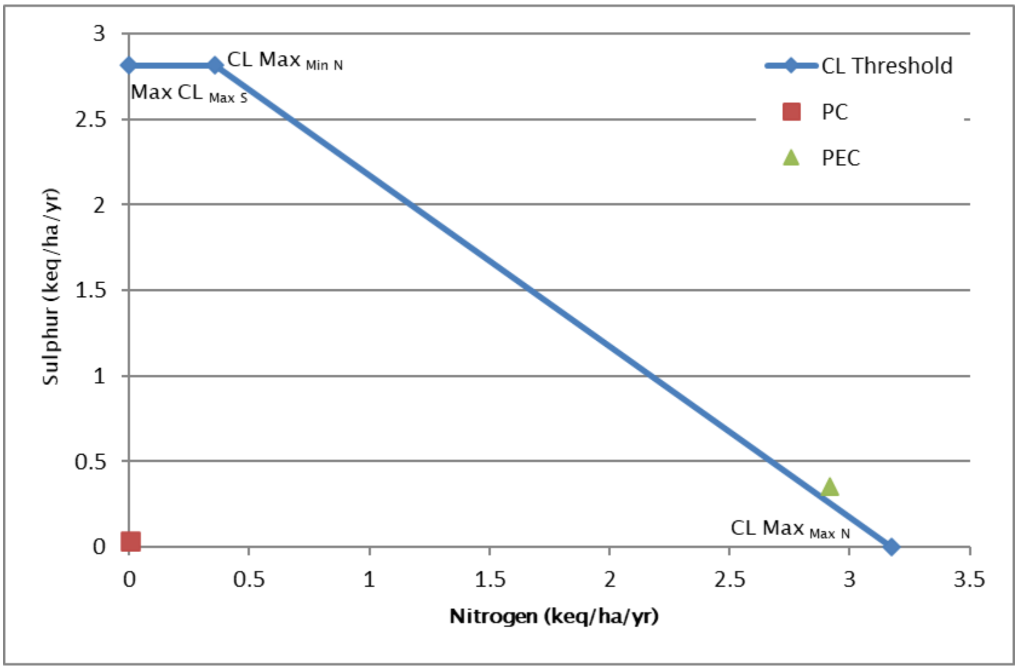
5.3.19 The Process Contributions to acid deposition at the Altham Clough Wood DAW are presented in **Table 16** and presented graphically against specified critical thresholds in **Figure 10.**

Table 16: Predicted acid deposition rates at Altham Clough Wood SAW – Scenario 1

Pollutant Emission	PC *[keq/ha/yr]*
NOx (as NO_2)	0.00515
SO_2	0.00372

5.3.20 The results show that precited rate of acidic deposition at Altham Clough Woods from emissions associated with the operation of the GUC only equate to a very small, insignificant fraction of the criteria loads functions. The contributions from the GUC are therefore considered to be insignificant.

Figure 10: Graphical representation of predicted acid deposition rates against the critical load thresholds at Altham Clough Wood DAW - Scenario 1



5.4 Scenario 2

5.4.1 Scenario 2 has been modelled to represent a situation where the proposed back-up engine (Engine 7) is operated in place of any of the existing 6 gas engines whilst maintenance is being carried out. On this basis, it is only proposed to operate Engine 7 intermittently during each year. This model scenario therefore conservatively represents its operation by assuming that it is operated continuously through the year in place of 'Engine 4'. The 3,000m³/hr HT flare is also assumed to be operating continuously during the year under this scenario. All engines and flares have been modelled to be operating at their maximum capacities, in which the combined landfill gas treatment capacity is greater than the predicted peak rate of landfill gas generation at Whinney Hill.

5.4.2 The maximum predicted ground level concentrations of modelled pollutants under Scenario 2 are summarised in **Table 17**. The maximum concentrations for each year of meteorological data modelled is present in **Appendix 3.**

Table 17: Maximum predicted ground level pollutant concentrations - Scenario 2 (µg/m³)

Parameter	Statistic	EAL	Max PC	PC %age of EAL	Back-ground	PEC	PEC %age of EAL
Long-Term							
NO_2[1]	Annual Mean	40	10.71	26.8%	26.3	37.01	92.5%
PM_{10}	Annual Mean	40	0.431	1.1%	26.3	26.731	66.8%
$PM_{2.5}$	Annual Mean	25	0.431	1.7%	8.71	9.141	36.6%
Benzene	Annual Mean	5	1.11	22.2%	0.322	1.432	28.6%
1,3-Butadiene	Annual Mean	2.25	1.11	49.3%	0.087	1.197	53.2%
Short-Term							
NO_2[2]	Hourly mean (99.79th %ile)	200	44.1	22.1%	52.6	96.7	48.4%
CO	8-hour running mean (100th %ile)	10,000	355	3.6%	200.2	555.2	5.6%
PM_{10}	Daily Mean (90.41st %ile)	50	1.29	2.6%	15.5	16.79	33.6%
SO2	15-minute mean (99.9th %ile)	266	101	38.0%	11.3	112.3	42.2%

Parameter	Statistic	EAL	Max PC	PC %age of EAL	Back-ground	PEC	PEC %age of EAL
SO2	hourly mean (99.73rd %ile)	350	90.8	25.9%	8.4	99.2	28.3%
SO2	Daily Mean (99.18th %ile)	125	49.7	39.8%	5	54.7	43.8%

[1] - assumes 70% conversation of total modelled NOx concentration
[2] - assumes 35% conversation of total modelled NOx concentration

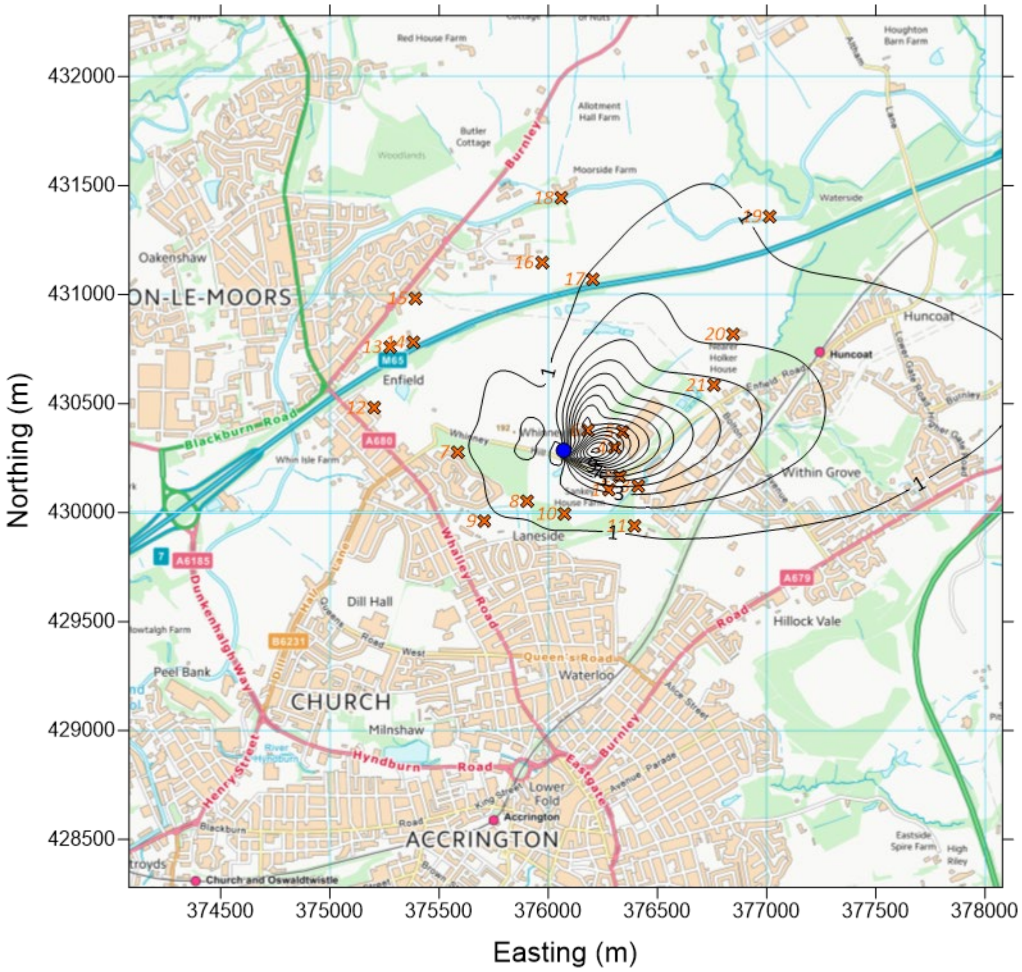
Nitrogen Dioxide

5.4.3 Under Scenario 2 the GUC is predicted to contribute to a maximum annual mean NO_2 ground level concentration of **~10.7 µg/m³**, which equates to **~27%** of the Air Quality Standard of **40 µg/m³.** This represents a **2.2 µg/m³** increase in peak annual mean ground level concentration to that predicted under Scenario 1. A contour plot showing the distribution of the PC to the annual mean ground level concentrations of NOx (as NO_2) is presented in **Figure 11**. As shown, the peak concentration is still predicted to occur ~140m ENE of the GUC on land that current comprises woodland. When the PC is added to the urban background concentration of **26.3 µg/m³** the PEC equates to **~93%** of the AQS. However, as discussed previously, the located that the maximum concentration is predicted to occur is away from the main urban areas of Accrington and the major highways networks, including the M65, where the background monitoring is carried out. This background concentration is also likely to include a small contribution from the operation of the GUC during the period that the monitoring from which the background concentration has been derived was carried. Background concentration is therefore considered conservative for this specific location. The model also assumes continuous emission of NOx at the ELV specified in the Environment Permit for each engine and the flare, whereas concentrations are likely to vary. Moreover, the model assumes that all engines and the flare are operating at their maximum capacities, which is greater than the maximum rate of landfill gas generation predicted for the landfill. An exceedance of the AQS is therefore unlikely.

5.4.4 The predicted NO_2 concentrations at specified receptor points in the vicinity of the GUC are presented in **Appendix 4.** Of the specified receptors modelled, the highest annual mean ground level concentration is predicted to occur within the brickworks, located adjacent to the woodland where the peak ground level concentration is predicted to occur. The annual mean PC and PEC within the brickworks site equates to **~22%** and **~88%** of the AQS and therefore unlikely to lead to an exceedance of the standards.

5.4.5 At Sankey House Farm (Receptor ‘1’) the adjacent caravan park (‘2’), which are located to the southeast of the GUC, the process contribution to the annual mean ground level concentration is predicted at **~2.8 µg/m³** and **~4.2 µg/m³** respectively, or **~7%** and **~11%** of the AQS. When combined with the selected urban background concentration of **26.3 µg/m³** the PECs equate to **~73% and ~76%** of the AQS and therefore unlikely to result in an exceedance of the standard at these receptors.

Figure 11: Contour plot of predicted process contribution to annual mean ground level concentrations of NOx (as NO_2) - Scenario 2

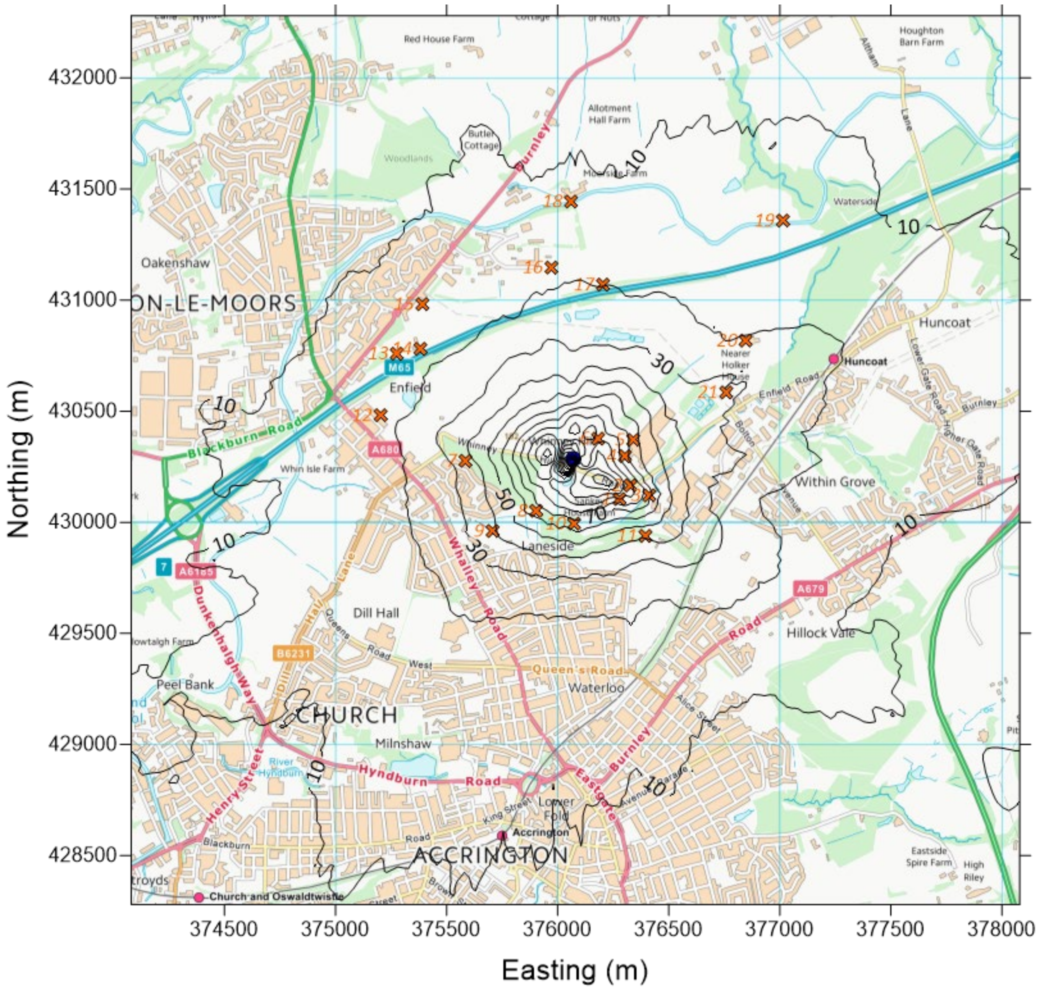


Units = µg/m³; Based on predicted concentration during the 2017 meteorological dataset, plotted concentrations exclude NO_2 conversion factors.

5.4.6 In the residential areas of Turnstall Drive ('7') and William Street ('12') to the west of the landfill site the process contributions to the annual mean NO_2 ground level concentrations are predicted at **~1 µg/m³ and ~0.4 µg/m³** respectively, or **~2.5%** and **~1%** of the AQS**.** These concentrations represent very marginal increases to those predicted under Scenario 1. Moreover, these concentrations are marginally above the EAs 1% significance screening threshold, but are very unlikely to lead to exceedances of the AQSs.

