Environmental Visage

DETAILED AIR QUALITY ASSESSMENT FOR A PROPOSED WASTE TREATMENT AND TRANSFER FACILITY AT AN EXISTING SITE

GRUNDON WASTE MANAGEMENT LIMITED
ZINC ROAD, AVONMOUTH

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Executive Summary

Grundon Waste Management Limited (Grundon) proposes to redevelop an existing low Carbon energy facility located on Zinc Road in the Avonmouth industrial area. The facility previously processed refuse derived fuel, although is believed to have ceased operation in 2016. Grundon Waste Management Limited has now acquired the site and intends to replace key plant with an alternative, smaller scale waste treatment and transfer facility (the Facility).

The new scheme includes a high temperature treatment process and hence, detailed atmospheric dispersion modelling has been undertaken to consider the potential impact of the emissions to atmosphere from the Facility. Modelling has considered normal operating conditions at maximum output, discharging emissions to atmosphere via a 36.5-metre-high stack, as well as short-term, half-hourly releases. Emissions were based upon the achievable limits for new plant, as specified in the European BAT-Conclusions document.

The assessment began with an iterative modelling assessment in order to confirm the required height of the stack, followed by a detailed dispersion model. Dispersion modelling was undertaken using the ADMS computer model, Version 6 and incorporated local conditions such as meteorology, terrain and surface roughness factors, along with data to consider the effect of local wind turbines.

Modelling predicted that, under normal operating conditions the maximum annual average process contribution for NO_2 would be approximately 0.95 µg m^{-3}, equating to 2.4 % of the 40 µg m^{-3} annual objective value. The location of the maximum process contribution was predicted to be about 105 metres to the east of the stack serving the Facility, with values considerably lower farther afield.

Although a process contribution of more than 1 % cannot immediately be screened as insignificant, the application of a local background concentration results in a predicted environmental concentration equating to approximately 33 % of the air quality objective and, being less than 70 % of the assessment level, is not considered to have the potential to significantly impact air quality in the area. The process contributions and predicted environmental concentrations of all prescribed pollutants indicated that there would be no exceedance of their respective objective values or relevant assessment levels, and indeed, most were screened as insignificant during the assessment. For contributions that could not be screened as insignificant, detailed analysis confirmed that none would be considered to be significant based on the likely composition of pollutants, where the emission included a combination of species, and the resultant predicted environmental concentrations compared to the specific assessment levels.

Short-term process contributions and predicted environmental concentrations also remained within their stated environmental quality standards when discharging at the allowable half-hourly limit values and were therefore screened as insignificant, although the impact of short-term emissions of some pollutants did exceed 20 % of the short-term average assessment levels.

An assessment of the cumulative impact of emissions from the Grundon Facility with those from other local operations confirmed that, despite the variation in reported contributions across a wider modelled area, the impact of the cumulative emissions either screened as insignificant, or would be considered not to have any significant impact in the locality.

The overall conclusion from detailed modelling of emissions from the Facility on the Avonmouth industrial estate, is that the potential impact on local air quality is likely to be small and is unlikely to have a significant impact on the health of people living and working nearby, or on the surrounding environment as a whole.

Contents

Issue and Revision Record

Issue	Date	Author	Review / Authorise	Description
DRAFT	20/12/2021	A. Owen	ENVISAGE	Initial draft for Client comment
1	21/12/2021	A. Owen	ENVISAGE	Issue 1
2	22/12/2021	A. Owen	ENVISAGE	Issue 2 – Editorial amendment
3	16/05/2022	A. Owen	ENVISAGE	Issue 3 – Increased building height
4 DRAFT	23/10/2023	A. Owen	ENVISAGE	AQ Update for Permitting - DRAFT
4	09/11/2023	A. Owen	ENVISAGE	AQ Update for Permitting
5	27/03/2024	A. Owen	ENVISAGE	Incorporating additional EALs
6 DRAFT	09/04/2024	A. Owen	ENVISAGE	VOC as Benzene and rationalised metals - DRAFT
6	10/04/2024	A. Owen	ENVISAGE	VOC as Benzene and rationalised metals

1. Introduction

Environmental Visage Limited (Envisage) was commissioned by Grundon Waste Management Limited to prepare a detailed air quality assessment in support of an application to vary the Environmental Permit for their waste treatment and transfer facility located on Zinc Road, Avonmouth.

An Environmental Permit (EP) was granted by the Environment Agency (EA) to New Earth Energy (West) Operations Limited for the operation of the Avonmouth Energy Facility in January 2013. The EP includes for the operation of a Schedule 1, Section 5.1 (A1) (c) activity:

The incineration of non-hazardous waste in a pyrolysis and gasifier plant with a capacity of 1 tonne or more per hour.

The EP was subsequently transferred to Avonmouth Bio Power Limited in October 2015.

Whilst the gasification plant was constructed and commissioned, it did not operate as it was intended. The gasification plant was eventually mothballed by Avonmouth Bio Power Limited in 2016. Grundon Waste Management Limited (Grundon) subsequently acquired the site from Avonmouth Bio Power Limited in February 2021 and now intends to replace key plant with an alternative, smaller scale waste treatment and transfer facility.

Grundon has removed all of the gasification process equipment, including the waste feed and flue gas treatment systems. Grundon is currently installing a new waste incineration combustion technology, and associated waste and flue gas treatment systems to process a mix of non-hazardous, clinical and hazardous wastes which require high temperature incineration, herein referred to as the Facility.

Grundon is applying for a Variation to the EP to allow for the high temperature incineration of hazardous and non-hazardous wastes.

This dispersion modelling assessment considers the impact of emissions from the Facility, and compares these with the currently permitted process contributions as detailed in the original Permit application (May 2012). The assessment also considers the impact on the wider area, taking account of other, newly Permitted or varied waste processes, in an assessment of the cumulative impact with other operations.

The redevelopment of the site requires some modification to the existing building layout, especially the roof height in some areas. The existing stack will remain, although will be extended in order to continue to provide effective dispersion of the flue-gas discharges, accounting for the changes in the building layout. This report considers the stack height requirements as a result of the changes proposed.

The objective of the modelling exercise was to assess the potential impact of the process emissions from the Facility on local air quality, in terms of ground level concentrations of pollutants designated by air quality standard objective values and other relevant environmental assessment levels recommended by the Environment Agency. Modelling was based upon emissions and process data, and site drawings supplied by GP Planning Limited, planning advisors to Grundon, and Fichtner Consulting Engineers Limited prepared the Environmental Permit application.

This report describes the data used, the methodology adopted, assumptions made, and the results generated by the model.

1.1 ADMS Model

The main modelling software used was ADMS Version 6, one of a range of atmospheric dispersion models available for assessing the impact on local air quality of pollutant emissions to atmosphere. The ADMS model uses two parameters to describe the atmospheric boundary layer, namely the boundary layer height (*h*) and the Monin-Obukhov Length (L_{MO}), and a skewed Gaussian concentration distribution to calculate dispersion under convective conditions. Models used routinely in the UK for this sort of application include United States Environmental Protection Agency (US-EPA) models such as AERMOD, and the ADMS models developed in the UK by Cambridge Environmental Research Consultants (CERC)[1].

The ADMS model can be used to assess ambient pollutant concentrations arising from 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 averages) or longer term (monthly, quarterly or annual averages).

1.2 Modelling Uncertainty

Atmospheric dispersion modelling is not a precise science and results can be impacted by a variety of factors such as:

- Model uncertainty - due to limitations in the dispersion algorithms incorporated into the model and their ability to replicate “real-life” situations;
- Data uncertainty - due to potential errors associated with emission estimates, discharge characteristics, land use characteristics and the relevance of the meteorological data to a particular location; and
- Variability - randomness of measurements used.

CERC models are continually validated against available measured data obtained from real world situations, field campaigns and wind tunnel experiments. Validation of the ADMS dispersion models has been performed using many experimental datasets that test different aspects of the models, for instance: ground / high level sources, passive and buoyant releases, buildings, complex terrain, chemistry, deposition and plume visibility. These studies are both short-term as well as annual, and involve tracer gases or specific pollutants of interest.

Potential uncertainties in model results derived from the current study have been minimised as far as practicable, and a series of worst-case assumptions have been applied to the input data in order to provide a robust assessment. This included the following:

- Selection of the dispersion model - ADMS 6 is a commonly used atmospheric dispersion model and results have been verified through a number of inter-comparison studies to ensure that model predictions are as accurate as possible;
- Meteorological data - Modelling was undertaken using hourly average meteorological data from the nearby Bristol Airport measurement station which is considered to be the most representative of local conditions;
- Plant operating conditions – Data on the likely discharge conditions from the installation were provided by Fichtner Consulting Engineers Limited, who prepared the Environmental Permit application on behalf of Grundon. As the Facility is not yet operational, all of the information provided regarding the discharge conditions is naturally theoretical;
- Receptor locations - A 5 km x 5 km Cartesian Grid (20-metre grid spacing) was utilised in the model in order to calculate maximum predicted concentrations in the vicinity of the Facility. Specific receptor locations were also included in the model to provide detailed assessment at these sensitive locations; and,
- Variability - All model inputs are as accurate as possible and worst-case conditions were considered as necessary in order to ensure a robust assessment of potential pollutant concentrations.

The application of the above measures to reduce uncertainty and the use of a series of worst-case assumptions relating to the operational performance of the process should result in model accuracy of an acceptable level.

1.3 Air Quality Standards and Environmental Assessment Levels

In the UK, limit values, targets, and air quality standards (AQS) and objectives for major pollutants are described in The Air Quality Strategy. In addition, the Environment Agency provide environmental assessment levels (EALs) for other pollutants. The results of the modelling were considered in the context of these limits, targets, objectives and assessment levels, as summarised in Table 1 over page.