5.4.7 The maximum 99.79th percentile of hourly mean ground level concentrations is predicted at ~**44 µg/m³**, or ~**22%** of the AQS. A contour plot showing the distribution of the 99.79th percentile of hourly mean ground level concentrations of NOx is presented in **Figure 12**. When added to twice the annual mean urban background concentration the PEC equates to **~48%** of the AQS, which represents a small increase above the predicted peak ground levels concentrations predicted under Scenario 1 and it is therefore unlikely to lead to an exceedance of the AQS.

Figure 12: Contour plot of predicted process contributions to the 99.79th percentile of hourly mean ground level concentrations of NOx - Scenario 2



Units = µg/m³; Based on predicted concentration during the 2016 meteorological dataset; plotted concentrations exclude NO_2 conversion factors.

<u>Particulates</u>

5.4.8 The maximum annual mean process contribution from the GUC to ground level concentrations of particulates is predicted at **~0.43 µg/m³.** This concentration equates to **~1%** of the AQS for PM_{10} and can therefore be screened as insignificant. If all particulate emissions are conservatively considered to be release as $PM_{2.5}$ the predicted ground level concentration equates to **~1.7%** of the AQS of **2.25 µg/m³.** Combined with a background concentration of **8.71 µg/m³** the PEC amount fo only **~37%** of the AQS. These emissions can therefore be screened as insignificant with the likelihood of an exceedance of the AQS is being very low.

5.4.9 The maximum 90.41st percentile of daily mean ground level concentrations of particulates is predicted at **~1.3 µg/m³,** which equates to less than **3%** of the AQS and is therefore insignificant.

<u>Carbon Monoxide (CO)</u>

5.4.10 The maximum 8-hour daily running mean ground level concentration is predicted at **355 µg/m³,** or less than **4%** of the AQS of **10,000 µg/m³** and is therefore considered insignificant.

Volatile Organic Compounds (VOCs)

5.4.11 The maximum annual mean process contribution from the GUC to ground level concentrations of VOCs is predicted at **~1.1 µg/m³.** On the conservative assumption that this concentration is released as either benzene of 1,3-butadienne this concentration equates to **~22%** and **~49%** respectively of the corresponding annual mean AQS for these compounds. When added to the annual mean background concentrations the PECs equate to only **~29**% and **~53%** of the AQS, respectively. Based on the conservative assumptions and that the predicted annual mean PECs will be less than 50% of the relevant AQSs it is unlikely that there will be an exceedance of any VOC standards.

Sulphur Dioxide

5.4.12 The modelled SO_2 releases from the GUC are predicted to return maximum 99.9th percentile 15-minute mean, 99,73rd percentile hourly mean and 99.18th percentile daily mean ground level concentrations of **101 µg/m³, ~91 µg/m³** and **~50 µg/m³** respectively, which equate to approximately **~38%, ~26% and ~40%** of their respective AQSs**.** When combined with the background concentrations the respective PECs only increase marginally to approximately **~42%, ~28%** and **~44%** of the AQSs. All these concentrations are less than 20% of the difference between AQS and twice the long-term background concentration and. Ground level concentrations of sulphur dioxide can therefore be screened out as insignificant on the basis that they are unlikely to lead to an exceedance of any of the AQSs.

Designated Habitats

Nitrogen Dioxide

5.4.13 The maximum ground level concentration of NOx (as NO_2) at the Altham Clough Wood Designated Ancient Woodland is predicted at **~0.34 µg/m³ (Appendix 4),** which equates to ~**1%** of the AQS of **30 µg/m³.** When combined with the background concentration of **21.54µg/m³,** the PEC equates to **~73%** of the AQS. It is therefore considered that exceedance of the AQS at the woodland habitat is unlikely.

Sulphur Dioxide

5.4.14 The maximum ground level concentration of SO_2 at the Altham Clough Wood Designated Ancient Woodland is predicted at **~0.6 µg/m³ (Appendix 4),** which equates to **~3%** of the AQS of **20 µg/m³.** When combined with the background concentration of **4.2 µg/m³,** the PEC equates to **~24%** of the AQS. It is therefore considered that exceedance of the AQS at the woodland habitat is unlikely.

Nitrogen Deposition

5.4.15 The results of the nutrient nitrogen deposition rate calculations for Altham Clough Wood DAW are summarised in **Table 18.**

Table 18: Process Contribution to nutrient nitrogen deposition at Atham Clough Wood DAW - Scenario 2

Deposition (kgN/ha/yr)	Critical Load (kgN/ha/yr)	% of Lower Critical Load	% of Higher Critical Load
0.079	10-20	0.79%	0.4%

5.4.16 The predicted nutrient nitrogen deposition attributable to emissions of NOx from operation of the GUC under Scenario 2 is predicted to be **~0.079 kgN/ha/yr**, which represents a very small increase over the predicted rate of deposit under Scenario 1. This represents a small fraction (<1%) of the site-specific critical load range. The potential contribution to nutrient nitrogen deposition from the operation of Engine 7 in place of any one of the existing engines is therefore considered to be insignificant.

Acid Deposition

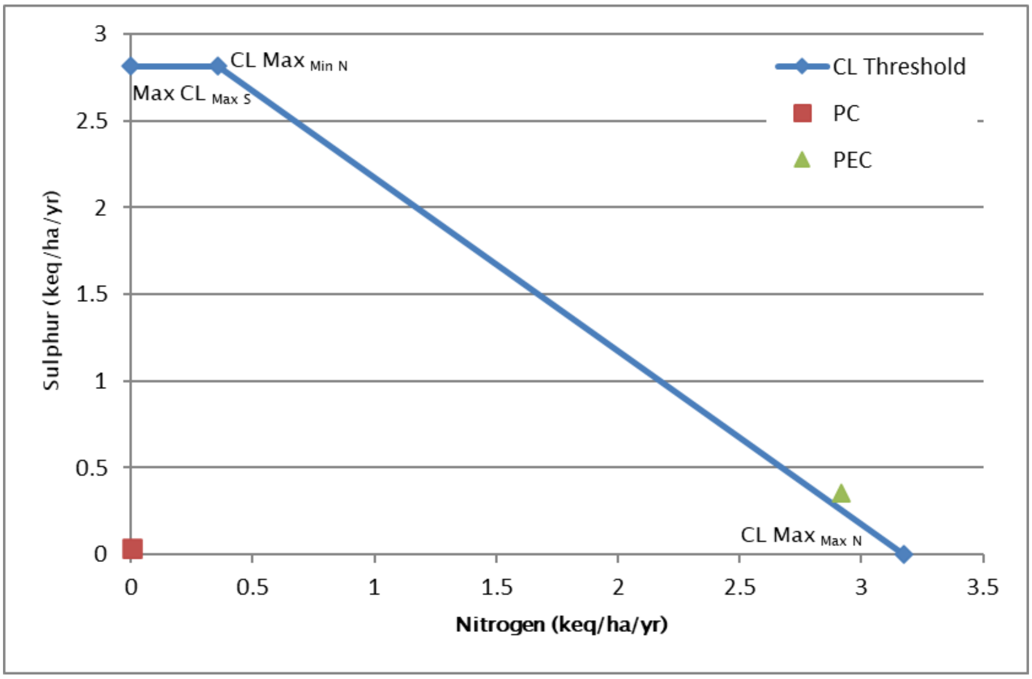
5.4.17 The Process Contributions to acid deposition at the Altham Clough Wood DAW are presented in **Table 19** and presented graphically against specified critical thresholds in **Figure 13.**

Table 19: Predicted acid deposition rates at Altham Clough Wood DAW – Scenario 2

Pollutant Emission	PC *[keq/ha/yr]*
NOx (as NO_2)	0.00566
SO_2	0.00361

5.4.18 The results show that predicted rate of acidic deposition at Altham Clough Woods from under Scenario 2 only equates to a very small, insignificant fraction of the criteria loads functions. The potential contribution to acid deposition from the operation of Engine 7 in place of any one of the existing engines is therefore considered to be insignificant.

Figure 13: Graphical representation of predicted acid deposition rates against the critical load thresholds at Altham Clough Wood DAW - Scenario 2



5.5 Scenario 3

5.5.1 Much like Scenario 2, Scenario 3 has been modelled to represent a situation where the proposed back-up engine is operated in place of any one of the existing six gas engines whilst maintenance is being carried out. However, it is only proposed to operate Engine 7 intermittently during each year. This model scenario therefore conservatively represents its proposed operation by assuming that it is operated continuously through the year instead of on existing 'Engine 4'. The key difference in Scenario 3 is that the 2,000m³/hr HT flare is assumed to be operating continuously during the year instead of the 3,000m³/hr HT flare. All engines and flares have been modelled to be operating at their maximum capacities, in which the combined landfill gas treatment capacity is greater than the predicted peak rate of landfill gas generation at Whinney Hill.

5.5.2 The maximum predicted ground level concentrations of modelled pollutants under Scenario 3 are summarised in **Table 20**. The maximum concentrations for each year of meteorological data modelled is present in **Appendix 3.**

Table 20: Maximum predicted ground level pollutant concentrations - Scenario 3 (µg/m³)

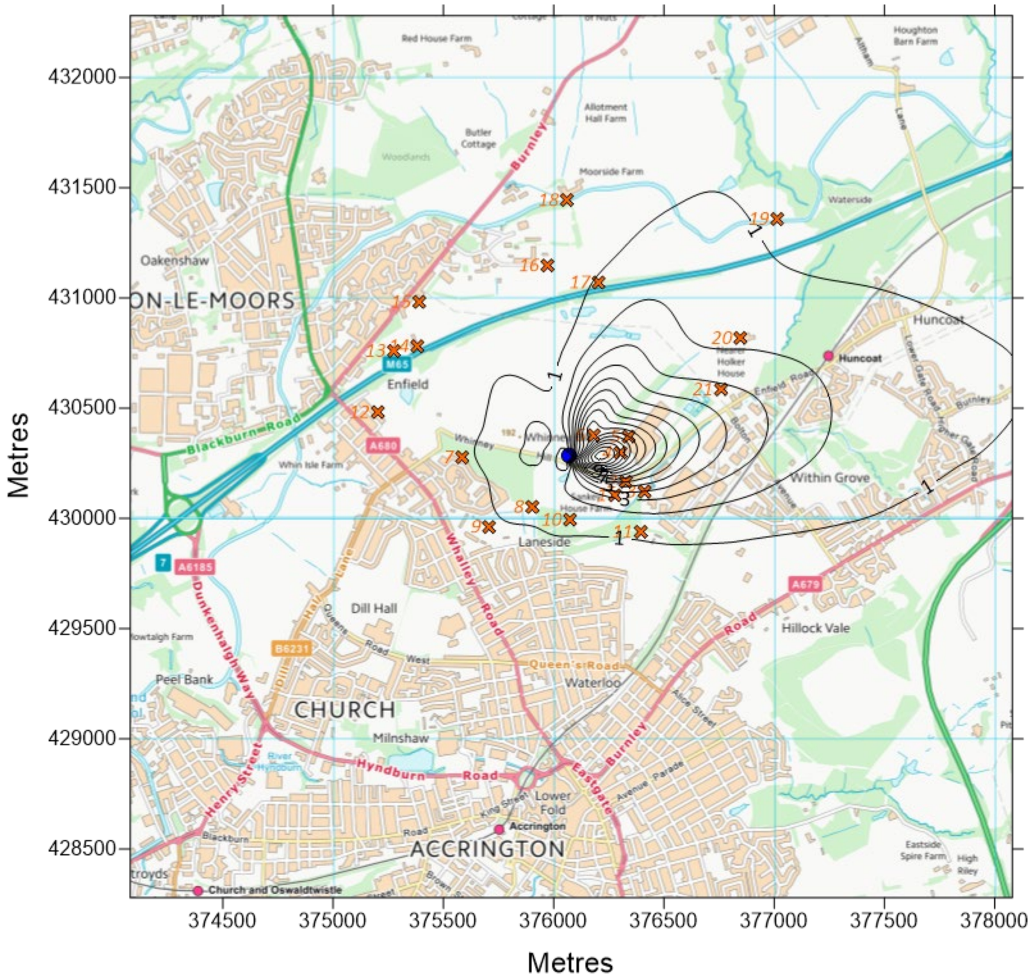
Parameter	Statistic	EAL	Max PC	PC %age of EAL	Back-ground	PEC	PEC %age of EAL
Long-Term							
NO_2[1]	Annual Mean	40	10.92	27.3%	26.3	37.22	93.1%
PM_{10}	Annual Mean	40	0.454	1.1%	13.1	13.554	33.9%
$PM_{2.5}$	Annual Mean	25	0.454	1.8%	8.71	9.164	36.7%
Benzene	Annual Mean	5	1.13	22.6%	0.322	1.452	29.0%
1,3-Butadiene	Annual Mean	2.25	1.13	50.2%	0.087	1.217	54.1%
Short-Term							
NO_2[2]	Hourly mean (99.79th %ile)	200	45.5	22.8%	52.6	98.1	49.1%
CO	8-hour running mean (100th %ile)	10,000	356	3.6%	200.2	556.2	5.6%
PM_{10}	Daily Mean (90.41st %ile)	50	1.29	2.6%	15.5	16.79	33.6%
SO2	15-minute mean (99.9th %ile)	266	92.5	34.8%	11.3	103.8	39.0%
SO2	hourly mean (99.73rd %ile)	350	81.4	23.3%	8.4	89.8	25.7%
SO2	Daily Mean (99.18th %ile)	125	47.2	37.8%	5	52.2	41.8%

[1] - assumes 70% conversation of total modelled NOx concentration
[2] - assumes 35% conversation of total modelled NOx concentration

Nitrogen Dioxide

5.5.3 Under Scenario 3 the GUC is predicted to contribute to a maximum annual mean NO_2 ground level concentration of **~10.9 µg/m³**, which equates to **~27%** of the Air Quality Standard of **40 µg/m³.** This represents a **~26%** increase in peak annual mean ground level concentration to that predicted under Scenario 1 and only a marginal increase above that predicted in Scenario 2. A contour plot showing the distribution of the PC to the annual mean ground level concentrations of NOx (as NO_2) is presented in **Figure 14.** As shown, the peak concentration is still predicted to occur ~140m ENE of the GUC, on land that currently comprises woodland. When the PC is added to the selected urban background concentration of **26.3 µg/m³** the PEC equates to **~93%** of the AQS. However, as discussed previously, the location that the maximum concentration is predicted is located away from the main urban areas of Accrington and the major highways networks, including the M65, where the background monitoring is carried out. This background concentration is also likely to include a small contribution from the operation of the GUC during the period that the monitoring from which the background concentration has been derived was carried. Background concentration is therefore considered conservative for this specific location. The model also assumes continuous emission of NOx at the ELV specified in the Environment Permit for each engine and the flare, whereas concentrations are likely to vary, with the ELV being the maximum. Moreover, the model assumes that all engines and the flare are operating at maximum capacities, which is greater than the maximum rate of landfill gas generation predicted for the landfill. An exceedance of the AQS is therefore very unlikely.