Table 1 Air Quality Standards and Environmental Assessment Levels

Substance	Assessment Level	Averaging time	Specific Receptors	Regulatory Source
Nitrogen Dioxide	200 µg m^{-3} with up to 18 exceedances (99.79th %)	1 hour mean	Human health / AQ	AQ and AQS Regulations (L)
Nitrogen Dioxide	40 µg m^{-3}	Annual mean	Human health / AQ	AQ and AQS Regulations (L)
Oxides of Nitrogen (expressed as Nitrogen Dioxide)	75 µg m^{-3}	Daily mean	Conservation / Habitats	Critical Level
Oxides of Nitrogen (expressed as Nitrogen Dioxide)	30 µg m^{-3}	Annual mean	Conservation / Habitats	Critical Level
Sulphur Dioxide	266 µg m^{-3} with up to 35 exceedances (99.9th %)	15 minute mean	Human health / AQ	AQ Regulations (O)
Sulphur Dioxide	350 µg m^{-3} with up to 24 exceedances (99.73rd %)	1 hour mean	Human health / AQ	AQ Regulations (L)
Sulphur Dioxide	125 µg m^{-3} with up to 3 exceedances (99.18th %)	24 hour mean	Human health / AQ	AQ Regulations (L)
Sulphur Dioxide	10 µg m^{-3} where lichens or bryophytes are present, 20 micrograms per cubic metre where they're not	Annual mean	Conservation / Habitats	Critical Level
Ammonia	2,500 µg m^{-3}	1 hour mean	Human health / AQ	EAL
Ammonia	180 µg m^{-3}	Annual mean	Human health / AQ	EAL
Ammonia	1 µg m^{-3} where lichens or bryophytes (including mosses, liverworts and hornworts) are present, 3 micrograms per cubic metre where they're not	Annual mean	Conservation / Habitats	Critical Level
Hydrogen Chloride	750 µg m^{-3}	1 hour mean	Human health / AQ	EAL
Hydrogen Fluoride	160 µg m^{-3}	1 hour mean	Human health / AQ	EAL
Hydrogen Fluoride	16 µg m^{-3}	Monthly mean	Human health / AQ	EAL
Hydrogen Fluoride	0.5 µg m^{-3}	Weekly mean	Conservation / Habitats	Critical Level
Hydrogen Fluoride	5 µg m^{-3}	Daily mean	Conservation / Habitats	Critical Level
Particulates (PM_{10})	50 µg m^{-3} with up to 35 exceedances (90.41st %)	24 hour mean	Human health / AQ	AQ and AQS Regulations (L)
Particulates (PM_{10})	40 µg m^{-3}	Annual mean	Human health / AQ	AQ and AQS Regulations (L)
Particulates ($PM_{2.5}$)	20 µg m^{-3}	Annual	Human health / AQ	AQS Regulations (L)
Particulates ($PM_{2.5}$)	10 µg m^{-3}	Annual from 2040	Human health / AQ	Env. Target 2040

Substance	Assessment Level	Averaging time	Specific Receptors	Regulatory Source
1,3-Butadiene	2.25 µg m^{-3}	Running annual mean	Human health / AQ	AQ Regulations (O)
1,3-Butadiene	2.25 µg m^{-3}	24 hour mean	Human health / AQ	EAL
Benzene	5 µg m^{-3}	Annual mean	Human health / AQ	AQ Regulations (L)
Benzene	30 µg m^{-3}	24 hour mean	Human health / AQ	EAL
Carbon Monoxide	10 mg m^{-3}	Max. 8 hour running mean in any daily period	Human health / AQ	AQ Regulations (L)
Cadmium	5 ng m^{-3}	Annual mean	Human health / AQ	AQS Regulations (T)
Cadmium	30 ng m^{-3}	24 hour mean	Human health / AQ	EAL
Mercury and compounds	0.6 µg m^{-3}	1 hour mean	Human health / AQ	EAL
Mercury and compounds	0.06 µg m^{-3}	24 hour mean	Human health / AQ	EAL
Lead	0.5 µg m^{-3}	Annual mean	Human health / AQ	AQ and AQS Regulations (L)
Lead	0.25 µg m^{-3}	Annual mean	Human health / AQ	AQ Regulations (O)
Arsenic	6 ng m^{-3}	Annual mean	Human health / AQ	AQS Regulations (T)
Antimony and compounds	150 µg m^{-3}	1 hour mean	Human health / AQ	EAL
Antimony and compounds	5 µg m^{-3}	Annual mean	Human health / AQ	EAL
Chromium (III) and Chromium (III) compounds	2 µg m^{-3}	24 hour mean	Human health / AQ	EAL
Chromium VI	0.00025 µg m^{-3}	Annual mean	Human health / AQ	EAL
Copper and its compounds	0.05 µg m^{-3}	24 hour mean	Human health / AQ	EAL
Manganese and compounds	1,500 µg m^{-3}	1 hour mean	Human health / AQ	EAL
Manganese and compounds	0.15 µg m^{-3}	Annual mean	Human health / AQ	EAL
Nickel and its compounds	0.7 µg m^{-3}	1 hour mean	Human health / AQ	EAL
Nickel	0.02 µg m^{-3}	Annual mean	Human health / AQ	AQS Regulations (T)
Vanadium	1 µg m^{-3}	24 hour mean	Human health / AQ	EAL
Polyaromatic Hydrocarbons (benzo(a)pyrene)	1 ng m^{-3}	Annual mean	Human health / AQ	AQS Regulations (T)
Polyaromatic Hydrocarbons (benzo(a)pyrene)	0.25 ng m^{-3}	Annual mean	Human health / AQ	AQS Regulations (O)
Polychlorinated Biphenyls (PCBs)	6 µg m^{-3}	1 hour mean	Human health / AQ	EAL
Polychlorinated Biphenyls (PCBs)	0.2 µg m^{-3}	Annual mean	Human health / AQ	EAL

Key to Table 1:

AQ Regulations	Air Quality (England) Regulations 2000 (as amended)[2]
AQS Regulations	Air Quality Standards Regulations 2010 Limit or Target Values and UK Air Quality Strategy Objectives[3]
Critical Level	Not habitat specific but cover broad vegetation types
EAL	Environmental Assessment Levels[4]
Env. Target 2040	The Environmental Targets (Fine Particulate Matter) (England) Regulations 2023[5]
(L)	Limit Value
(O)	Objective Value
(T)	Target Value

Note: Although assessment levels are available for various species of volatile organic compounds, including 1,3-Butadiene, Environment Agency guidance[4] states that if the individual composition of substances within the total VOC release is not known, the unknown species should be treated as Benzene in the risk assessment.

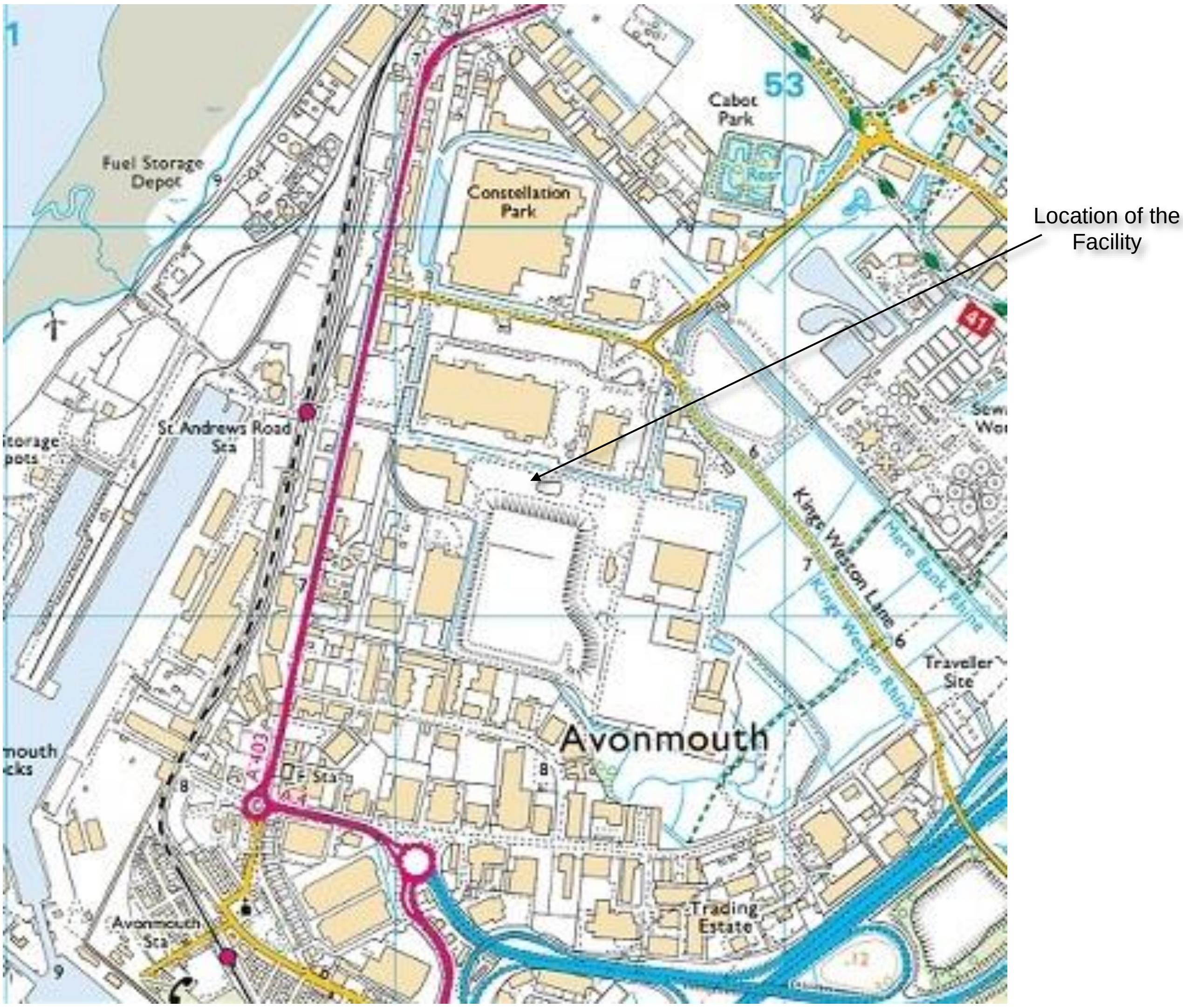
2. Modelling Input Data

2.1 The Facility

A description of the site and the proposed combustion technology is presented in the Supporting Information within the Application Pack.

Figure 1 below shows the local setting of the Facility.

Figure 1 The Local Setting of the Facility



Ordnance Survey on behalf of the Controller of His Majesty's Stationary Office, © Crown Copyright 100055158 (2024) Environmental Visage Limited

2.2 Emissions Data

The operation of the Facility will be regulated by the Environment Agency in line with the conditions of an Environmental Permit that will need to be varied prior to the commissioning or operation of the plant. The process will be regulated under the Environmental Permitting (England and Wales) Regulations 2016 (as amended) and will be operated in accordance with conditions for waste incineration plant as defined by the Industrial Emissions Directive (IED).

Details of the release characteristics to be considered have their base in the maximum allowable emission limits which will likely be imposed on the site operations. The IED is supported by Best Available Techniques Reference notes (BREFs) and BAT-Conclusions documents, and these specify the allowable emission limits from each regulated process. The Waste Incineration BREF Note[6] and BAT-Conclusions documents[7] specify more stringent emission limits than those originally detailed in the IED, and Grundon is committed to employing best available techniques at the site and meeting the relevant emission limits specified. As such, this air quality assessment has been undertaken considering the relevant emission limit values (ELVs) specified for new plant.

The modelled source and emissions data applied to the model are summarised in Tables 2 and 3 respectively. The data apply to the single waste incineration line and its dedicated stack.

Table 2 Emission Source Parameters

Parameter	Value
Stack Height (m)	36.5
Stack Diameter (m)	1.2
Efflux Temperature (° C)	130
Oxygen Content (% dry)	13.28
Moisture Content (%)	13.61
Flue-gas Volumetric Flowrate (Am^3/s)	21.21
Flue-gas Volumetric Flowrate (Nm^3/s)	9.62
Efflux Velocity ($m\ s^{-1}$)	18.76
Location (x, y)	352338, 179323

Table 3 Modelled Emissions Data

Substance	Emission Limit Value ($mg\ Nm^{-3}$)	Maximum Long-Term Mass Emission Rate ($g\ s^{-1}$)
Nitrogen Oxides (as NO_2)	120	1.15
Sulphur Dioxide	30	0.288
Carbon Monoxide	50	0.480
Particulates (PM_{10})	5	0.048
VOCs	10	0.096
HCl	6	0.0577
HF	1	0.0096
Cadmium / Thallium	0.02	0.00019
Mercury	0.02	0.00019
Other Metals – Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V	0.3	0.00288
Ammonia	10	0.096
Dioxins and Furans	4×10^{-08}	3.84×10^{-10}
Dioxins, Furans and PCBs	6×10^{-08}	5.76×10^{-10}
PAH (as B[a]P only)	0.001	9.6×10^{-06}

Although no limit is specified for PAH within the IED, or the BREF Note[6] or BAT-Conclusions[7] documents which support it, the BREF does suggest an achievable range of PAH emission from incineration plant of 0.00000001 - 0.05 mg m^{-3} as total PAH or 0.000000004 - 0.001 mg m^{-3} as B[a]P. The upper end of this latter range was applied in the modelling, and results are compared with the air quality objective value of 0.25 ng m^{-3} B[a]P.

The pollutant emission rates calculated for the initial modelling exercise represent a worst-case scenario under normal operating conditions with emissions throughout the year at the maximum levels that are expected to be included as conditions in the Environmental Permit for the process.

2.3 Atmospheric Chemistry

Emissions of NO_x will comprise contributions of Nitric Oxide (NO) and Nitrogen Dioxide (NO_2). Air quality assessments are made against the concentration of NO_2, although assessments for the impact on vegetation are made against the concentrations of NO_x as NO_2. As emissions of NO_2 are only ever a proportion of the total emissions of NO_x, an allowance for the quantity of NO_2 in NO_x has to be made. The following procedure recommended by the Environment Agency was used to calculate annual average and hourly average NO_2 ground-level concentrations from the reported annual average NO_x concentrations:

Emissions of Oxides of Nitrogen should be recorded as Nitrogen Dioxide because Nitrogen Oxide converts to Nitrogen Dioxide over time:

- For short-term process contributions (PC) and predicted environmental concentrations (PEC), assume only 50 % of emissions of Oxides of Nitrogen convert to Nitrogen Dioxide in the environment;
- For long-term PCs and PECs, assume all Oxides of Nitrogen convert to Nitrogen Dioxide.

Further guidance[8] from the Air Quality Monitoring and Assessment Unit regarding the preparation of dispersion models for Environmental Permitting specifically, goes on to clarify that:

For combustion processes where no more than 10 % of Nitrogen Oxides are emitted as Nitrogen Dioxide, you can assume worst case conversion ratios to Nitrogen Dioxide of:

- 35 % for short-term average concentrations
- 70 % for long-term average concentrations

This assessment will follow a step-wise approach to the modelling of Nitrogen Dioxide.

Predicted environmental concentrations for NO_2 are calculated using the following formulae:

Equation 1 Calculation of Annual Average NO_2 PEC:
= (Annual NO_x Modelled x 0.7) + Annual NO_2 Monitored

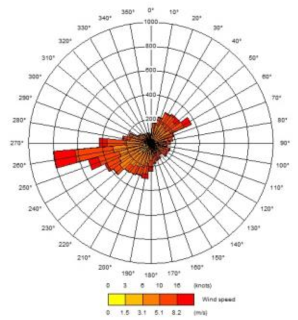
Equation 2 Calculation of Hourly Average NO_2 PEC:
= (Hourly NO_x Modelled x 0.35) + (Annual NO_2 Monitored x 2)

Despite the recognition that only a portion of the discharge comprises NO_2, this method may still overestimate concentrations of NO_2 in close proximity to the site as the conversion of NO_x to NO_2 is unlikely to be instantaneous, requiring the mixing of the plume with ambient air and its associated oxidant species such as Ozone (O_3) etc.

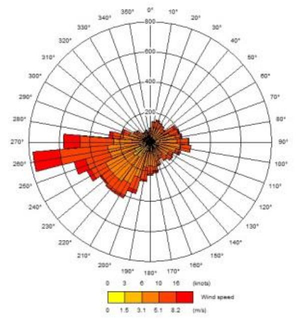
2.4 Meteorological Data

Hourly averaged meteorological data from the Bristol Airport measurement station, located approximately 14.5 km to the south of the Avonmouth development site was applied to the models. Five years' of data for 2018 to 2022 were used in the detailed modelling assessment and the wind roses from the data applied are shown in Figure 2.

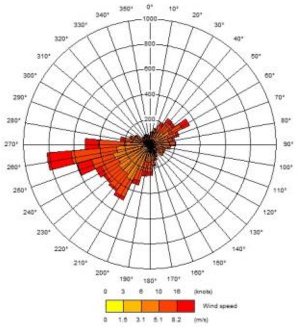
Figure 2 Wind Roses for the Bristol Airport Measurement Station



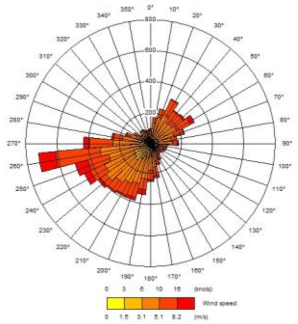
2018 Wind Rose



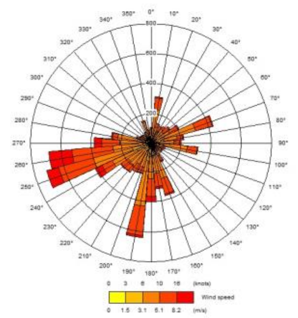
2019 Wind Rose



2020 Wind Rose



2021 Wind Rose



2022 Wind Rose

All meteorological data used in the assessment were provided by Atmospheric Dispersion Modelling (ADM) Limited, which is an accredited distributor of meteorological data within the UK. The data indicate the prevailing wind bring from the west, and the south-west quadrant, and the application of multiple years' of data enables the effects of inter-annual variations to be taken into account.

The meteorological data included within the model incorporated the nine parameters defined below:

Parameter	**Description**
YEAR	Year of observation
TDAY	Julian Day (1 to 366) of observation
THOUR	Hour of Observation
T0C	Temperature (º C)
U	Wind speed (m s^{-1})
PHI	Wind Direction (nearest 10 degrees)
P	Precipitation (mm)
CL	Cloud cover (Oktas)
RHUM	Relative Humidity (%)

2.5 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

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, woodland, etc.). Agricultural areas may have a surface roughness of approximately 0.2m to 0.3m whereas large cities and woodlands may have a roughness of 1 to 1.5m.

Land use in the immediate vicinity of the development site is predominantly industrial and commercial, with some open areas of scrubland. However, the additional presence of other features such as the Severn Estuary to the west, prompted the use of a spatially variable surface roughness file to accurately detail the surface roughness across the modelled grid. Where it was not appropriate to apply the variable roughness file to model runs, such as when considering more distant receptors, a surface roughness factor of 1 metre was considered appropriate to provide a generic description of the built-up, industrial nature of the dispersion site. This roughness describes cities and woodland areas generally.

Additionally, a surface roughness of 0.3 m which is relevant for describing areas akin to agricultural areas, including fields, trees, buildings and infrastructure was applied to describe the area at the Bristol Airport meteorological monitoring location.

Sensitivity of Surface Roughness

Although considered wholly appropriate to include a spatially variable surface roughness file to accurately describe the roughness across the modelled area, a sensitivity analysis was prepared to consider the effect of applying different surface roughness factors to the meteorological monitoring site.