Figure 14: Contour plot of predicted process contribution to annual mean ground level concentrations of NOx (as NO_2) - Scenario 3



Units = µg/m³; Based on predicted concentration during the 2017 meteorological dataset, plotted concentrations exclude NO_2 conversion factors.

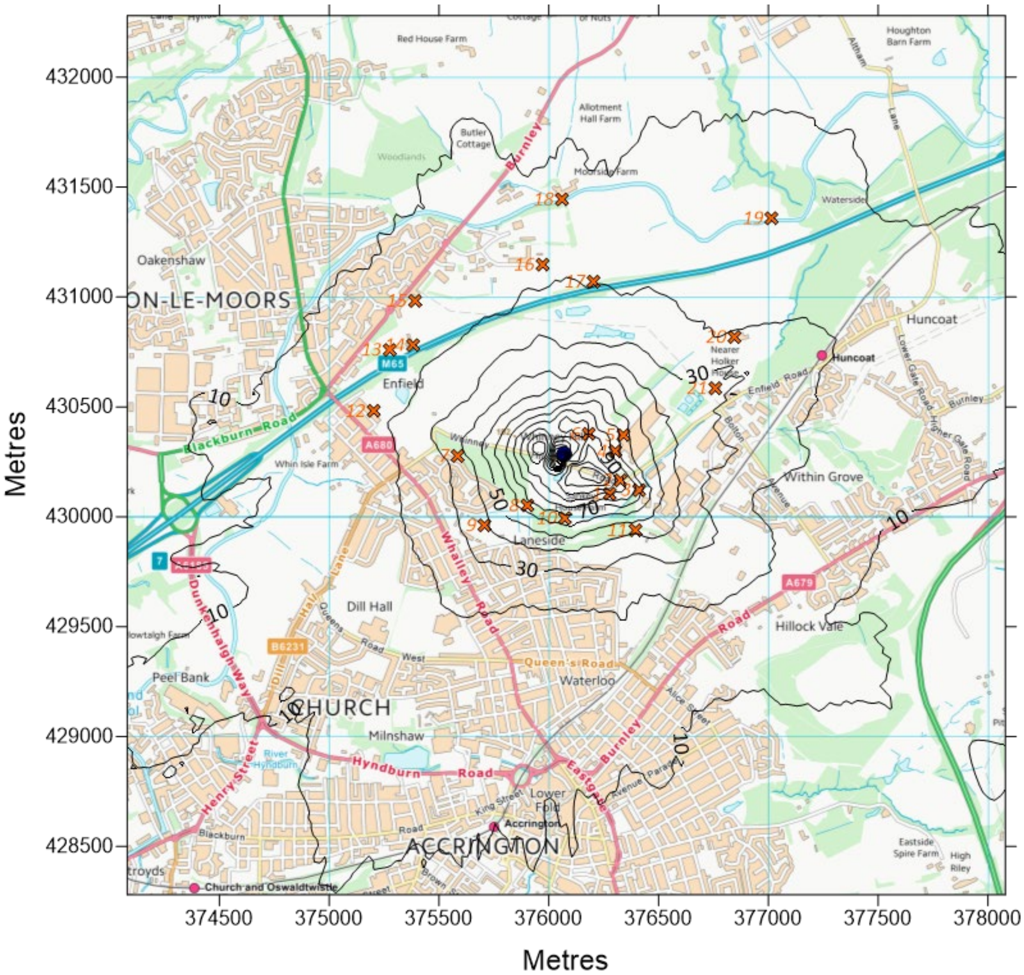
5.5.4 The predicted NO_2 concentrations at specified receptor points in the vicinity of the GUC are presented in **Appendix 4.** Of the specified receptors modelled the highest annual mean ground level concentration is predicted to occur within the brickworks located adjacent to the location that the peak ground level concentration is predicted to occur. The annual mean PC and PEC within the brickworks site equates to **~23%** and **~88%** of the AQS and therefore unlikely to lead to an exceedance of the standard.

5.5.5 At Sankey House Farm (Receptor '1') the adjacent caravan park ('2'), which are located to the southeast of the GUC, the process contribution to the annual mean ground level concentration is predicted at **~2.8 µg/m³** and **~4.2 µg/m³** respectively, or **~7%** and **~11%** of the AQS. When combined with the selected urban background concentration of **26.3 µg/m³** the PECs equate to **~73%** and **~76%** of the AQS and therefore unlikely to result in an exceedance of the standard at these receptors.

5.5.6 In the residential areas of Turnstall Drive ('7') and William Street ('12') to the west of the landfill site the process contributions to the annual mean NO_2 ground level concentrations are predicted at **~1 µg/m³ and ~0.4 µg/m³** respectively, or **~2.5%** and **~1%** of the AQS**.** These concentrations represent very marginal increases to those predicted under Scenario 1, and are similar to those predicted at these receptors points under Scenario 2. Moreover, these concentrations are only marginally above the EAs 1% significance screening threshold and are therefore very unlikely to lead to an exceedance of the AQS.

5.5.7 The maximum 99.79th percentile of hourly mean ground level concentrations of NO_2 is predicted at **~46 µg/m³**, or **~23%** of the AQS. A contour plot showing the distribution of the 99.79th percentile of hourly mean ground level concentrations of NOx (as NO_2) is presented in **Figure 15**. When added to twice the annual mean urban background concentration the PEC equates to **~49%** of the AQS, which represents a small increase above the predicted peak ground levels concentrations predicted under Scenario 1 and a marginal increase above that predicted in Scenario 2. The predicted concentration therefore again considered very unlikely to lead to an exceedance of the AQS.

Figure 15: Contour plot of predicted process contributions to the 99.79th percentile of hourly mean ground level concentrations of NOx - Scenario 3



Units = µg/m³; Based on predicted concentration during the 2016 meteorological dataset; plotted concentrations exclude NO_2 conversion factors.

Particulates

5.5.8 The maximum annual mean process contribution from the GUC to ground level concentrations of particulates is predicted at **~0.45 µg/m³.** This concentration equates to **~1%** of the AQS for PM_{10} and can therefore be screened as insignificant. If all particulate emissions are conservatively considered to be release as $PM_{2.5}$ the predicted ground level concentration equates to **~1.8%** of the AQS of **2.25 µg/m³.** Combined with a background concentration of **8.71 µg/m³** the PEC amount fo only **~37%** of the AQS. The likelihood of an exceedance of the AQS is therefore very low.

5.5.9 The maximum 90.41st percentile of daily mean ground level concentrations of particulates is predicted at **~1.3 µg/m³,** which equates to less than **3%** of the AQS and is therefore insignificant.

Carbon Monoxide (CO)

5.5.10 The maximum 8-hour daily running mean ground level concentration is predicted at **356 µg/m³,** or less than **4%** of the AQS of **10,000 µg/m³** and can therefore be screened out as insignificant.

Volatile Organic Compounds (VOCs)

5.5.11 The maximum annual mean process contribution from the GUC to ground level concentrations of VOCs is predicted at **~1.13 µg/m³.** On the conservative assumption that this concentration is released as either benzene of 1,3-butadienne this concentration equates to **~23%** and **~50%** respectively of the corresponding annual mean AQS for these compounds. When added to the annual mean background concentrations the PECs equate to only **~29**% and **~54%** of the AQS, respectively. Based on the conservative assumptions and that the predicted annual mean PECs will be less than 50% of the relevant AQSs the emissions can be screened as insignificant as it is very unlikely that there will be an exceedance of any relevant standards.

Sulphur Dioxide

5.5.12 The modelled SO_2 releases from the GUC are predicted to return maximum 99.9th percentile 15-minute mean, 99,73rd percentile hourly mean and 99.18th percentile daily mean ground level concentrations of ~**93 µg/m³, ~81 µg/m³** and **~47 µg/m³** respectively, which equate to approximately **~35%, ~23% and ~38%** of their respective AQSs**.** When combined with the background concentrations the respective PECs only increase marginally to approximately **~39%, ~26%** and **~42%** of the AQSs. Ground level concentrations of sulphur dioxide are therefore unlikely to exceed the AQSs.

Designated Habitats

Nitrogen Dioxide

5.5.13 The maximum ground level concentration of NOx (as NO_2) at the Altham Clough Wood Designated Ancient Woodland is predicted at **~1µg/m³ (Appendix 4),** which equates to ~**5%** of the AQS of **30 µg/m³.** When combined with the modelled background concentration of **20.75 µg/m³** for this site, the PEC equates to **~73%** of the AQS. It is therefore considered that exceedance of the AQS at the woodland habitat is very unlikely.

Sulphur Dioxide

5.5.14 The maximum ground level concentration of SO_2 at the Altham Clough Wood Designated Ancient Woodland is predicted at **~0.6 µg/m³ (Appendix 4),** which equates to **~3%** of the AQS of **20 µg/m³.** When combined with the background concentration of **4.2 µg/m³,** the PEC equates to **~24%** of the AQS. It is therefore considered that exceedance of the AQS at the woodland habitat is very unlikely.

Nitrogen Deposition

5.5.15 The results of the nutrient nitrogen deposition rate calculations for Altham Clough Wood DAW are summarised in **Table 21.**

Table 21: Process Contribution to nutrient nitrogen deposition at Altham Clough Wood DAW - Scenario 3

Deposition (kgN/ha/yr)	Critical Load (kgN/ha/yr)	% of Lower Critical Load	% of Higher Critical Load
0.072	10-20	0.72%	0.36%

5.5.16 The predicted nutrient nitrogen deposition attributable to emissions of NOx from operation of the GUC under Scenario 3 is predicted to be **~0.072 kgN/ha/yr**, which represents similar to the predicted rate of deposit under Scenario 1. This rate represents a small fraction (<1%) of the site-specific critical load range. The potential contribution to nutrient nitrogen deposition from the operation of Engine 7 in place of any one of the existing engines and the 2,000m^3/hr HT flare is therefore considered to be insignificant.

Acid Deposition

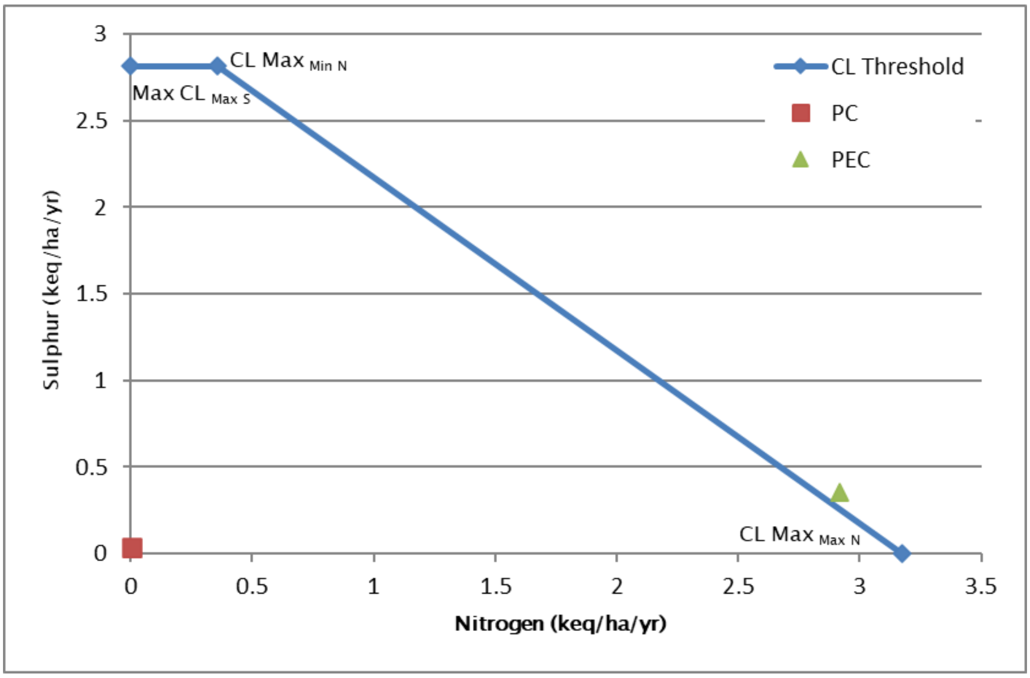
5.5.17 The Process Contributions to acid deposition at the Altham Clough Wood DAW are presented in **Table 22** and presented graphically against specified critical thresholds in **Figure 16.**

Table 22: Predicted acid deposition rates at Altham Clough Wood SAW – Scenario 3

Pollutant Emission	PC *[keq/ha/yr]*
NOx (as NO_2)	0.00515
SO_2	0.0331

5.5.18 The results show that predicted rate of acidic deposition at Altham Clough Woods from under Scenario 3 only equates to a very small, insignificant fraction of the criteria loads functions. The potential contribution to acid deposition from the operation of Engine 7 in place of any one of the existing engines and the operation of the 2,000m^3/hr HT flare is therefore considered to be insignificant.

Figure 16: Graphical representation of predicted acid deposition rates against the critical load thresholds at Altham Clough Wood DAW - Scenario 3



5.6 Scenario 4

5.6.1 Scenario 4 considers the potential emissions associated with the operation of the existing and proposed HT flares when operated continuously throughout the year. All engines are assumed to not be operating in this scenario.