Test models were run which considered two alternative surface roughness factors for the monitoring site at Bristol airport, 0.2 m which is representative of open fields within agricultural areas, and 0.5 which is representative of parkland or open suburbia. The impact of varying the surface roughness factors is detailed below.

NO_x as NO_2	**SR = 0.2**	**SR = 0.3**	**SR = 0.5**
Maximum Annual Average (NO_2 = 100 % NO_x)	1.24	1.35	1.54
Maximum Hourly Average (NO_2 = 50 % NO_x)	19.90	19.82	20.56

When considering the relevant averaging periods for process contributions of Oxides of Nitrogen (NO_x), the impact of varying the surface roughness factor at the meteorological monitoring site was found to be limited, although it is noted that this was not the case for the 100th percentile (maximum hourly average) figures, which appeared to be negatively affected by the 0.3 m surface roughness.

However, on the basis of the assessment of the averaging periods for NO_x as NO_2, the demonstrated similarity of the relevant results despite the variable surface roughness figures, and the more appropriate description of the surface roughness in the locale of the airport as agricultural land, a meteorological site surface roughness factor of 0.3 m was applied. Further consideration of any negative impact identified over very short averaging periods is provided in the detailed results and discussion section of this report.

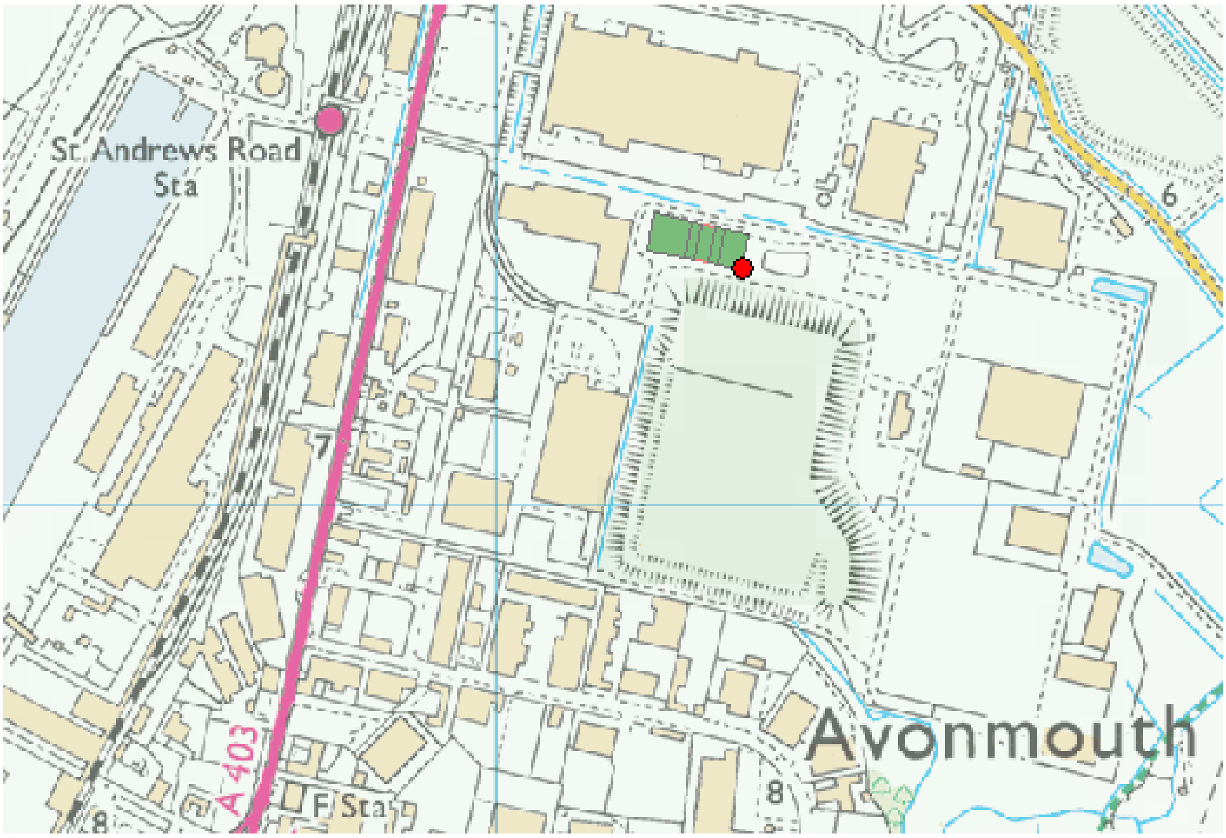
Nearby Buildings and Structures

The proximity of solid structures, such as buildings, to an emission source can affect the dispersion of a plume emitted from an adjacent stack, particularly in the vicinity of that structure. The effects of this were included into the model based on the data presented in Table 4, and graphically in Figure 3.

Table 4 Modelled Building Data

Building	Height (m)	Length (m)	Width (m)	Angle (Degrees)
Elevated Roof Line	28.378	19.80	50.96	102
Lower Roof Line 1	14.01	33.00	50.96	102
Lower Roof Line 2	20.00	13.20	50.96	102
Lower Roof Line 3	20.00	13.20	50.96	102
Lower Roof Line 4	14.01	52.80	50.96	102

Figure 3 Site Layout as Modelled



Sensitivity of Building Inputs

Although considered wholly appropriate to include the site buildings such that any down-wash effects would be appropriately modelled, a sensitivity analysis was prepared to determine the impact of modelling without the site buildings included. The impact of removing the buildings from the model is detailed below.

NO_x as NO_2	Buildings Included	No Buildings
Maximum Annual Average (NO_2 = 100 % NO_x)	1.35	0.73
Maximum Hourly Average (NO_2 = 50 % NO_x)	19.82	6.22

As would be expected, removing the detail of the buildings from the assessment, thereby naturally removing the potential for any negative effects of building down-wash, is beneficial to the dispersion of the plume and thereby results in lower process contributions. However, the site does include some relatively significant structures and in order to present the most comprehensive and conservative case the model should include these. Data on the site buildings were therefore included in each of the detailed modelling runs.

Wind Turbines

There are a number of wind turbines in the local area, with one located at the Accolade Wines warehousing and distribution centre and four at the Wessex Water Avonmouth Wastewater Treatment Works.

The Accolade Wines turbine is understood to be a Vensys 121 2.5 MW capacity turbine, with a hub height of 85 m and a rotor diameter of 82.3 m, giving a total turbine height of 126.15 m.

The four turbines located around the Avonmouth Wastewater Treatment Works are understood to be Senvion (REpower) MM92 turbines, each with a hub height of 80 m and a rotor diameter of 92.5 m, giving a total turbine height of 126.25 m.

The disturbance of air flow caused by a wind turbine can significantly impact the dispersion of emissions from process plant and as such, the ADMS model has the capability to model the effects of wind turbines on dispersion. The model calculates changes in the flow field due to the rotation of a wind turbine, and then calculates how this modified flow field affects dispersion of emissions from nearby sources. An "Additional Input" *"AAI"* wind turbine data file was therefore created for inclusion within the model, specifying the location of each of the turbines and the wind velocity / thrust coefficient data for the two different models.

Due to the location of the turbines in the immediate vicinity of the Grundon Facility, wind turbine data was included as a standard feature in each of the model runs and scenarios, as the presence of the turbines could be expected to generally impact on the process discharges.

The new 150-metre high Lawrence Western wind-turbine located to the north, north east of the Facility has not been modelled as it is located more than 2.5 km distant from the site.

Local Terrain

Local terrain can affect wind flow patterns and, consequently, can affect the dispersion of atmospheric pollutants. The effects of terrain are not normally noticeable where the gradient is less than 10 % (otherwise described as a 1:10 slope). Ordnance Survey mapping for the area generally shows the absence of significant terrain in the vicinity of the Facility although the land immediately to the south of the site is elevated. The gradient has not been measured accurately but is estimated to be approximately 40 % (a 1:2.5 slope).

As such, an initial sensitivity check was run to confirm the effects of incorporating terrain data into the modelling exercise.

Sensitivity of Local Terrain

Although considered wholly appropriate to include detailed information on the local terrain in order that the effects of the raised bank would be incorporated into the model, a sensitivity analysis was prepared to determine the impact of modelling without terrain effects included. The impact of modelling without any information on the local terrain is detailed below.

NO_x as NO_2	**Terrain Included**	**No Terrain**
Maximum Annual Average (NO_2 = 100 % NO_x)	1.35	1.40
Maximum Hourly Average (NO_2 = 50 % NO_x)	19.82	17.91

A slight difference was reported when modelling with and without the terrain data, with longer-term process contributions being marginally higher without terrain data, whilst shorter-term process concentrations were slightly lower. As such, the inclusion of terrain was confirmed as influencing the modelling results and hence, a spatially variable terrain file was included within the assessment in order to ensure the most accurate representation of local conditions.

Coastal Effects

The effect of a coastline on the dispersion of emissions will generally only be significant for discharges from elevated point sources that are within a few kilometres (up to a maximum of 5 km) of the coast. ADMS 6 has the ability to model the effects of a coastline, although additional data such as terrain and surface roughness files, and information on local buildings and other infrastructure such as wind turbines cannot be modelled at the same time.

The coastline module is only invoked when:

- The wind is blowing onshore (from the sea to the land);
- The land is warmer than the sea;
- The meteorological conditions over the land are unstable (convective).

When the coastline option is selected, the model checks these conditions automatically for each line of meteorological data used in the calculation. If the conditions are not satisfied, then the coastline module is disabled for that meteorological data line.

Due to the location of the Facility within the Avonmouth industrial area which is situated on the bank of the Severn Estuary, a sensitivity check was run, when preparing the model for planning purposes in December 2021, to assess the impact of coastal influences on the modelling results.

Monthly measured sea surface temperature data from 2020 were included within the 2020 meteorological conditions and, although the results suggested a slight increase in the annual average process contributions at the maximum point of impact across the modelled grid, the resultant short-term contributions were significantly lower than the models which accounted for terrain and surface roughness variations, the presence of local buildings and wind turbines. As such, the coastline module was not applied to the models in order to ensure a more comprehensive assessment of the local conditions.

Output Grid

When setting up a receptor grid it is important to ensure that there are sufficient receptor points to be able to accurately 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. Modelling of the Facility was undertaken using a 5 km x 5 km grid with 20-metre grid spacing.

It is important to note that, although the modelled grids applied when considering the Grundon site in isolation and when modelled cumulatively with other local developments both considered 5 km x 5 km areas with 20 m grid spacing, the gridded areas were different in order to incorporate all of the sources being considered. As such, the reported results of the Grundon only and the cumulative assessments are not directly comparable because the location of the gridded results vary.

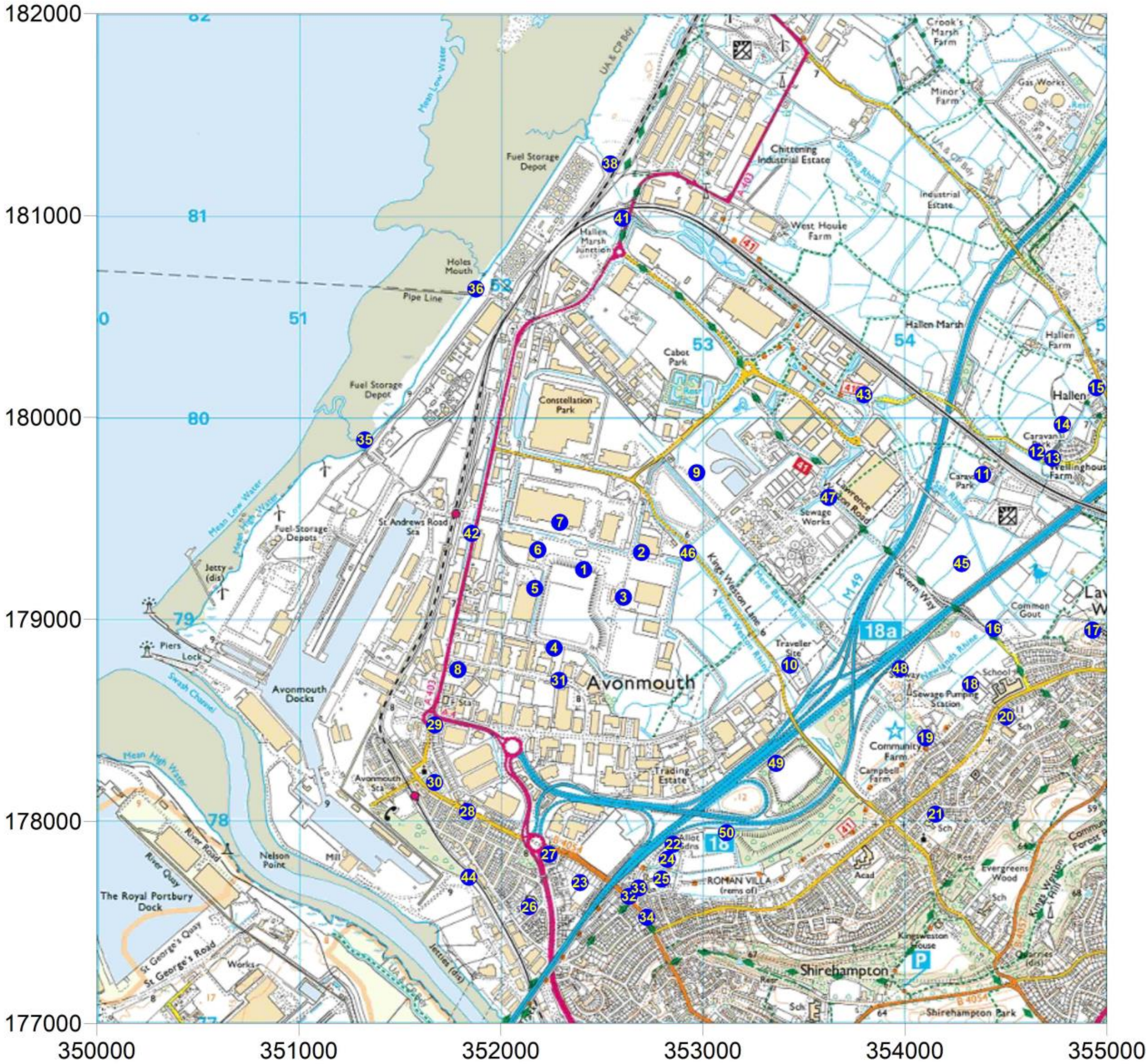
Thirty specific receptors, representing nearby residential properties or locations where people may congregate for significant periods of time, were entered into the model, as were four key air quality sites. Additionally, sixteen sensitive ecological receptors were modelled, and these represent nationally designated sites within 2 km of the Facility, or areas of the national site network (previously known as European designated sites) within 10 km of the site. Details of the sensitive receptor locations are presented in the following table.

Table 5 Specific Receptors Included in Detailed Modelling

Number	X	Y	Distance from Site (m)	Receptor Name
1	352410	179247	105	Open Space off Zinc Road
2	352696	179332	358	Business to the East
3	352607	179110	343	Business to the South-East
4	352264	178859	470	Business to the South
5	352168	179154	240	Business to the South-West
6	352183	179345	157	Business to the West
7	352292	179481	165	Business to the North-West
8	351787	178752	794	Business to South-West
9	352969	179727	749	The Mere Bank / Avonmouth Sewage Works and Hoar Gout
10	353431	178774	1,223	Kings Weston Lane Travellers Site
11	354385	179719	2,085	Properties by Tim Blakemore Racing
12	354653	179830	2,370	All Weather Pitch Hallen
13	354731	179798	2,440	Hi-Ways Park
14	354779	179966	2,524	Hallen A.F.C.
15	354948	180147	2,737	Hallen (North)
16	354439	178955	2,133	Atwood Drive Allotments
17	354929	178947	2,618	Oasis Academy
18	354325	178679	2,089	St. Bedes College
19	354102	178414	1,984	Lawrence Weston Community Farm
20	354502	178518	2,309	Bristol Gateway School
21	354152	178036	2,224	Our Lady of the Rosary Schools
22	352852	177887	1,525	Avonmouth Old Boys Rugby Football Club
23	352391	177697	1,627	Avonmouth (Youth) Football Club
24	352823	177813	1,586	Barracks Lane Allotments
25	352795	177715	1,672	Nova Primary School
26	352140	177577	1,757	Avonmouth CEVC Primary School
27	352237	177837	1,489	Avonmouth 1
28	351834	178049	1,370	Avonmouth 2
29	351672	178478	1,076	Avonmouth 3
30	351672	178193	1,312	Avonmouth Park
31	352287	178698	627	Third Way (AQA) DT 16
32	352634	177629	1,720	12 Avonmouth Road DT 489 – no longer monitored
33	352683	177670	1,689	Avon School DT 490 – no longer monitored
34	352722	177525	1,839	76 Avonmouth Road DT 491 – no longer monitored
35	351326	179889	1,160	Severn Estuary 1
36	351876	180637	1,393	Severn Estuary 2
37	352057	176967	2,373	Severn Estuary 3
38	352541	181256	1,944	Severn Estuary 4
39	354806	175634	4,438	Avon Gorge Woodlands 1
40	356441	172900	7,622	Avon Gorge Woodlands 2
41	352601	180987	1,685	Hallen Marsh Junction
42	351855	179426	494	St Andrews Road Rhine
43	353797	180113	1,659	Salt Rhine and Moorhouse Rhine
44	351841	177724	1,674	Gloucester Road Railway Siding
45	354280	179277	1,943	Fields along the M5
46	352926	179329	588	Kings Weston Lane Rhine
47	353622	179604	1,314	Lawrence Weston Road Rhines
48	353976	178757	1,733	Long Cross Tip
49	353362	178288	1,456	Lawrence Weston Bowl
50	353116	177944	1,583	Barracks Lane Rhine Complex

Receptor number 9 represents an area considered for potential impacts on both human health and ecology.

Figure 4 Receptor Locations



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Background Air Quality

Estimates of background concentrations for NO_x, NO_2, PM_{10} and $PM_{2.5}$ are provided on the UK-AIR[9] website hosted by DEFRA at a resolution of 1 km x 1 km grid spacing. The development site is located within an area under the jurisdiction of Bristol City Council, and data were obtained for 2024 for the locality around the Facility, representing the earliest date of the revised operations. The data show that future estimates of background concentrations for the pollutants included within the model and without any process contribution from the Facility, are well below their respective air quality standards.

Data in the four grid squares immediately surrounding the site were considered and, being similar in their reported concentrations, were averaged to provide an assessment of background air quality in the area around the site. Concentrations at the nearest point down-wind of the Facility (352500, 179500) were also considered. However, as these were consistently below the averaged values, the latter was used to describe the background concentrations.

Table 6 Background Air Quality Data in the Vicinity of the Facility (2024)

Pollutant	Annual Average Concentration (µg m^{-3})
Nitrogen Dioxide (NO_2)	12.326
Oxides of Nitrogen (NO_x)	16.603
Particulate Matter as PM_{10}	13.293
Particulate Matter as $PM_{2.5}$	8.076
Sulphur Dioxide (SO_2 – 2001 data)	6.480
Carbon Monoxide (CO) mg m^{-3}	0.131
Benzene (for VOC)	0.218
Average of concentrations from 351500,178500; 352500,179500; 351500,178500; and 352500,179500	

Bristol City Council has declared an Air Quality Management Area (AQMA) which covers the city centre and parts of the main radial roads including the M32, for long and short-term NO_2 levels and 24-hourly levels of PM_{10}. The AQMA is not local to the Facility. However, the Council does undertake air quality monitoring across the wider area in connection with its Local Air Quality Management obligations and annual data from nearby NO_2 diffusion tube monitoring locations for 2015 to 2021 (where available) showed the following trends in annual average NO_2 concentrations[10].