5.6.2 The maximum predicted ground level concentrations of modelled pollutants under Scenario 4 are summarised in **Table 23**. The maximum predicted concentrations for each year of meteorological data modelled is present in **Appendix 3.**

Table 23: Maximum predicted ground level pollutant concentrations - Scenario 4 (μg/m³)

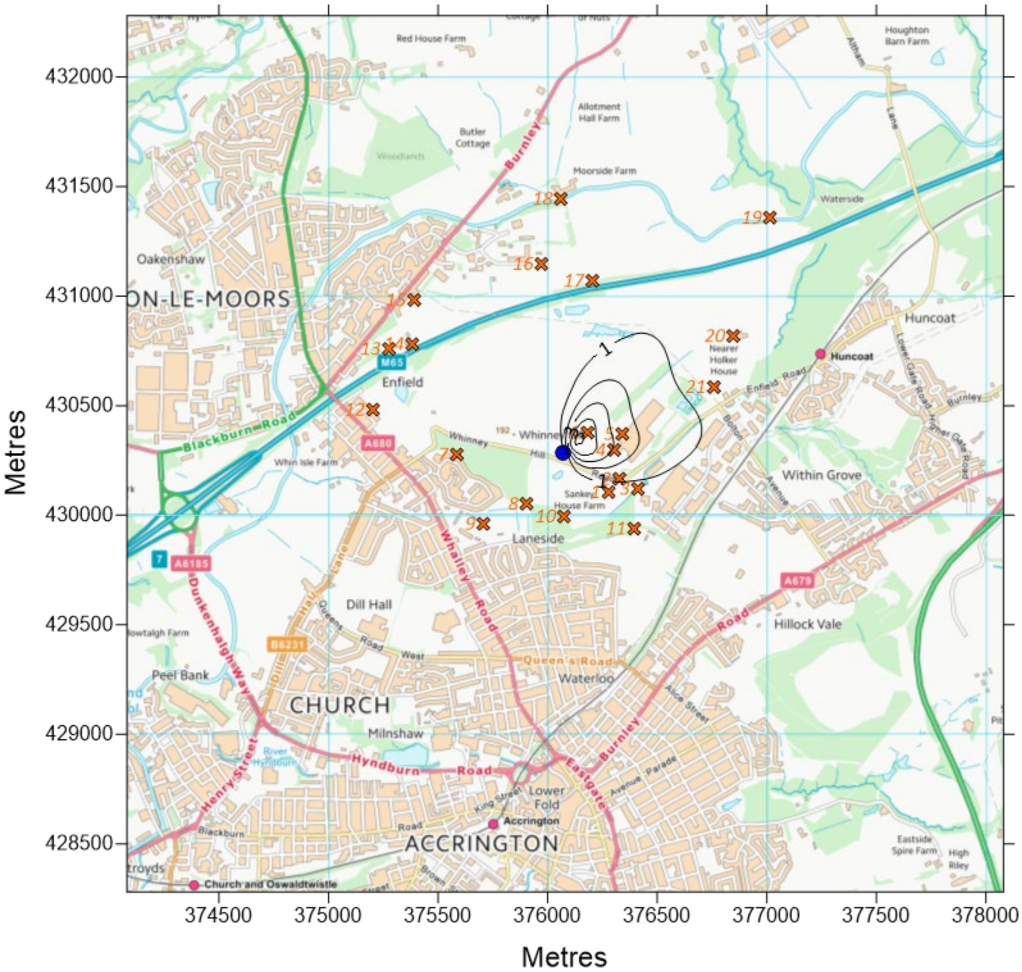
Parameter	Statistic	EAL	Max PC	PC %age of EAL	Back-ground	PEC	PEC %age of EAL
Long-Term							
NO_2[1]	Annual Mean	40	3.65	9.1%	26.3	29.95	74.9%
PM_{10}	Annual Mean	40	0.341	0.9%	13.1	13.441	33.6%
$PM_{2.5}$	Annual Mean	25	0.341	1.4%	8.71	9.051	36.2%
Benzene	Annual Mean	5	0.341	6.8%	0.322	0.663	13.3%
1,3-Butadiene	Annual Mean	2.25	0.341	15.2%	0.087	0.428	19.0%
Short-Term							
NO_2[2]	Hourly mean (99.79th %ile)	200	28.35	14.2%	52.6	80.95	40.5%
CO	8-hour running mean (100th %ile)	10,000	30	0.3%	200.2	230.2	2.3%
PM_{10}	Daily Mean (90.41st %ile)	50	1.1	2.2%	15.5	16.6	33.2%
SO2	15-minute mean (99.9th %ile)	266	138	51.9%	11.3	149.3	56.1%
SO2	hourly mean (99.73rd %ile)	350	123	35.1%	8.4	131.4	37.5%
SO2	Daily Mean (99.18th %ile)	125	73.5	58.8%	5	78.5	62.8%

[1] - assumes 70% conversation of total modelled NOx concentration
[2] - assumes 35% conversation of total modelled NOx concentration

<u>Nitrogen Dioxide</u>

5.6.3 Under Scenario 4 the GUC is predicted to contribute to a maximum annual mean NO_2 ground level concentration of **~3.7 μg/m³**, which equates to **~9%** of the Air Quality Standard of **40 μg/m³.** A contour plot showing the distribution of the PC to the annual mean ground level concentrations of NOx is presented in **Figure 17.** As shown, the peak concentration is predicted to occur ~50m NE of the GUC, at the edge of the HWRC. When the PC is added to the urban background concentration of **26.3 μg/m³** the PEC equates to **~75%** of the AQS. However, as discussed previously, the location that the maximum concentration is predicted is located away from the main urban areas of Accrington and the major highways networks, including the M65, where the background monitoring is carried out. This background concentration is also likely to include a small contribution from the operation of the GUC during the period that the monitoring from which the background concentration has been derived was carried. Background concentration is therefore considered conservative for this specific location. The model also assumes continuous emission of NOx at the ELV specified in the Environment Permit for each flare unit, whereas concentrations are likely to vary, with the ELV being the maximum. Moreover, the model assumes that each flare is operating at maximum operating capacity. An exceedance of the AQS is therefore unlikely.

Figure 17: Contour plot of predicted process contribution to annual mean ground level concentrations of NOx (as NO_2) - Scenario 4



Units = µg/m³; Based on predicted concentration during the 2017 meteorological dataset, plotted concentrations exclude NO_2 conversion factors.

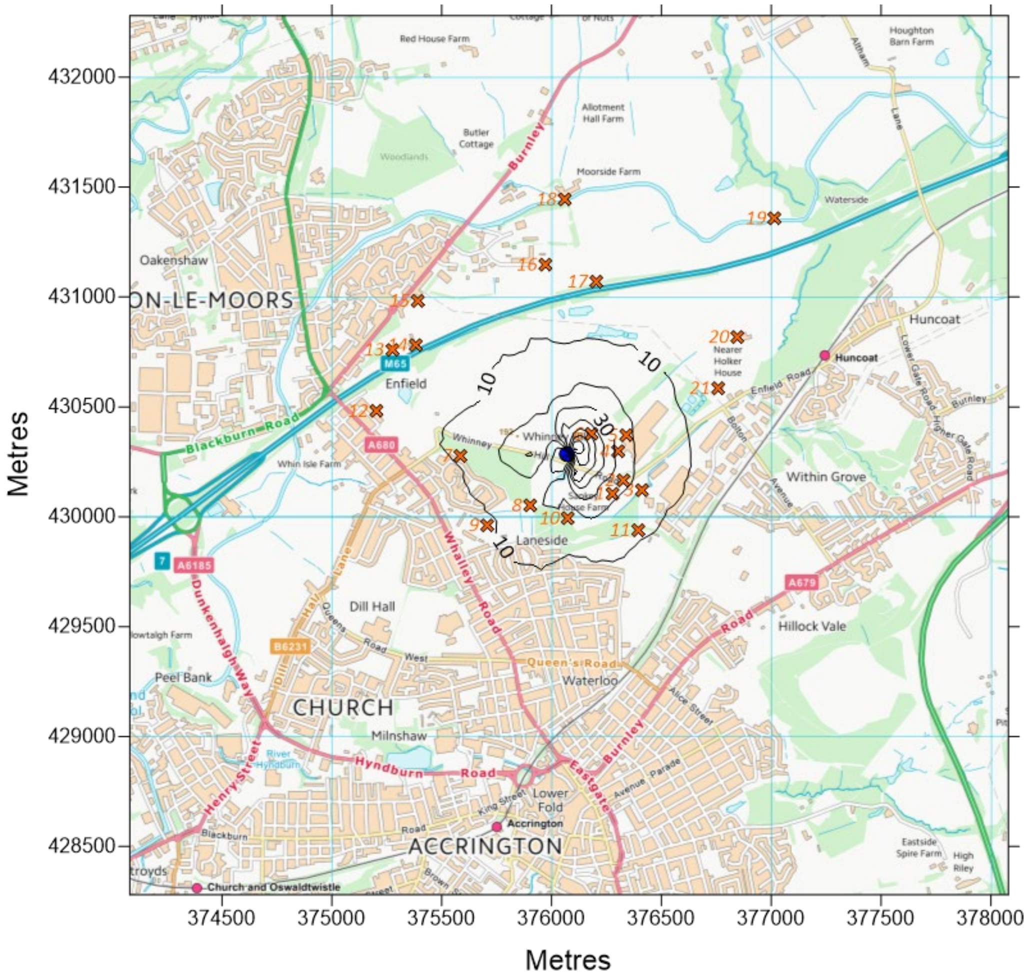
5.6.4 The predicted NO_2 concentrations at specified receptor points in the vicinity of the GUC are presented in **Appendix 4.** Of the specified receptors modelled, the highest annual mean ground level concentration is predicted to occur within the HWRC. The annual mean PC and PEC within the HWRC site equates to **~5%** and **~71%** of the AQS and therefore unlikely to lead to an exceedance of the standard.

5.6.5 At Sankey House Farm (Receptor '1') the adjacent caravan park ('2'), which are located to the southeast of the GUC, the process contribution to the annual mean ground level concentration is predicted at **~0.6 µg/m³** and **~0.9 µg/m³** respectively, or **~1.4%** and **~2%** of the AQS. When combined with the selected urban background concentration of **26.3 µg/m³** the PECs equate to **~67% and ~68%** of the AQS and therefore unlikely to result in an exceedance of the standard at these receptors.

5.6.6 In the residential areas of Turnstall Drive ('7') and William Street ('12') to the west of the landfill site the process contributions to the annual mean NO_2 ground level concentrations are predicted at **~0.26 µg/m³ and ~0.1 µg/m³** respectively, or **~0.3%** and **~0.1%** of the AQS**.** In accordance with the EAs screening thresholds, these contributions are considered insignificant.

5.6.7 The maximum 99.79th percentile of hourly mean ground level concentrations is predicted at ~**28 µg/m³**, or ~**14%** of the AQS. A contour plot showing the distribution of the 99.79th percentile of hourly mean ground level concentrations of NOx (as NO_2) is presented in **Figure 18**. When added to twice the annual mean urban background concentration the PEC equates to **~41%** of the AQS, which is therefore considered very unlikely to lead to an exceedance of the AQS.

Figure 18: Contour plot of predicted process contributions to the 99.79th percentile of hourly mean ground level concentrations of NOx - Scenario 4



Units = μg/m³; Based on predicted concentration during the 2016 meteorological dataset; plotted concentrations exclude NO_2 conversion factors.

<u>Particulates</u>

5.6.8 The maximum annual mean process contribution from the GUC to ground level concentrations of particulates is predicted at **~0.34 μg/m³.** This concentration equates to **~1%** of the AQS for PM_{10} and can therefore be screened as insignificant. If all particulate emissions are conservatively considered to be release as $PM_{2.5}$ the predicted ground level concentration equates to **~1.4%** of the AQS of **2.25 μg/m³.** Combined with a background concentration of **8.71 μg/m³** the PEC amount fo only **~36%** of the AQS. The likelihood of an exceedance of the AQS is therefore very low.

5.6.9 The maximum 90.41st percentile of daily mean ground level concentrations of particulates is predicted at **~1.1 μg/m³,** which equates to less than **2%** of the AQS and is therefore insignificant.

Carbon Monoxide (CO)

5.6.10 The maximum 8-hour daily running mean ground level concentration is predicted at **30 µg/m³,** or less than **1%** of the AQS of **10,000 µg/m³** and is therefore considered insignificant.

Volatile Organic Compounds (VOCs)

5.6.11 The maximum annual mean process contribution from the GUC to ground level concentrations of VOCs is predicted at **~0.34 µg/m³.** On the conservative assumption that this concentration is released as either benzene of 1,3-butadienne this concentration equates to **~7%** and **~15%** respectively of the corresponding annual mean AQS for these compounds. When added to the annual mean background concentrations the PECs equate to only **~13**% and **~19%** of the AQS, respectively. Based on the conservative assumptions and that the predicted annual mean PECs will be less than 50% of the relevant AQSs it is very unlikely that there will be an exceedance of any VOC standards.

Sulphur Dioxide

5.6.12 The modelled SO_2 releases from the GUC are predicted to return maximum 99.9th percentile 15-minute mean, 99,73rd percentile hourly mean and 99.18th percentile daily mean ground level concentrations of **138 µg/m³, ~123 µg/m³** and **~74 µg/m³** respectively, which equate to approximately **~52%, ~35% and ~59%** of their respective AQSs**.** When combined with the background concentrations the respective PECs only increase marginally to approximately **~56%, ~38% and ~63%** of the AQSs. Ground level concentrations of sulphur dioxide are therefore very unlikely to exceed the AQSs.

Designated Habitats

Nitrogen Dioxide

5.6.13 The maximum ground level concentration of NOx (as NO_2) at the Altham Clough Wood Designated Ancient Woodland is predicted at **~0.34 µg/m³ (Appendix 4),** which equates to ~**1.1%** of the AQS of **30 µg/m³.** When combined with the background concentration of **20.75 µg/m³,** the PEC equates to **~75%** of the AQS. It is therefore considered that exceedance of the AQS at the woodland habitat is unlikely.

Sulphur Dioxide

5.6.14 The maximum ground level concentration of SO_2 at the Altham Clough Wood Designated Ancient Woodland is predicted at **~0.54 µg/m³ (Appendix 4),** which equates to **~3%** of the AQS of **20 µg/m³.** When combined with the background concentration of **4.2 µg/m³,** the PEC equates to **~24%** of the AQS. It is therefore considered that exceedance of the AQS at the woodland habitat is very unlikely.

Nitrogen Deposition

5.6.15 The results of the nutrient nitrogen deposition rate calculations for Altham Clough Wood DAW are summarised in **Table 24.**

Table 24: Process Contribution to nutrient nitrogen deposition at Altham Clough Wood DAW - Scenario 4

Deposition (kgN/ha/yr)	Critical Load (kgN/ha/yr)	% of Lower Critical Load	% of Higher Critical Load
0.0018	10-20	<0.1%	<0.1%

5.6.16 The predicted nutrient nitrogen deposition attributable to emissions of NOx from operation of the GUC under Scenario 4 is predicted to be **~0.0018 kgN/ha/yr**, which represents a very small increase over the predicted rate of deposit under Scenario 1. This represents a small fraction (<1%) of the site-specific critical load range. The potential contribution to nutrient nitrogen deposition from the operation of both flares is therefore considered to be insignificant.

Acid Deposition

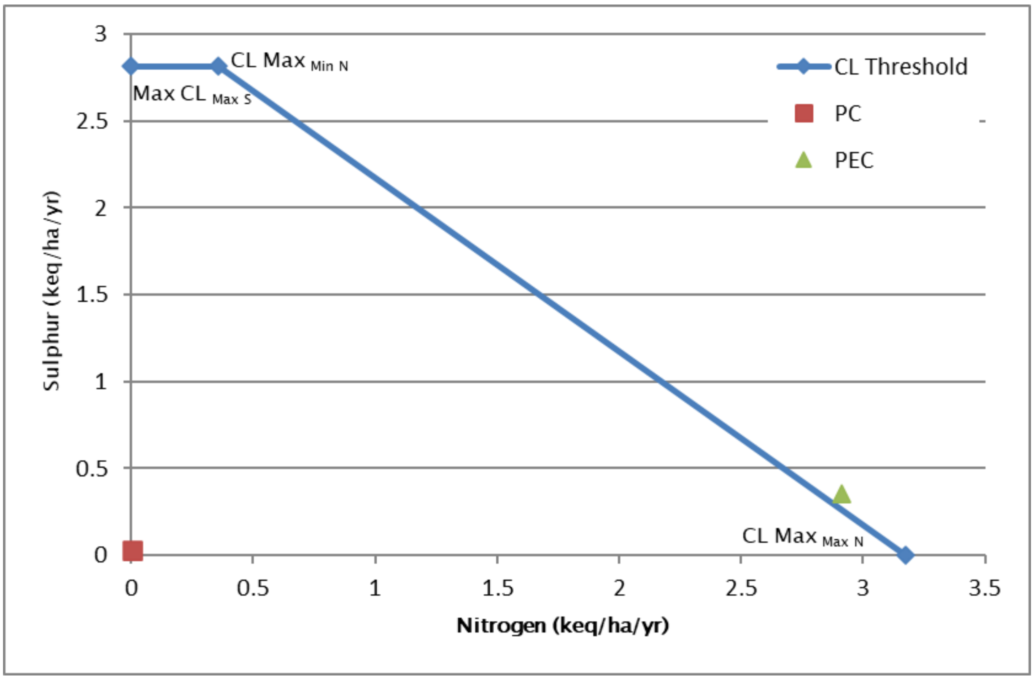
5.6.17 The Process Contributions to acid deposition at the Altham Clough Wood DAW are presented in **Table 25** and presented graphically against specified critical thresholds in **Figure 19.**

Table 25: Predicted acid deposition rates at Altham Clough Wood DAW – Scenario 4

Pollutant Emission	PC *[keq/ha/yr]*
NOx (as NO_2)	0.0018
SO_2	0.032

5.6.18 The results show that precited rate of acidic deposition at Altham Clough Woods from under Scenario 4 only equates to a very small, insignificant fraction of the criteria loads functions. The potential contribution to acid deposition from the operation of both HT flares continuously throughout the year is therefore considered to be insignificant.

Figure 19: Graphical representation of predicted acid deposition rates against critical load threshold for Altham Clough Wood DAW - Scenario 4



6 CONCLUSIONS

6.1.1 Suez Recycling and Recovery UK Limited operate Whinney Hill Landfill site under Environmental Permit EPR/BL9500IJ. Landfill gas is actively extracted from the waste mass via a network of extraction wells and pipework that directs landfill gas to the Gas Utilisation Compound (GUC) located in the south-eastern corner of the landfill site, where the gas is treated by a combination of gas engines to generate electricity and a High Temperature Enclosed Flare.

6.1.2 An updated landfill gas model predicted that the quantity of landfill gas generated by the landfill will peak at ~5,000m^3/hr in 2022. The GUC currently comprises six Jenbacher 320 gas engines and a 3000m^3/hr HT Enclosed Flare unit. The combined treatment capacity of the compounds equates to ~6,600m^3/hr. Suez propose to install a seventh gas engine to provide back-up capacity for when any of the current six engines are shut down for maintenance requirements. Additionally, it is proposed to install a 2,000m^3/hr HT flare alongside the existing HT flare, to ensure that sufficient treatment capacity is available to treat the full quantity of landfill gas extracted from the waste mass in the event that all engines are non-operational. Each existing gas engine is fitted with 20m high exhaust stack that were installed in response to the conclusions of a previous detailed air dispersion modelling carried out for the facility in 2012. Due to the occasional operation of the seventh back-up engine, it is proposed that this engine will only be fitted with a factory fitted exhaust stack of 7.4m.

6.1.3 The permitted operation of the seventh gas engine and additional HT flare is being sought as part of an application to vary Environmental Permit EPR/BL9500IJ. A detailed air dispersion model has been prepared in support of the application to determine if the proposed operation of the seventh engine and replacement flare unit will significantly influence local air quality.

6.1.4 The site is located within the administrative authority of Hyndburn Borough Council. There are currently no Air Quality Management Areas designated within the borough, however due to the presence of the M65 and urban road networks the urban and kerbside NO_2 concentrations are monitored to be elevated within Accrington town centre and surrounding suburbs. Diffusion tube monitoring has been carried out annually since 2012 which determine background concentrations of NO_2 at a total of 14 locations located around the main arterial road networks and surrounding urban areas. The monitoring networks have show reduction of between ~4 and ~10 µg/m³ across each monitoring site since 2012, with annual average kerbside and urban background concentrations recorded at the monitoring points within the immediate vicinity of the landfill achieved a mean concentration of ~26.3 µg/m³ in 2019, or ~66% of the AQS. This mean monitored concentration is significantly greater than the DEFRA background NO_2 of ~19.6 µg/m³ predicted for the same year for the 1kmx1km grid square in which the site is located. However, it is recognised that a the current emissions from the GUC is likely to be contributing to very small proportion of the background concentration monitored in the vicinity of the site. Consequently a level of conservatism should be applied in assessment of the GUC contributions and when applying these urban background concentration at areas located away from the main road networks of Accrington.

6.1.5 Detailed air dispersion modelling has been undertaken using ADMS5.2 supported by sensitivity analysis to determine the significance of various model parameters in line with EA guidance. The assessment considers four operating scenarios:

- ***Scenario 1*** – Six existing engines together with the 3,000m³/hr capacity flare (existing operating scenario);
- ***Scenario 2*** – 5 existing engines, engine 7 and 3,000m³/hr capacity HT flare;
- ***Scenario 3*** - 5 existing engines, engine 7 and 2,000m³/hr capacity HT flare; and
- ***Scenario 4*** – Both HT flares only.

6.1.6 Each model assumes that all gas engines and flare units operated continuously through the year at their maximum operating capacities, with emission concentrations set at the relevant ELVs or other appropriate emission values.

6.1.7 Under Scenario 1, the maximum Process Contribution (PC) to ground level concentrations of NO_2 is predicted at **~8.5 µg/m³**, or **~21%** of the Air Quality Standard (AQS). When combined with the selected annual mean background concentration of **26.3** µg/m³ the Predicted Environment Concentration (PEC) equates to **~87%** of the AQS. This peak concentration was predicted to occur within woodland to the immediate east of the GUC, away from any specified receptors. The greatest contribution to annual mean ground level concentrations was predicted at the brickworks located a short distance to the east of the woodland where the peak concentration is predicted to occur. The contribution to annual mean NO_2 ground levels concentrations at the brickworks is predicted at **~7.8** µg/m³ or **~20%** of the AQS, with the PEC predicted at **~85%** of the standard. All other specified receptors locations modelled returned PECs of no more than **75%** of the AQS.

6.1.8 The operation of the additional back-up engine (Engine 7) in place of one of the existing engines under Scenario 2 predicted a maximum ground level concentration to occur at the same location at a concentration **~2.2 µg/m³** higher (i.e. **~10.7 µg/m³**) than predicted under Scenario 1. This equates to **~27%** of the AQS, or **~93%** of the standard when added to the selected annual mean background concentration. A further, but smaller increase of **~0.2 µg/m³** was subsequently predicted under Scenario 3.

6.1.9 The operation of both flare units alone under Scenario 4 predicted a maximum PC to ground level NO_2 concentrations of **~3.6 µg/m³**, or **~9%** of the AQS. When combined with the selected background concentration the PEC equates to **~75%** of the standard.

6.1.10 The maximum annual mean ground level concentrations of NO_2 are predicted to occur in areas to the east of the landfill which are located a significant distance from the urban road networks in which the selected background NO_2 concentration has been derived. The application of the urban annual mean NO_2 background concentration is therefore considered a conservative representation of background concentrations in the areas to the east of the landfill site and further afield. On this basis the PECs to the east of the landfill will be lower than those calculated and consequently the likelihood of an exceedance of the annual mean AQS for NO_2 is considered low.

6.1.11 The 99.79th percentile of hourly mean ground level concentrations of NO_2 is predicted at **~38.9 µg/m³**, or **~19%** of the AQS under Scenario 1. Under the Scenarios 2 and 3 the GUC contributions increase to respective concentrations of ~**44 µg/m³** and **~46 µg/m³**, or **~22%** and ~**23%** of the AQS. Under Scenario 4, the contribution to ground level concentrations is only **~28.4 µg/m³,** or **14%** fo the AQS. When combined with the selected background concentration the 99.79th percentiles of the hourly mean PECs are predicted to be less than 50% of the AQS under all model scenarios.

6.1.12 The assessment also modelled the emissions of particulates ($PM_{2.5}$ and PM_{10}), VOCs and sulphur dioxide (SO_2). The maximum annual mean PECs for particulates and VOCs (conservatively assessed as benzene and 1,3-butadienne) were less than **70%** of the AQS in all scenarios and are therefore considered to be insignificant and very unlikely to result in an exceedance in the corresponding AQSs. Similarly, the short-term concentrations for carbon monoxide, particulates and sulphur dioxide were also predicted as presenting a low risk of exceeding the relevant AQSs.

6.1.13 An assessment of the potential impact on air quality and nutrient and acid deposition at Altham Clough Wood Designated Ancient Woodland (DAW) was carried out against all four model scenarios. The ground level concentrations of NOx and SO_2 predicted at the DAW under all scenarios were all **<5%** of the AQS and are therefore considered insignificant. Similarly, the predicted contributions to nutrient nitrogen and acid deposits were **<1%** of the Critical Load thresholds specified for this habitat.

6.1.14 The results of the assessment therefore indicates that the installation and intermittent operation of a seventh engine with an exhaust stack height of 7.4m and an additional HT flare unit will not result in a significant deterioration in local air quality. Moreover, the scenarios also illustrate that the operation of any combination of 6 engines with either enclosed flare unit will not result in a significant deterioration of local air quality.

REFERENCES

Air Quality Advisory Group, 2014. *AQTAG06 Technical guidance on detailed modelling approach for an appropriate assessment for emissions to air*

Environment Agency, 2002*. Guidance on Landfill Gas Flaring.*

Environment Agency, 2010a. *Guidance for monitoring enclosed landfill gas flares. LFTGN05 (v2).*

Environment Agency, 2010b. *Guidance for monitoring landfill gas engine emissions. LFTGN08 (v2)*

Golders Associates (UK) Ltd, 2012. *Whinney Hill Atmospheric Dispersion Modelling Assessment*. Report No. 12514270315.500/A.2

APPENDIX 1

Input Parameter Details

APPENDIX 1 *Detailed Discussion on Model Input Data*

Atmospheric Chemistry

A component of the ADMS model contains algorithms to calculate the chemical reactions in the atmosphere between nitric oxide (NO), nitrogen dioxide (NO_2) and ozone (O_3) and the resultant concentration of each pollutant within the plume.

In England and Wales the Environment Agency has traditionally preferred a methodology for calculating annual average and hourly average NO_2 ground-level concentration based upon conversion of NO_X model predictions as shown in Equation 2 and Equation 3:-

Equation 1 Calculation of Annual Average NO_2 Predicted Environmental Concentration

$$(\text{Annual } NO_{X\ \text{Modelled}} \times 0.7) + \text{Annual } NO_{2\ \text{Monitored}}$$

Equation 2 Calculation of Hourly Average NO_2 Predicted Environmental Concentration

$$(\text{Hourly } NO_{X\ \text{Modelled}} \times 0.35) + (\text{Annual } NO_{2\ \text{Monitored}} \times 2)$$

This methodology is likely to overestimate the PEC for NO_2 in close proximity to the site as conversion of NO_X to NO_2 is unlikely to be instantaneous as it requires mixing of the plume with the ambient air and its associated oxidant species (O_3, etc). Accordingly, applying the 70% conversion of NO_X to NO_2 at locations close to the point of release may overestimate significantly the potential NO_2 concentrations at these locations. As the plume migrates away from the stack it disperses and mixes with the ambient air resulting in lower concentrations of pollutants, so the PC for NO_X and hence associated NO_2, will be lower farther afield.

Meteorological Data

When modelling plume dispersion, the following meteorological data are required as a minimum:

- wind speed (m s^{-1})
- wind direction (degrees)
- cloud cover (Oktas)
- mixing height

For the purpose of this exercise, available meteorological data for 2015 to 2019 from the nearby Stonyhurst measurement station was combined with the other required parameters from the Bingley No2 measurement station were utilised. The wind roses each year is presented in Appendix 2.

The data indicated a predominance of winds from westerly and south-westerly directions.

Local Environmental Conditions

Local environmental conditions describe the factors that might influence the dispersion process (such as nearby structures, sharply rising terrain, etc.) and also describe the locations at which pollutant concentrations are to be predicted. These include:

Surface Roughness

It is sometimes necessary to define a term, which describes the degree of ground turbulence caused by the passage of wind across surface structures, also called the surface roughness. The degree of ground turbulence is much greater in urban areas (due to the presence of tall buildings) than in rural areas (which contain smaller obstacles at the surface). The dispersion model may require the user to select “urban” or “rural” conditions, or to specify a “surface roughness length” according to defined criteria. Calculations of dispersion, which take account of the greater aerodynamic roughness of the surface structures in urban areas, tend to predict higher concentrations closer to the stack than calculations under equivalent conditions, which assume typical rural roughness.

For the purpose of this model a surface roughness factor of 0.5m was initially chosen, characteristic of open suburbia and parkland. Following completion of the sensitivity analysis this value was confirmed as the most appropriate value for the site.

Nearby Buildings and Structures

If the stack is located on the top of a building, or adjacent to a tall building, then the size of these buildings may need to be considered. As a general guide, building downwash problems (where emissions are caught in the turbulent wake caused by wind blowing around the building) may occur if the stack height is less than 2½ times the height of the building upon which it sits. Adjacent buildings may need to be taken into account if they are within about 5 stack heights of the point of release.

To take account of local building effects, models generally require information related to the dimensions and location of the structures with respect to the stack. The building data used in this modelling exercise are presented in **Figure 2.** All gas engine, flare, storage and welfare accommodation within the GUC were modelled under a single building entry due ot relative proximity of each unit to each other.

Complex Terrain Data

The presence of steep hills in the vicinity of a stack may affect the dispersion of pollutants. During more stable conditions, an elevated plume may impact upon a nearby hillside, resulting in much higher ground level concentrations than would occur over flat terrain. The more sophisticated models can take account of these terrain effects, and require the input of contour heights in the immediate area surrounding the stack. Terrain effects are unlikely to be significant where the hills have a slope of less than about 10%.

Topographic data for the locality is presented in **Figure 4**. The terrain model indicated that the location of the site was within a ground depression, with ground of higher elevation to the south and east of the site.

For screening purposes, modelling was undertaken to determine the significance of the local topography and it was shown to have a potential impact on the modelling results. Terrain effects were therefore included as part of the detailed assessment.

Output Grid and Specific Points

It is necessary to define the locations at which ground level concentrations are to be calculated by the model. In selecting receptor locations, it is general practice to identify the nearest, sensitive locations to the chimney stack, such as residential housing, hospitals *etc*.

Many models allow the user to specify a “grid” of receptor locations. However, when setting up a receptor grid it is important to ensure that there are sufficient receptor points to able to predict the magnitude and location of the maximum concentration. If the grid of receptor points is too widely spaced, the maximum concentration may be missed.

In light of the variable exhaust stack heights modelled at a grid spacing of 25m, which is a reduction of 50% to that modelled in 2012. Therefore, a receptor grid covering an area 4,000 m x 4,000 m in a 161 x 161 grid was incorporated into the model in order to assess the potential impact of pollutant emissions from the GUC on the surrounding area. The model was set to predict concentrations at ground level (0m).