Table 7 Annual Average NO_2 Concentrations at Nearby Diffusion Tube Monitoring Locations (µg m^{-3})

	2015	2016	2017	2018	2019	2020	2021
DT 16	35.9	35.7	35.2	32.6	28.6	23.2	24.9
DT 489	36.9	38.6	37.7	35.5	28.6	22.8	No longer monitored
DT 490	31.9	32.4	31.0	26.8	22.4	18.6	No longer monitored
DT 491	33.8	36.5	34.4	33.5	27.3	22.0	No longer monitored

Although the background levels measured are seen to be elevated and representative of the urban environment that they are located in, levels are seen to generally be reducing over time at each of the diffusion tube monitoring locations detailed. Located within the modelled grid, the above diffusion tube monitoring locations were included as specific receptors in the model and, in order to discount any impact of Covid lockdown periods, the measured 2019 data was applied at these locations where required by the assessment.

Background levels for other pollutants were obtained from the most appropriate national monitoring network location as required to inform the assessment as follows:

Table 8 Air Quality Data from National Monitoring Network Sites (Maximum Reported Annual Concentration 2019 – 2022)

Pollutant	Annual Average Concentration (µg m^{-3})	Source and Date of Background Data
Antimony	No data	
Arsenic	0.00076	Chilbolton Observatory 2020
Cadmium	0.00013	
Chromium	0.00096	Chilbolton Observatory 2019
Cobalt	0.000048	Chilbolton Observatory 2022
Copper	0.0035	Chilbolton Observatory 2020
Lead	0.0036	Chilbolton Observatory 2019
Mercury (gaseous)	0.0015	Chilbolton Observatory 2022
Manganese	0.003	
Nickel	0.00081	
Vanadium	0.00086	Chilbolton Observatory 2021
Ammonia	2.955	Chilbolton Observatory 2019
Polycyclic Aromatic Hydrocarbons (as Benzo[a]Pyrene)	0.5	Bristol St. Pauls 2019
	0.1	Interactive mapping for Avonmouth 2019 – 2021 https://uk-air.defra.gov.uk/data/gis-mapping/
Polycyclic Biphenyls	0.0000434	Urban Average 2018 (London and Manchester Sites)
Dioxins and Furans	1.675×10^{-08}	Urban Average 2016 (London and Manchester Sites)
Hydrogen Chloride	0.41	EPAQS Guidelines for Halogens and Hydrogen Halides in Ambient Air for Protecting Human Health against Acute Irritancy Effects 2006
Hydrogen Fluoride	2.35	

2.6 Model Default Values Applied

The following values were retained as the default inputs defined by the model, in the absence of any site-specific data for the site location or the meteorological measurement station:

Surface Albedo; 0.23 representing an area of non-snow covered land.

Priestley-Taylor Parameter; 1 representing moist grassland.

Minimum Monin-Obukhov Length; 1 m.

3. Stack Height Assessment

Prior to the submission of the planning application for the redevelopment of the site, a stack height assessment was undertaken using both the D1 calculation procedure and iterative modelling of the reducing process contributions with increasing stack height using the ADMS model.

Since the original stack height assessment was undertaken, changes have been incorporated into the design of the redevelopment and the heights of the site buildings have changed. This includes an increase in the highest building from 20 m to approximately 28.4 m. As such, a revised assessment of the appropriate stack height for the high temperature treatment process within the Facility is provided here. The D1 calculation has not been repeated, however iterative dispersion modelling has been undertaken with a range of stack heights for the Facility from 31.5 m to 40.5 m applying all 5-years of meteorological conditions.

The input data for the modelling assumed a unitised mass release of 1 g s^{-1}, the results from which could then be pro-rated to account for the relevant daily and half-hourly release concentrations which in the case of Oxides of Nitrogen (NO_x) would be:

Daily emission limit value = 120 mg Nm^{-3} x 9.62 Nm^3 s^{-1} = 1.15 g s^{-1}
Half-hourly emission limit value = 400 mg Nm^{-3} x 9.62 Nm^3 s^{-1} = 3.85 g s^{-1}

Similarly, contributions of particulate matter and Sulphur Dioxide were calculated from the unitized data as follows:

Table 9 Multiplication Factors for Process Contributions from Unitized Stack Height Assessment

Pollutant and Averaging Period	Concentration (mg Nm^{-3})	Mass Release (g s^{-1}) / Multiplication Factor
Nitrogen Dioxide (NO_2) (Daily ELV)	120	1.154
NO_2 (Half-Hourly ELV)	400	3.847
Particulate (PM_{10} or $PM_{2.5}$) (Daily ELV)	5	0.048
PM_{10} or $PM_{2.5}$ (Half-Hourly ELV)	30	0.289
Sulphur Dioxide (SO_2) (Daily ELV)	30	0.289
SO_2 (Half-Hourly ELV)	200	1.924

The following tables present the long and short-term process contributions at the point of maximum impact. Where concentrations are greater than 1 % of the long-term air quality standard (AQS) or 10 % of the short term AQS, these are highlighted in bold. It should be noted that the stack heights are references above surrounding ground level and that the proposed stack height, as approved by planning consent 22/00639/F, is 36.5 m above ground level.

Table 10 Results from Iterative Stack Height Assessment – Annual Process Contributions of Nitrogen Dioxide and Particulate Matter

Stack Height (m)	Maximum Annual Average PC (µg m^{-3}) modelling at 1 g s^{-1}	NO_2 as a Percent of Annual AQS (40 µg m^{-3})	PM_{10} as a Percent of Annual AQS (40 µg m^{-3})	$PM_{2.5}$ as a Percent of Annual AQS (20 µg m^{-3})
31.5	2.035	**4.1 %**	0.24 %	0.49 %
32.5	1.848	**3.7 %**	0.22 %	0.44 %
33.5	1.684	**3.4 %**	0.20 %	0.41 %
34.5	1.520	**3.1 %**	0.18 %	0.37 %
35.5	1.368	**2.8 %**	0.16 %	0.33 %
36.5	1.170	**2.4 %**	0.14 %	0.28 %
37.5	1.012	**2.0 %**	0.12 %	0.24 %
38.5	0.888	**1.8 %**	0.11 %	0.21 %
39.5	0.765	**1.5 %**	0.09 %	0.18 %
40.5	0.661	**1.3 %**	0.08 %	0.16 %
Modelling was undertaken with spatially variable surface roughness and terrain files; the building and wind turbine effects modules activated; and 2019 meteorological data from Bristol Airport. NO_2 = 70 % NO_x				

Although not immediately screened as insignificant, the process contributions of Nitrogen Dioxide are low, equating to 2.4 % of the annual average Air Quality Standard at the proposed discharge height of 36.5 m. Emissions of particulate matter are immediately screened as insignificant at all modelled heights, whether considered to comprise PM_{10} or $PM_{2.5}$.

Table 11 Results from Iterative Stack Height Assessment – Short-Term Process Contributions of Nitrogen Dioxide and Particulate Matter from Daily Average Releases

Stack Height (m)	NO_2 99.79th % Hourly Average as a Percent of AQS (200 µg m^{-3})	PM_{10} 90.41st % Daily Average as a Percent of AQS (50 µg m^{-3})
31.5	9.9 %	0.68 %
32.5	9.4 %	0.65 %
33.5	8.8 %	0.59 %
34.5	8.4 %	0.53 %
35.5	7.7 %	0.49 %
36.5	7.1 %	0.44 %
37.5	6.6 %	0.40 %
38.5	6.0 %	0.35 %
39.5	5.5 %	0.30 %
40.5	4.9 %	0.26 %
Modelling was undertaken with spatially variable surface roughness and terrain files; the building and wind turbine effects modules activated; and 2018 meteorological data from Bristol Airport. NO_2 = 35 % NO_x		

Short-term contributions of Nitrogen Dioxide (reported as 35 % NO_x) and PM_{10} consistently screen as insignificant at all stack heights, equating to less than 10 % of the short-term AQS.

Table 12 Results from Iterative Stack Height Assessment – Short-Term Process Contributions of Sulphur Dioxide from Daily Average Releases

Stack Height (m)	SO_2 99.18th % Daily Average as a Percent of AQS (125 µg m^{-3})	SO_2 99.73rd % Hourly Average as a Percent of AQS Objective Value (350 µg m^{-3})	SO_2 99.9th % 15-Minute as a Percent of AQS Objective Value (266 µg m^{-3})
31.5	4.0 %	3.9 %	5.9 %
32.5	3.8 %	3.8 %	5.6 %
33.5	3.6 %	3.5 %	5.3 %
34.5	3.3 %	3.3 %	4.9 %
35.5	3.1 %	3.1 %	4.6 %
36.5	2.9 %	2.9 %	4.3 %
37.5	2.8 %	2.6 %	3.9 %
38.5	2.4 %	2.4 %	3.6 %
39.5	2.1 %	2.2 %	3.3 %
40.5	1.8 %	2.0 %	2.9 %
Modelling was undertaken with spatially variable surface roughness and terrain files; the building and wind turbine effects modules activated; and 2018 meteorological data from Bristol Airport.			

Short-term contributions of Sulphur Dioxide consistently screen as insignificant at all stack heights, equating to less than 10 % of the short-term AQS.

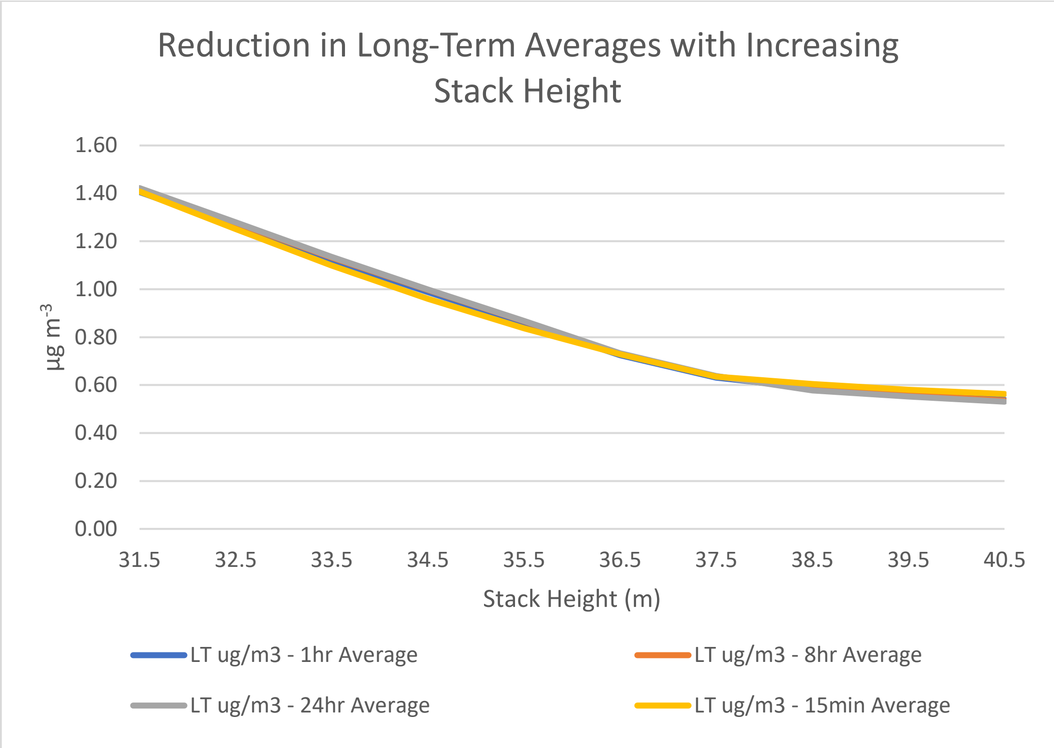
Table 13 Results from Iterative Stack Height Assessment – Short-Term Process Contributions of Nitrogen Dioxide and Sulphur Dioxide from Half-Hourly Average Releases

Stack Height (m)	NO_2 99.79th % Hourly Average as a Percent of AQS (200 µg m^{-3})	SO_2 99.73rd % Hourly Average as a Percent of AQS Objective Value (350 µg m^{-3})	SO_2 99.9th % 15-Minute as a Percent of AQS Objective Value (266 µg m^{-3})
31.5	**32.8 %**	**26.3 %**	**39.6 %**
32.5	**31.3 %**	**25.1 %**	**37.6 %**
33.5	**29.4 %**	**23.5 %**	**35.3 %**
34.5	**27.8 %**	**22.2 %**	**32.8 %**
35.5	**25.6 %**	**20.7 %**	**30.5 %**
36.5	**23.7 %**	**19.1 %**	**28.4 %**
37.5	**22.1 %**	**17.6 %**	**26.3 %**
38.5	**20.1 %**	**16.2 %**	**24.0 %**
39.5	**18.2 %**	**14.7 %**	**22.0 %**
40.5	**16.5 %**	**13.2 %**	**19.5 %**
Modelling was undertaken with spatially variable surface roughness and terrain files; the building and wind turbine effects modules activated; and 2018 meteorological data from Bristol Airport. NO_2 = 35 % NO_x			

Although none of the reported short-term process contributions screen as insignificant when modelling the maximum permitted half-hourly average release rates, contributions remain well within the relevant AQS, with short-term contributions of NO_2 and SO_2 equating to less than 30 % of the assessment level when discharging through a 36.5 m high stack. It is noted that contributions are reported at the point of maximum impact, which does not necessarily represent a sensitive human health or ecological receptor.

When the results are plotted on a graph, the pattern of the reduction in contributions modelled at a release rate of 1 g s^{-1} are as follows:

Figure 5 Reduction in Process Contributions When Considering the Overall Average of Various Referencing Periods



Changes in gradient of plotted curves are generally considered to indicate the height at which emissions from a stack escape from the effects of downwash, associated with the passage of the wind over adjacent buildings and structures. In this case, the gradient of the curve does reduce at 37.5 m although at that point, process contributions are still not screened as insignificant where they do not already screen.

The corresponding graphs for the shorter-term (percentile) averaging periods are shown in the following figures.

Higher percentile values show a relatively consistent reduction in process contributions, with no specific step-change in the gradient of the curve. Whereas the 90.41st percentile of the daily average process contribution suggests a notable reduction in the curve gradient from approximately 35.5 m, before reducing further at 37.5 m.

However, the short-term process contributions included in the iterative modelling exercise are all screened as insignificant when considering the permitted daily emission limit values for NO_x, SO_2 and particulate matter.

Figure 6 Variation in Maximum Hourly Average Process Contribution of NO_2 (µg m^{-3}) with Different Stack Heights

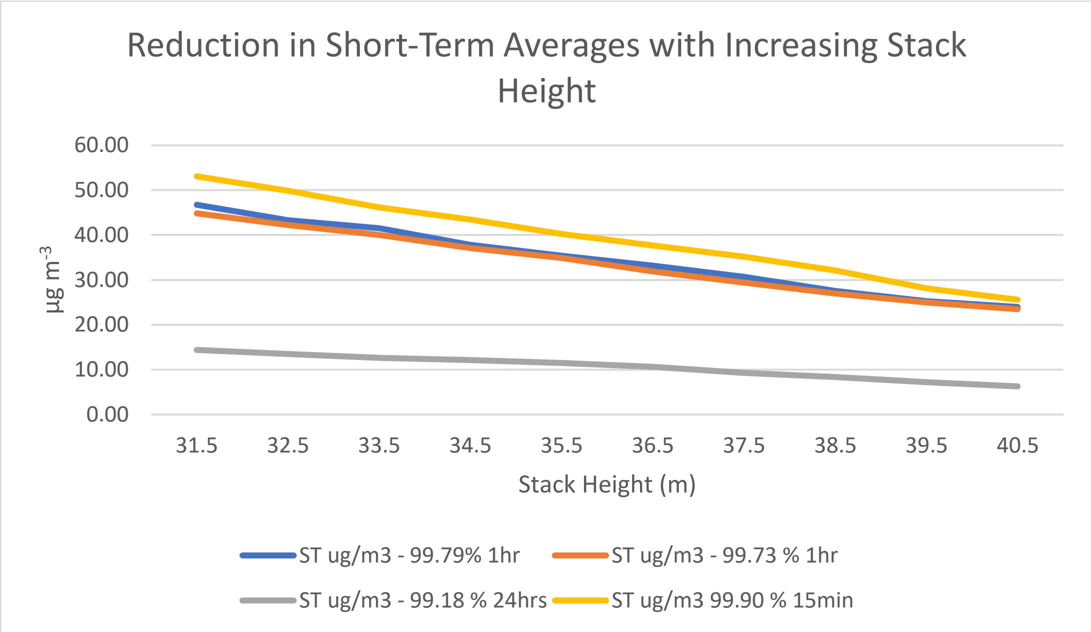
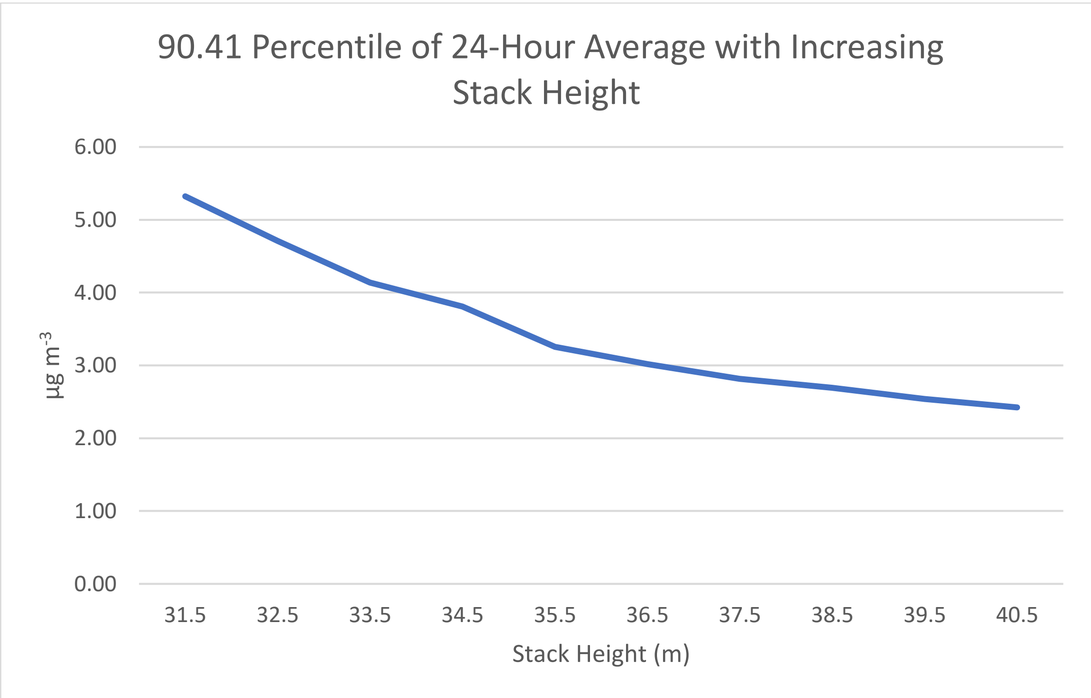


Figure 7 Variation in Maximum Hourly Average Process Contribution of NO_2 (µg m^{-3}) with Different Stack Heights



Despite the long-term process contributions not immediately screening as insignificant and the short-term process contributions when modelling emissions at the half-hourly average emission limit values not immediately screening as insignificant, detailed modelling has been undertaken assuming a consented stack height of 36.5 m. The resultant assessment reported in the following sections of this report demonstrate why, despite not screening as insignificant, the Facility will not have a significant impact on air quality.