Twenty-one specific receptors were modelled indicating the location of nearby residential properties, schools, farms, allotments and playing fields identified from Ordnance Survey mapping data. One of the specific receptors relates to a Designated Ancient Woodland located within 2km fo the GUC. The model was set to predict concentrations at ground level (0m) at the specific receptors.

The combined modelling of a grid spacing and specified receptors was considered to provide an appropriate levels of confidence to predict the maximum ground levels concentrations of pollutants from the GUC.

APPENDIX 2

Wind Roses

APPENDIX 2 *Wind Roses*

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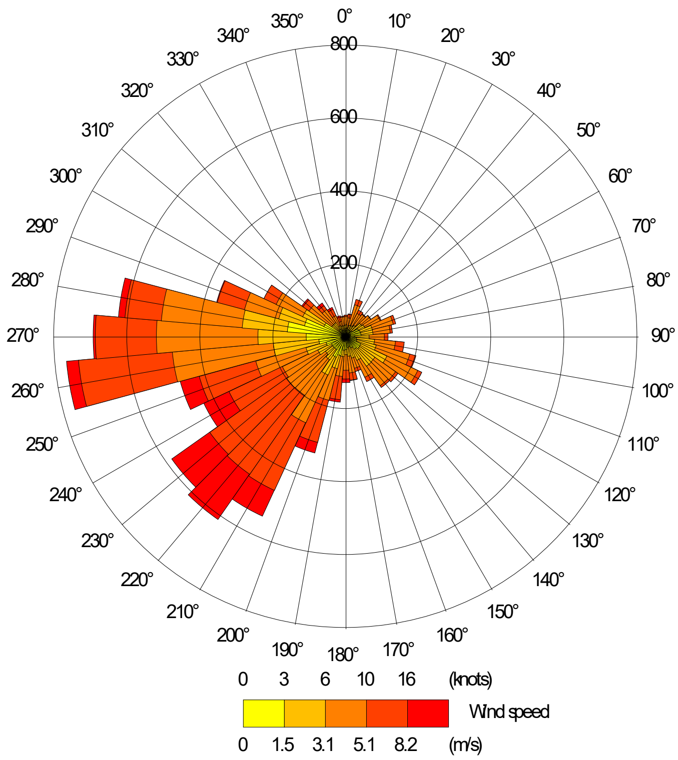
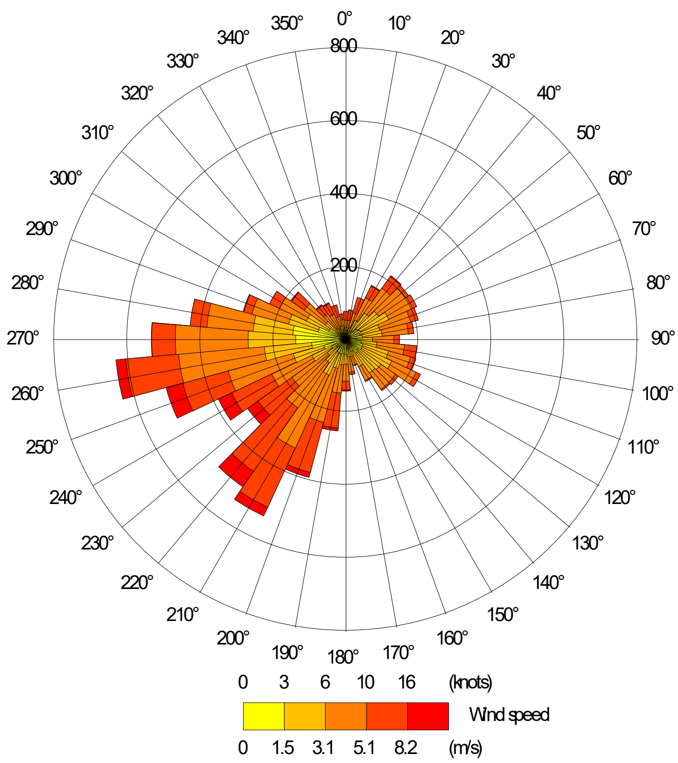
2015



2016



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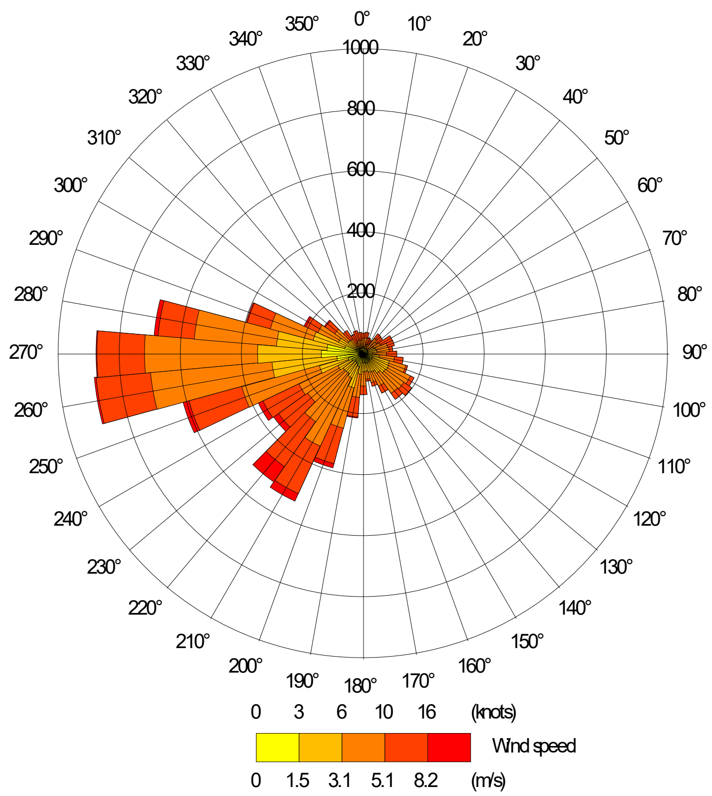
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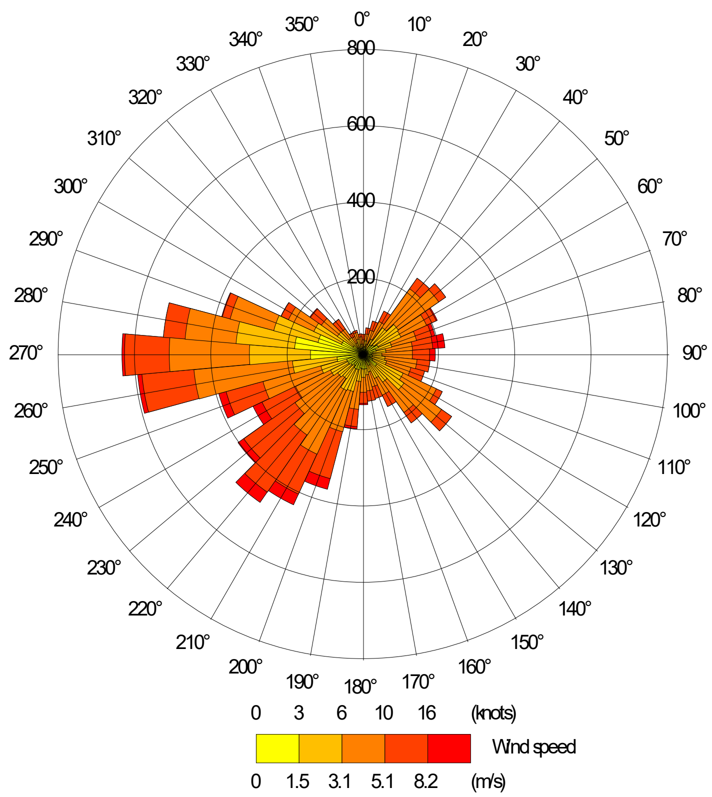
2018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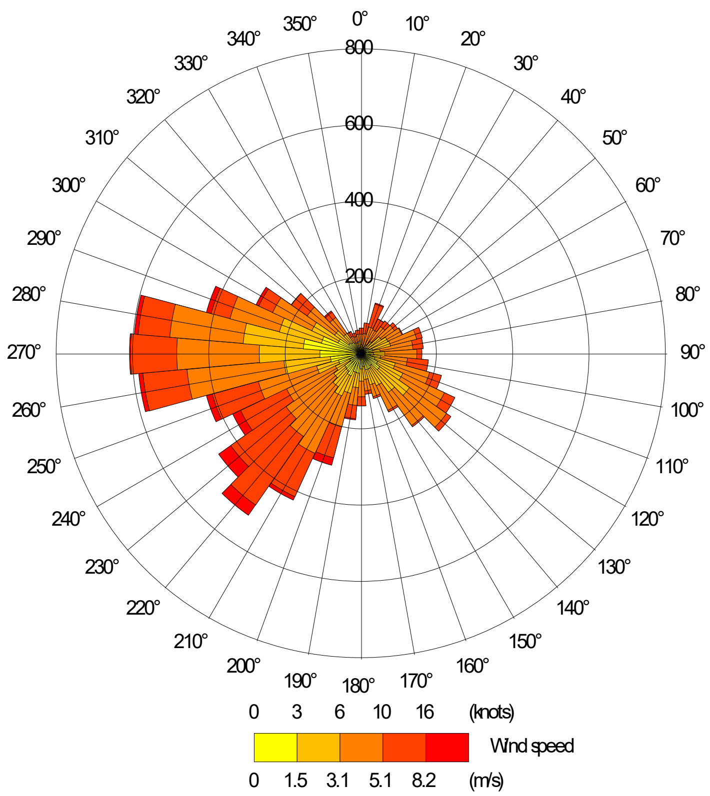
2019



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APPENDIX 3

Predicted Peak Ground Level Concentrations

Scenario 1

Parameter	Statistic	2016	2017	2018	2019	EAL	Max PC	PC %age of EAL	Background	PEC	PEC %age of EAL	Notes
Long-term												
(NOx	*Annual Mean*	*8.4*	*12.2*	*8.29*	*8.98*	*40*	*12.2*	*30.5%*	*26.3*	*38.5*	*96.3%*	
NO2	Annual Mean	5.88	8.54	5.803	6.286	40	*8.54*	*21.4%*	*26.3*	*34.84*	*87.1%*	assumes 70% conversion to NO2
PM10	Annual Mean	0.254	0.356	0.242	0.264	40	0.356	0.9%	13.1	13.456	33.6%	
PM2.5	Annual Mean	0.254	0.356	0.242	0.264	25	0.356	1.4%	8.71	9.066	36.3%	
Benzene	Annual Mean	0.61	0.89	0.605	0.654	5	0.89	17.8%	0.322	1.212	24.2%	
1,3-Butadiene	Annual Mean	0.61	0.89	0.605	0.654	2.25	0.89	39.6%	0.087	0.977	43.4%	
Short-term												
(Nox	*Hourly mean (99.79th percentile)*	*111*	*107*	*103*	*108*	*200*	*111*	*55.5%*	*52.6*	*163.6*	*81.8%*	
NO2	Hourly mean (99.79th percentile)	38.85	37.45	36.05	37.8	200	38.85	19.4%	52.6	91.45	45.7%	assumes 35% conversion to NO2
CO	8-hour running mean (100th percentile)	274	259	266	253	10000	274	2.7%	200.2	474.2	4.7%	
PM10	Daily Mean (90.41st percentile)	0.863	1.05	0.782	0.868	50	1.05	2.1%	15.5	16.55	33.1%	
SO2	15-minute mean (99.9th percentile)	76.3	77.4	78.7	80	266	80	30.1%	11.3	91.3	34.3%	
SO2	hourly mean (99.73rd percentile)	64.1	65.4	66.4	67.6	350	67.6	19.3%	8.4	76	21.7%	
SO2	Daily Mean (99.18th percentile)	44	37.2	46.7	38.1	125	46.7	37.4%	5	51.7	41.4%	

Scenario 2

Parameter	Statistic	2016	2017	2018	2019	EAL	Max PC	PC %age of EAL	Background	PEC	PEC %age of EAL	Notes
Long-term												
(NOx	*Annual Mean*	*10.3*	*15.3*	*10.2*	*11.2*	*40*	*15.3*	*38.3%*	*27.6*	*42.9*	*107.3%*	
NO2	Annual Mean	7.21	10.71	7.14	7.84	40	*10.71*	*26.8%*	*26.3*	*37.01*	*92.5%*	assumes 70% conversion to NO2
PM10	Annual Mean	0.298	0.431	0.288	0.318	40	0.431	1.1%	26.3	26.731	66.8%	
PM2.5	Annual Mean	0.298	0.431	0.288	0.318	25	0.431	1.7%	8.71	9.141	36.6%	
Benzene	Annual Mean	0.746	1.11	0.742	0.815	5	1.11	22.2%	0.322	1.432	28.6%	
1,3-Butadiene	Annual Mean	0.746	1.11	0.742	0.815	2.25	1.11	49.3%	0.087	1.197	53.2%	
Short-term												
(Nox	*Hourly mean (99.79th percentile)*	*126*	*123*	*118*	*124*	*200*	*126*	*63.0%*	*52.6*	*178.6*	*89.3%*	
NO2	Hourly mean (99.79th percentile)	44.1	43.05	41.3	43.4	200	44.1	22.1%	52.6	96.7	48.4%	assumes 35% conversion to NO2
CO	8-hour running mean (100th percentile)	307	317	299	294	10000	317	3.2%	200.2	517.2	5.2%	
PM10	Daily Mean (90.41st percentile)	0.979	1.22	0.924	0.995	50	1.22	2.4%	15.5	16.72	33.4%	
SO2	15-minute mean (99.9th percentile)	81.2	90.2	82	87.04	266	90.2	33.9%	11.3	101.5	38.2%	
SO2	hourly mean (99.73rd percentile)	69.2	68.5	68.1	71.8	350	71.8	20.5%	8.4	80.2	22.9%	
SO2	Daily Mean (99.18th percentile)	46.6	38.5	49.3	41	125	49.3	39.4%	5	54.3	43.4%	

Scenario 3

Parameter	Statistic	2016	2017	2018	2019	EAL	Max PC	PC %age of EAL	Background	PEC	PEC %age of EAL	Notes
Long-term												
(NOx	*Annual Mean*	*10.6*	*15.6*	*10.5*	*11.5*	*40*	*15.6*	*39.0%*	*26.3*	*41.9*	*104.8%*	
NO2	Annual Mean	7.42	10.92	7.35	8.05	40	*10.92*	*27.3%*	*26.3*	*37.22*	*93.1%*	assumes 70% conversion to NO2
PM10	Annual Mean	0.315	0.454	0.301	0.335	40	0.454	1.1%	13.1	13.554	33.9%	
PM2.5	Annual Mean	0.315	0.454	0.301	0.335	25	0.454	1.8%	8.71	9.164	36.7%	
Benzene	Annual Mean	0.763	1.13	0.759	0.832	5	1.13	22.6%	0.322	1.452	29.0%	
1,3-Butadiene	Annual Mean	0.763	1.13	0.759	0.832	2.25	1.13	50.2%	0.087	1.217	54.1%	
Short-term												
(Nox	*Hourly mean (99.79th percentile)*	*130*	*128*	*121*	*129*	*200*	*130*	*65.0%*	*52.6*	*182.6*	*91.3%*	
NO2	Hourly mean (99.79th percentile)	45.5	44.8	42.35	45.15	200	45.5	22.8%	52.6	98.1	49.1%	assumes 35% conversion to NO2
CO	8-hour running mean (100th percentile)	308	310	299	296	10000	310	3.1%	200.2	510.2	5.1%	
PM10	Daily Mean (90.41st percentile)	1.02	1.26	0.946	1.07	50	1.26	2.5%	15.5	16.76	33.5%	
SO2	15-minute mean (99.9th percentile)	85.3	86.2	82.9	92.5	266	92.5	34.8%	11.3	103.8	39.0%	
SO2	hourly mean (99.73rd percentile)	75.7	76.6	74.1	81.4	350	81.4	23.3%	8.4	89.8	25.7%	
SO2	Daily Mean (99.18th percentile)	47.2	42.2	45.5	43.5	125	47.2	37.8%	5	52.2	41.8%	

Scenario 4

Parameter	Statistic	2015	2016	2017	2018	2019	EAL	Max PC	PC %age of EAL	Background	PEC	PEC %age of EAL	Notes
Long-term													
(NOx	*Annual Mean*	*5.22*	*2.98*	*3.61*	*2.55*	*2.82*	*40*	*5.22*	*13.1%*	*26.3*	*31.52*	*78.8%*	
NO2	Annual Mean	3.65	2.09	2.53	1.79	1.97	40	*3.654*	*9.1%*	*26.3*	*29.954*	*74.9%*	assumes 70% conversion to NO2
PM10	Annual Mean	0.341	0.194	0.236	0.166	0.184	40	0.341	0.9%	13.1	13.441	33.6%	
PM2.5	Annual Mean	0.341	0.194	0.236	0.166	0.184	25	0.341	1.4%	8.71	9.051	36.2%	
Benzene	Annual Mean	0.341	0.194	0.236	0.166	0.184	5	0.341	6.8%	0.322	0.663	13.3%	
1,3-Butadiene	Annual Mean	0.341	0.194	0.236	0.166	0.184	2.25	0.341	15.2%	0.087	0.428	19.0%	
Short-term													
(Nox	*Hourly mean (99.79th percentile)*	*81*	*64*	*67.2*	*59.7*	*75.7*	*200*	*81*	*40.5%*	*52.6*	*133.6*	*66.8%*	
NO2	Hourly mean (99.79th percentile)	28.35	22.40	23.52	20.90	26.50	200	28.35	14.2%	52.6	80.95	40.5%	assumes 35% conversion to NO2
CO	8-hour running mean (100th percentile)	28.5	24.2	30	21.4	27.5	10000	30	0.3%	200.2	230.2	2.3%	
PM10	Daily Mean (90.41st percentile)	1.1	0.615	0.728	0.622	0.709	50	1.1	2.2%	15.5	16.6	33.2%	
SO2	15-minute mean (99.9th percentile)	136	114	138	108	136	266	138	51.9%	11.3	149.3	56.1%	
SO2	hourly mean (99.73rd percentile)	123	101	102	92.5	116	350	123	35.1%	8.4	131.4	37.5%	
SO2	Daily Mean (99.18th percentile)	73.5	71.8	50.1	57.9	51.7	125	73.5	58.8%	5	78.5	62.8%	

APPENDIX 4

Predicted Ground Level Concentrations at Specified Receptors

Scenario 1

NOx Annual Mean

Receptor Name	**2015**	**2016**	**2017**	**2018**	**2019**	**PC**	**Conversion**	**EAL**	**PC %**	**Bkgrd**	**PEC**	**PEC%**
Sankey House Farm	2.9	3.2	3.0	2.9	3.6	3.6	2.5	40	6.2%	26.3	28.8	72.0%
Caravan Park	4.6	3.9	5.3	4.0	5.2	5.3	3.7	40	9.3%	26.3	30.0	75.0%
Huntcoat Industrial	3.2	2.8	3.6	2.8	3.6	3.6	2.6	40	6.4%	26.3	28.9	72.1%
Brickworks S	10.1	7.0	11.2	7.5	8.1	11.2	7.8	40	19.6%	26.3	34.1	85.3%
Brickworks N	8.5	6.7	9.1	6.3	6.7	9.1	6.4	40	16.0%	26.3	32.7	81.7%
HWDC 1	9.5	6.5	6.7	6.0	6.7	9.5	6.7	40	16.6%	26.3	33.0	82.4%
Tunstall Drive	0.8	1.0	0.8	1.3	1.1	1.3	0.9	40	2.4%	26.3	27.2	68.1%
Playing Field S	1.3	2.6	1.2	2.7	1.7	2.7	1.9	40	4.7%	26.3	28.2	70.4%
Football Ground S	0.7	1.6	0.8	1.8	0.9	1.8	1.3	40	3.2%	26.3	27.6	68.9%
Footpath S	0.9	1.4	1.2	0.9	1.1	1.4	0.9	40	2.4%	26.3	27.2	68.1%
Tennis/Cricket Groun	1.2	1.4	1.2	1.2	1.5	1.5	1.0	40	2.6%	26.3	27.3	68.3%
William Street	0.5	0.5	0.4	0.5	0.6	0.6	0.4	40	1.0%	26.3	26.7	66.8%
Football Ground W	0.4	0.4	0.4	0.5	0.6	0.6	0.4	40	1.0%	26.3	26.7	66.7%
Bold Venture Farm	0.5	0.4	0.4	0.6	0.6	0.6	0.4	40	1.1%	26.3	26.7	66.8%
Hawthorne Bank	0.4	0.3	0.4	0.5	0.5	0.5	0.4	40	0.9%	26.3	26.7	66.6%
Moorfield Industrial	0.4	0.5	0.4	0.4	0.4	0.5	0.3	40	0.8%	26.3	26.6	66.6%
Footpath N	1.0	1.2	1.1	1.0	0.8	1.2	0.9	40	2.1%	26.3	27.2	67.9%
Moorside House	0.3	0.4	0.4	0.4	0.3	0.4	0.3	40	0.7%	26.3	26.6	66.5%
Clough Bank Bridge & Altham Clough Wood (DAW)	1.0	0.8	0.8	0.8	0.9	1.0	0.7	40	1.8%	26.3	27.0	67.5%
Nearer Holker House	1.7	1.5	1.7	1.3	1.5	1.7	1.2	40	3.0%	26.3	27.5	68.7%
Oak Bank	2.6	2.2	3.1	2.1	2.2	3.1	2.1	40	5.4%	26.3	28.4	71.1%

NOx Hourly Mean (99.79th %ile)

Receptor Name	**2015**	**2016**	**2017**	**2018**	**2019**	**PC**	**Conversion**	**EAL**	**PC %**	**Bkgrd**	**PEC**	**PEC%**
Sankey House Farm	78.0	84.2	80.0	78.6	80.6	84.2	29.5	200	14.7%	52.6	82.1	41.0%
Caravan Park	81.8	88.6	86.4	73.3	84.6	88.6	31.0	200	15.5%	52.6	83.6	41.8%
Huntcoat Industrial	60.7	75.0	72.2	61.1	70.9	75.0	26.3	200	13.1%	52.6	78.9	39.4%
Brickworks S	69.5	68.0	69.8	68.9	68.7	69.8	24.4	200	12.2%	52.6	77.0	38.5%
Brickworks N	61.4	60.7	60.4	59.8	60.5	61.4	21.5	200	10.7%	52.6	74.1	37.0%
HWDC 1	79.1	76.3	79.8	79.8	76.1	79.8	27.9	200	14.0%	52.6	80.5	40.3%
Tunstall Drive	33.1	34.1	34.1	34.9	33.7	34.9	12.2	200	6.1%	52.6	64.8	32.4%
Playing Field S	54.7	58.9	58.3	59.8	59.0	59.8	20.9	200	10.5%	52.6	73.5	36.8%
Football Ground S	31.4	36.2	35.3	35.6	34.0	36.2	12.7	200	6.3%	52.6	65.3	32.6%
Footpath S	56.6	61.9	61.4	59.4	58.9	61.9	21.6	200	10.8%	52.6	74.2	37.1%
Tennis/Cricket Groun	37.6	43.9	38.4	39.2	42.8	43.9	15.4	200	7.7%	52.6	68.0	34.0%
William Street	16.3	16.5	15.9	16.5	16.8	16.8	5.9	200	2.9%	52.6	58.5	29.2%
Football Ground W	15.1	15.3	14.7	15.2	15.7	15.7	5.5	200	2.7%	52.6	58.1	29.0%
Bold Venture Farm	16.9	16.9	17.7	17.8	17.4	17.8	6.2	200	3.1%	52.6	58.8	29.4%
Hawthorne Bank	13.2	12.9	13.7	13.7	13.2	13.7	4.8	200	2.4%	52.6	57.4	28.7%
Moorfield Industrial	16.6	16.3	16.2	16.1	16.0	16.6	5.8	200	2.9%	52.6	58.4	29.2%
Footpath N	19.0	19.1	19.3	19.0	19.0	19.3	6.7	200	3.4%	52.6	59.3	29.7%
Moorside House	11.0	11.1	10.5	11.2	10.7	11.2	3.9	200	2.0%	52.6	56.5	28.3%
Clough Bank Bridge & Altham Clough Wood (DAW)	11.9	11.8	12.0	12.1	12.1	12.1	4.2	200	2.1%	52.6	56.8	28.4%
Nearer Holker House	19.7	19.9	21.5	20.3	20.3	21.5	7.5	200	3.8%	52.6	60.1	30.1%
Oak Bank	30.9	30.7	31.2	28.5	30.4	31.2	10.9	200	5.5%	52.6	63.5	31.8%

Scenario 2

NOx Annual Mean

Receptor Name	**2015**	**2016**	**2017**	**2018**	**2019**	**PC**	**Conversion**	**EAL**	**PC %**	**Bkgrd**	**PEC**	**PEC%**
Sankey House Farm	3.2	3.5	3.3	3.2	3.9	3.9	2.8	40	6.9%	26.3	29.1	72.7%
Caravan Park	5.2	4.3	6.0	4.5	5.8	6.0	4.2	40	10.5%	26.3	30.5	76.2%
Huntcoat Industrial	3.5	3.0	3.9	3.1	3.9	3.9	2.8	40	6.9%	26.3	29.1	72.6%
Brickworks S	11.3	7.9	12.7	8.5	9.1	12.7	8.9	40	22.2%	26.3	35.2	88.0%
Brickworks N	9.2	7.3	10.0	6.9	7.3	10.0	7.0	40	17.6%	26.3	33.3	83.3%
HWDC 1	12.3	8.8	9.1	8.1	9.1	12.3	8.6	40	21.6%	26.3	34.9	87.3%
Tunstall Drive	0.9	1.1	0.9	1.4	1.2	1.4	1.0	40	2.5%	26.3	27.3	68.3%
Playing Field S	1.5	3.0	1.4	3.1	2.0	3.1	2.2	40	5.4%	26.3	28.5	71.2%
Football Ground S	0.8	1.7	0.8	2.0	1.0	2.0	1.4	40	3.5%	26.3	27.7	69.2%
Footpath S	1.0	1.5	1.3	1.0	1.2	1.5	1.0	40	2.6%	26.3	27.3	68.4%
Tennis/Cricket Groun	1.3	1.5	1.2	1.3	1.5	1.5	1.1	40	2.7%	26.3	27.4	68.4%
William Street	0.5	0.5	0.4	0.6	0.6	0.6	0.4	40	1.1%	26.3	26.7	66.8%
Football Ground W	0.5	0.4	0.4	0.6	0.6	0.6	0.4	40	1.0%	26.3	26.7	66.8%
Bold Venture Farm	0.5	0.4	0.5	0.6	0.7	0.7	0.5	40	1.1%	26.3	26.8	66.9%
Hawthorne Bank	0.4	0.3	0.4	0.5	0.5	0.5	0.4	40	0.9%	26.3	26.7	66.7%
Moorfield Industrial	0.5	0.5	0.4	0.5	0.4	0.5	0.3	40	0.9%	26.3	26.6	66.6%
Footpath N	1.0	1.3	1.1	1.1	0.9	1.3	0.9	40	2.2%	26.3	27.2	68.0%
Moorside House	0.4	0.4	0.4	0.4	0.3	0.4	0.3	40	0.8%	26.3	26.6	66.5%
Clough Bank Bridge & Altham Clough Wood (DAW)	1.1	0.9	0.9	0.8	0.9	1.1	0.7	40	1.8%	26.3	27.0	67.6%
Nearer Holker House	1.8	1.5	1.8	1.4	1.6	1.8	1.3	40	3.1%	26.3	27.6	68.9%
Oak Bank	2.8	2.4	3.2	2.2	2.3	3.2	2.3	40	5.7%	26.3	28.6	71.4%

NOx Hourly Mean (99.79th %ile)

Receptor Name	**2015**	**2016**	**2017**	**2018**	**2019**	**PC**	**Conversion**	**EAL**	**PC %**	**Bkgrd**	**PEC**	**PEC%**
Sankey House Farm	83.1	90.4	82.5	83.5	84.1	90.4	31.6	200	15.8%	52.6	84.2	42.1%
Caravan Park	86.3	93.0	95.7	82.3	91.5	95.7	33.5	200	16.8%	52.6	86.1	43.1%
Huntcoat Industrial	63.5	71.3	72.3	65.0	71.3	72.3	25.3	200	12.7%	52.6	77.9	39.0%
Brickworks S	75.4	73.6	75.4	74.5	73.4	75.4	26.4	200	13.2%	52.6	79.0	39.5%
Brickworks N	65.0	64.6	63.9	63.8	64.2	65.0	22.8	200	11.4%	52.6	75.4	37.7%
HWDC 1	90.2	87.7	89.9	88.9	87.0	90.2	31.6	200	15.8%	52.6	84.2	42.1%
Tunstall Drive	34.7	36.1	36.1	37.0	35.4	37.0	12.9	200	6.5%	52.6	65.5	32.8%
Playing Field S	59.8	65.2	64.2	65.6	65.8	65.8	23.0	200	11.5%	52.6	75.6	37.8%
Football Ground S	33.3	38.1	37.3	37.5	36.2	38.1	13.3	200	6.7%	52.6	65.9	33.0%
Footpath S	61.7	66.7	65.2	62.9	64.5	66.7	23.3	200	11.7%	52.6	75.9	38.0%
Tennis/Cricket Groun	38.0	41.7	39.5	40.4	46.0	46.0	16.1	200	8.1%	52.6	68.7	34.4%
William Street	17.0	17.1	16.2	17.1	17.4	17.4	6.1	200	3.0%	52.6	58.7	29.3%
Football Ground W	15.5	15.6	15.1	15.7	16.2	16.2	5.7	200	2.8%	52.6	58.3	29.1%
Bold Venture Farm	17.3	17.3	18.3	18.4	18.1	18.4	6.4	200	3.2%	52.6	59.0	29.5%
Hawthorne Bank	13.6	13.2	14.3	14.1	13.6	14.3	5.0	200	2.5%	52.6	57.6	28.8%
Moorfield Industrial	17.1	16.9	16.7	16.5	16.4	17.1	6.0	200	3.0%	52.6	58.6	29.3%
Footpath N	19.7	19.7	19.9	19.6	19.6	19.9	7.0	200	3.5%	52.6	59.6	29.8%
Moorside House	11.3	11.7	10.9	11.4	11.0	11.7	4.1	200	2.0%	52.6	56.7	28.3%
Clough Bank Bridge & Altham Clough Wood (DAW)	12.2	12.2	12.6	12.7	12.7	12.7	4.4	200	2.2%	52.6	57.0	28.5%
Nearer Holker House	20.5	21.0	22.8	21.1	22.2	22.8	8.0	200	4.0%	52.6	60.6	30.3%
Oak Bank	32.9	32.9	33.7	29.7	31.3	33.7	11.8	200	5.9%	52.6	64.4	32.2%

Scenario 3

NOx Annual Mean

Receptor Name	**2015**	**2016**	**2017**	**2018**	**2019**	**PC**	**Conversion**	**EAL**	**PC %**	**Bkgrd**	**PEC**	**PEC%**
Sankey House Farm	3.2	3.5	3.4	3.2	4.0	4.0	2.8	40	6.9%	26.3	29.1	72.7%
Caravan Park	5.2	4.4	6.0	4.6	5.8	6.0	4.2	40	10.5%	26.3	30.5	76.3%
Huntcoat Industrial	3.5	3.0	3.9	3.1	4.0	4.0	2.8	40	6.9%	26.3	29.1	72.7%
Brickworks S	11.5	8.0	12.9	8.6	9.2	12.9	9.0	40	22.5%	26.3	35.3	88.2%
Brickworks N	9.2	7.3	10.1	6.9	7.4	10.1	7.0	40	17.6%	26.3	33.3	83.4%
HWDC 1	12.6	9.0	9.3	8.3	9.3	12.6	8.8	40	22.0%	26.3	35.1	87.7%
Tunstall Drive	0.9	1.1	0.8	1.4	1.2	1.4	1.0	40	2.5%	26.3	27.3	68.2%
Playing Field S	1.6	3.1	1.4	3.2	2.0	3.2	2.2	40	5.5%	26.3	28.5	71.3%
Football Ground S	0.8	1.7	0.8	2.0	1.0	2.0	1.4	40	3.4%	26.3	27.7	69.2%
Footpath S	1.0	1.5	1.3	1.0	1.2	1.5	1.0	40	2.6%	26.3	27.3	68.4%
Tennis/Cricket Groun	1.3	1.5	1.2	1.3	1.5	1.5	1.1	40	2.7%	26.3	27.4	68.4%
William Street	0.5	0.5	0.4	0.6	0.6	0.6	0.4	40	1.1%	26.3	26.7	66.8%
Football Ground W	0.5	0.4	0.4	0.5	0.6	0.6	0.4	40	1.0%	26.3	26.7	66.8%
Bold Venture Farm	0.5	0.4	0.5	0.6	0.6	0.6	0.5	40	1.1%	26.3	26.8	66.9%
Hawthorne Bank	0.4	0.3	0.4	0.5	0.5	0.5	0.4	40	0.9%	26.3	26.7	66.7%
Moorfield Industrial	0.5	0.5	0.4	0.5	0.4	0.5	0.3	40	0.8%	26.3	26.6	66.6%
Footpath N	1.0	1.2	1.1	1.0	0.8	1.2	0.9	40	2.2%	26.3	27.2	67.9%
Moorside House	0.4	0.4	0.4	0.4	0.3	0.4	0.3	40	0.8%	26.3	26.6	66.5%
Clough Bank Bridge & Altham Clough Wood (DAW)	1.0	0.8	0.9	0.8	0.9	1.0	0.7	40	1.8%	26.3	27.0	67.5%
Nearer Holker House	1.7	1.5	1.8	1.4	1.5	1.8	1.2	40	3.1%	26.3	27.5	68.8%
Oak Bank	2.7	2.3	3.2	2.2	2.3	3.2	2.2	40	5.6%	26.3	28.5	71.3%

NOx Hourly Mean (99.79th %ile)

Receptor Name	**2015**	**2016**	**2017**	**2018**	**2019**	**PC**	**Conversion**	**EAL**	**PC %**	**Bkgrd**	**PEC**	**PEC%**
Sankey House Farm	83.8	93.0	84.8	85.6	85.3	93.0	32.6	200	16.3%	52.6	85.2	42.6%
Caravan Park	88.1	95.3	96.6	84.3	91.9	96.6	33.8	200	16.9%	52.6	86.4	43.2%
Huntcoat Industrial	63.9	74.0	74.0	65.4	74.0	74.0	25.9	200	13.0%	52.6	78.5	39.3%
Brickworks S	76.6	74.0	77.0	75.1	73.4	77.0	27.0	200	13.5%	52.6	79.6	39.8%
Brickworks N	65.0	65.2	64.2	64.1	64.2	65.2	22.8	200	11.4%	52.6	75.4	37.7%
HWDC 1	91.0	88.3	90.3	91.7	87.9	91.7	32.1	200	16.1%	52.6	84.7	42.4%
Tunstall Drive	33.9	35.9	35.0	36.2	34.7	36.2	12.7	200	6.3%	52.6	65.3	32.6%
Playing Field S	60.0	65.7	64.7	66.5	66.5	66.5	23.3	200	11.6%	52.6	75.9	37.9%
Football Ground S	33.1	37.5	36.2	37.6	35.8	37.6	13.2	200	6.6%	52.6	65.8	32.9%
Footpath S	61.9	67.1	65.4	63.9	63.9	67.1	23.5	200	11.7%	52.6	76.1	38.0%
Tennis/Cricket Groun	39.0	42.2	40.0	41.1	47.3	47.3	16.6	200	8.3%	52.6	69.2	34.6%
William Street	16.7	17.2	16.2	16.7	17.4	17.4	6.1	200	3.0%	52.6	58.7	29.3%
Football Ground W	15.2	15.2	14.8	15.4	16.0	16.0	5.6	200	2.8%	52.6	58.2	29.1%
Bold Venture Farm	17.0	17.1	17.9	18.2	17.9	18.2	6.4	200	3.2%	52.6	59.0	29.5%
Hawthorne Bank	13.6	13.2	14.3	14.0	13.6	14.3	5.0	200	2.5%	52.6	57.6	28.8%
Moorfield Industrial	16.9	16.2	16.3	16.3	16.1	16.9	5.9	200	3.0%	52.6	58.5	29.3%
Footpath N	19.3	19.3	19.5	19.4	19.1	19.5	6.8	200	3.4%	52.6	59.4	29.7%
Moorside House	11.3	11.5	10.8	11.5	10.9	11.5	4.0	200	2.0%	52.6	56.6	28.3%
Clough Bank Bridge & Altham Clough Wood (DAW)	12.2	12.4	12.8	12.9	13.0	13.0	4.5	200	2.3%	52.6	57.1	28.6%
Nearer Holker House	20.8	21.3	23.2	21.5	22.4	23.2	8.1	200	4.1%	52.6	60.7	30.4%
Oak Bank	33.4	33.5	34.2	29.7	32.0	34.2	12.0	200	6.0%	52.6	64.6	32.3%

Scenario 4

NOx Annual Mean

Receptor Name	2015	2016	2017	2018	2019	PC	Conversion	EAL	PC %	Bkgrd	PEC	PEC%
Sankey House Farm	0.7	0.7	0.7	0.6	0.8	0.8	0.6	40	1.4%	26.3	26.9	67.2%
Caravan Park	1.15	0.80	1.27	0.83	1.16	1.27	0.89	40	2.2%	26.3	27.2	68.0%
Huntcoat Industrial	0.77	0.58	0.86	0.59	0.81	0.86	0.60	40	1.5%	26.3	26.9	67.2%
Brickworks S	2.89	1.84	2.77	1.85	2.03	2.89	2.03	40	5.1%	26.3	28.3	70.8%
Brickworks N	2.53	1.83	2.25	1.60	1.75	2.53	1.77	40	4.4%	26.3	28.1	70.2%
HWDC 1	4.74	2.81	2.69	2.47	2.77	4.74	3.32	40	8.3%	26.3	29.6	74.0%
Tunstall Drive	0.21	0.24	0.21	0.37	0.29	0.37	0.26	40	0.7%	26.3	26.6	66.4%
Playing Field S	0.24	0.61	0.31	0.60	0.42	0.61	0.42	40	1.1%	26.3	26.7	66.8%
Football Ground S	0.15	0.34	0.21	0.41	0.19	0.41	0.29	40	0.7%	26.3	26.6	66.5%
Footpath S	0.18	0.35	0.33	0.20	0.25	0.35	0.25	40	0.6%	26.3	26.5	66.4%
Tennis/Cricket Groun	0.30	0.35	0.30	0.30	0.35	0.35	0.25	40	0.6%	26.3	26.5	66.4%
William Street	0.11	0.11	0.09	0.14	0.15	0.15	0.10	40	0.3%	26.3	26.4	66.0%
Football Ground W	0.10	0.09	0.09	0.13	0.14	0.14	0.10	40	0.2%	26.3	26.4	66.0%
Bold Venture Farm	0.11	0.09	0.11	0.15	0.15	0.15	0.10	40	0.3%	26.3	26.4	66.0%
Hawthorne Bank	0.09	0.06	0.10	0.12	0.11	0.12	0.08	40	0.2%	26.3	26.4	66.0%
Moorfield Industrial	0.12	0.12	0.10	0.11	0.09	0.12	0.09	40	0.2%	26.3	26.4	66.0%
Footpath N	0.32	0.37	0.31	0.29	0.23	0.37	0.26	40	0.7%	26.3	26.6	66.4%
Moorside House	0.10	0.12	0.09	0.09	0.08	0.12	0.08	40	0.2%	26.3	26.4	66.0%
Clough Bank Bridge & Altham Clough Wood (DAW)	0.34	0.24	0.24	0.23	0.26	0.34	0.23	40	0.6%	26.3	26.5	66.3%
Nearer Holker House	0.54	0.41	0.44	0.36	0.42	0.54	0.38	40	0.9%	26.3	26.7	66.7%
Oak Bank	0.76	0.60	0.74	0.52	0.58	0.76	0.54	40	1.3%	26.3	26.8	67.1%

NOx Hourly Mean (99.79th %ile)

Receptor Name	2015	2016	2017	2018	2019	PC	Conversion	EAL	PC %	Bkgrd	PEC	PEC%
Sankey House Farm	22.4	24.1	24.1	24.2	24.1	24.2	8.5	200	4.2%	52.6	61.1	30.5%
Caravan Park	23.3	21.5	23.9	22.2	23.9	23.9	8.4	200	4.2%	52.6	61.0	30.5%
Huntcoat Industrial	15.8	15.6	16.2	15.6	15.9	16.2	5.7	200	2.8%	52.6	58.3	29.1%
Brickworks S	27.8	27.3	26.7	27.5	27.1	27.8	9.7	200	4.9%	52.6	62.3	31.2%
Brickworks N	22.8	22.6	22.4	22.2	22.4	22.8	8.0	200	4.0%	52.6	60.6	30.3%
HWDC 1	47.7	42.8	41.1	41.4	43.7	47.7	16.7	200	8.4%	52.6	69.3	34.7%
Tunstall Drive	11.4	11.5	12.3	12.6	12.0	12.6	4.4	200	2.2%	52.6	57.0	28.5%
Playing Field S	15.5	22.0	19.6	21.5	20.8	22.0	7.7	200	3.9%	52.6	60.3	30.2%
Football Ground S	9.1	11.3	11.7	11.6	10.0	11.7	4.1	200	2.1%	52.6	56.7	28.4%
Footpath S	15.3	22.3	21.8	17.8	20.8	22.3	7.8	200	3.9%	52.6	60.4	30.2%
Tennis/Cricket Groun	11.4	11.9	12.2	11.9	11.9	12.2	4.3	200	2.1%	52.6	56.9	28.4%
William Street	5.1	5.2	4.8	5.4	5.3	5.4	1.9	200	0.9%	52.6	54.5	27.2%
Football Ground W	4.7	4.7	4.9	5.1	5.0	5.1	1.8	200	0.9%	52.6	54.4	27.2%
Bold Venture Farm	5.2	5.0	5.7	5.9	5.4	5.9	2.1	200	1.0%	52.6	54.7	27.3%
Hawthorne Bank	4.0	3.7	4.5	4.6	4.1	4.6	1.6	200	0.8%	52.6	54.2	27.1%
Moorfield Industrial	5.5	5.4	5.6	5.5	5.4	5.6	2.0	200	1.0%	52.6	54.6	27.3%
Footpath N	6.6	6.7	6.6	6.6	6.6	6.7	2.4	200	1.2%	52.6	55.0	27.5%
Moorside House	3.6	3.5	3.6	3.6	3.6	3.6	1.3	200	0.6%	52.6	53.9	26.9%
Clough Bank Bridge & Altham Clough Wood (DAW)	3.5	3.2	3.1	3.1	3.6	3.6	1.2	200	0.6%	52.6	53.8	26.9%
Nearer Holker House	5.2	5.3	5.1	5.0	5.2	5.3	1.9	200	0.9%	52.6	54.5	27.2%
Oak Bank	7.1	6.9	6.8	6.7	6.9	7.1	2.5	200	1.2%	52.6	55.1	27.5%

Scenario 1

SO2 - Annual Mean

Receptor Name	2015	2016	2017	2018	2019	PC	EAL	PC %	Bkgrd	PEC	PEC%
Clough Bank Bridge & Altham Clough Wood (DAW)	0.63	0.48	0.50	0.47	0.53	0.63	20	3.1%	4.2	4.8	24.1%

Scenario 2

SO2 - Annual Mean

Receptor Name	2015	2016	2017	2018	2019	PC	EAL	PC %	Bkgrd	PEC	PEC%
Clough Bank Bridge & Altham Clough Wood (DAW)	0.61	0.47	0.48	0.46	0.51	0.61	20	3.1%	4.2	4.8	24.1%

Scenario 3

SO2 - Annual Mean

Receptor Name	2015	2016	2017	2018	2019	PC	EAL	PC %	Bkgrd	PEC	PEC%
Clough Bank Bridge & Altham Clough Wood (DAW)	0.56	0.44	0.45	0.43	0.48	0.56	20	2.8%	4.2	4.8	23.8%

Scenario 4

SO2 - Annual Mean

Receptor Name	2015	2016	2017	2018	2019	PC	EAL	PC %	Bkgrd	PEC	PEC%
Clough Bank Bridge & Altham Clough Wood (DAW)	0.54	0.39	0.39	0.37	0.42	0.54	20	2.7%	4.2	4.7	23.7%

APPENDIX 5

Models Files (Electronic Format)