4. Detailed Modelling – Results and Discussion

4.1 Modelled Parameters

Detailed atmospheric dispersion modelling of emissions from the Facility was undertaken on the basis of the conclusions of the sensitivity analyses as follows:

Release height: 36.5 metres
Building downwash module: active
Terrain effects: active, with a spatially variable file
Wind turbine effects: active
Surface roughness (grid): spatially variable surface roughness file or 1 metre beyond the grid
Surface roughness (meteorological site): 0.3 metre
Meteorological data: Bristol Airport 2018 to 2022

Emissions of NO_x, SO_2, CO, Particles (PM_{10}), VOCs, HCl, HF, Ammonia, Mercury, Cadmium, Other Metals, Dioxins and Furans, PCBs and PAH (as Benzo[a]Pyrene), were assessed in line with the air quality standards and their objective values (where applicable), or against specific pollutant EALs detailed in EA guidance[4].

The modelled emissions data were as summarised in Tables 2 and 3. The results from detailed modelling of the normal operational case are discussed in Sections 4.3 to 4.18. Results are presented in terms of the maximum process contribution and, where the PC cannot immediately be screened as insignificant are also reported as the predicted environmental concentration taking into account the PC and the estimated background concentration for the area.

4.2 Determining Significance

This report details the assessment of comprehensive modelling undertaken for the Facility. The significance or otherwise of the results regarding the potential impact on human health or national ecological sites are assessed using a two-stage approach, aligned with the Environment Agency (EA) requirements.

The EA provides guidance[4] for screening the significance of air quality impacts associated with the operation of industrial processes. For long-term impacts, the guidance recommends a 1 % insignificance threshold of process contributions relative to a long-term AQS or EAL, with a corresponding 10 % insignificance threshold for the assessment of short-term PCs.

Where the long-term PC is greater than 1 % but the PEC remains within 70 % of the long-term assessment level, the emissions do not screen as insignificant, but are not considered to be significant. Similarly, where the short-term PC is more than 10 % of the assessment level, but is less than 20 % of the assessment level minus twice the long-term background concentration, emissions are confirmed as not significant.

When considering local nature sites in the area, the requirement is different, and the guidance specifies that no further assessment is required where the short-term and / or long-term PC is less than 100 % of relevant environmental standard.

Contour plots are provided for pollutants assessed against air quality objectives, and where the process contribution cannot be screened as insignificant.

4.3 Nitrogen Dioxide (NO_2)

The results of the NO_2 modelling are presented in Table 14. The data presented are for both the maximum process contribution (PC) and the predicted environmental concentration (PEC) for NO_2 and are based upon the maximum values for the 2018 to 2022 meteorological data. The PEC values take into account the average estimated background concentration of NO_2 around the Facility in 2024 (12.33 $\mu g\ m^{-3}$) and conversion of the NO_x released from the process, based upon empirical formulae recommended by the Environment Agency; 50 % conversion for short-term assessment and 100 % conversion for long-term assessment.

The maximum reported values (annual average process contributions) are predicted by the modelling to occur at a location about 105 metres to the east of the Facility stack, and reduce significantly with distance from the site.

Table 14 Results from Detailed Assessment for Nitrogen Dioxide and Oxides of Nitrogen

Pollutant	Statistic	Assessment Level	Averaging Period	Process Contribution (µg m^{-3})	Percentage of the AQS
Oxides of Nitrogen (NO_X) –	Annual PC Protection of Ecosystems	30	Annual	1.35	**4.5 %**
Nitrogen Dioxide (NO_2)	Annual PC	40	Annual	1.35	**3.4 %**
	Annual PEC			13.68	34 %
	Short-term 99.79% PC	200	1hr	20.48	**10.2 %**
	Short-term 99.79% PEC			45.14	22.6 %
	Revised ST Assessment Level (AQS – background x 2)	175		20.48	11.7 %

The results from modelling predict that the process contribution (PC) from the Facility will equate to approximately 4.5 % of the annual average for the protection of ecosystems, or approximately 3.4 % of the annual average for the protection of human health at the point of maximum process contribution, when the Facility is operational. These contributions cannot immediately be screened as insignificant although this point of maximum impact is not located at either an ecological receptor, or a specific human health receptor, occurring instead within the industrial estate where long periods of access by the general public are not anticipated.

Receptors of annual average duration exposure would usually include locations where members of the public might be regularly exposed, such as building façades of residential properties, schools, hospitals, care homes etc. The air quality objectives do not usually apply at the building façades of offices or other places of work where members of the public do not have regular access and thus annual average contributions will not generally be of concern at such locations.

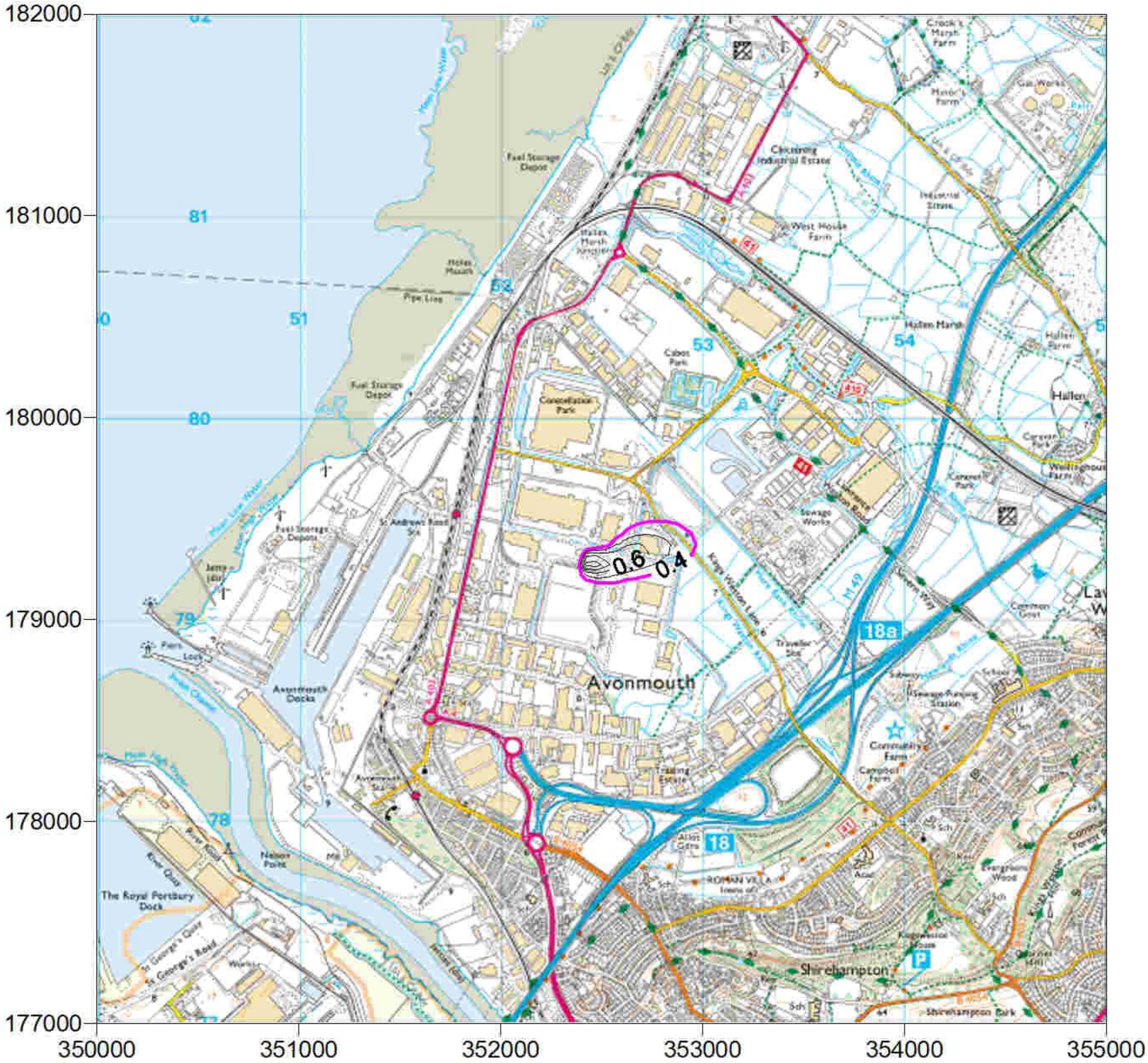
The assessment was made assuming that 100 % of the long-term NO_x converts fully to Nitrogen Dioxide (NO_2) which is a worst-case estimate. Applying the conservative assumption, that only 70 % of the NO_x will actually convert to NO_2 in the long-term, results in a process contribution of 0.95 µg m^{-3}, or 2.4 % of the annual average Air Quality Standard (AQS).

Applying the estimated background concentration of NO_2 around the Facility in 2024 (12.33 µg m^{-3}) in order to calculate the predicted environmental concentration (PEC) results in a PEC of 13.68 µg m^{-3} (when modelling 100 % NO_x as NO_2) or 34 % of the AQS, reducing to 33 % when the process contribution of NO_2 is assumed to be 70 % of the total NO_x.

Therefore, although the annual average PC does not screen as insignificant at the initial assessment stage, the maximum PEC remains well within 70 % of the AQS and will therefore not have any significant effect on air quality.

The process contribution plot for Nitrogen Dioxide, where the long-term process contribution of NO_2 is 70 % of total NO_x, is presented in Figure 8.

Figure 8 Annual Average Process Contribution of NO_x as NO_2 (µg m^{-3}); 2019 Meteorological Conditions. Magenta Isopleth Denotes the Point of Insignificance (1 % of the Objective Value)



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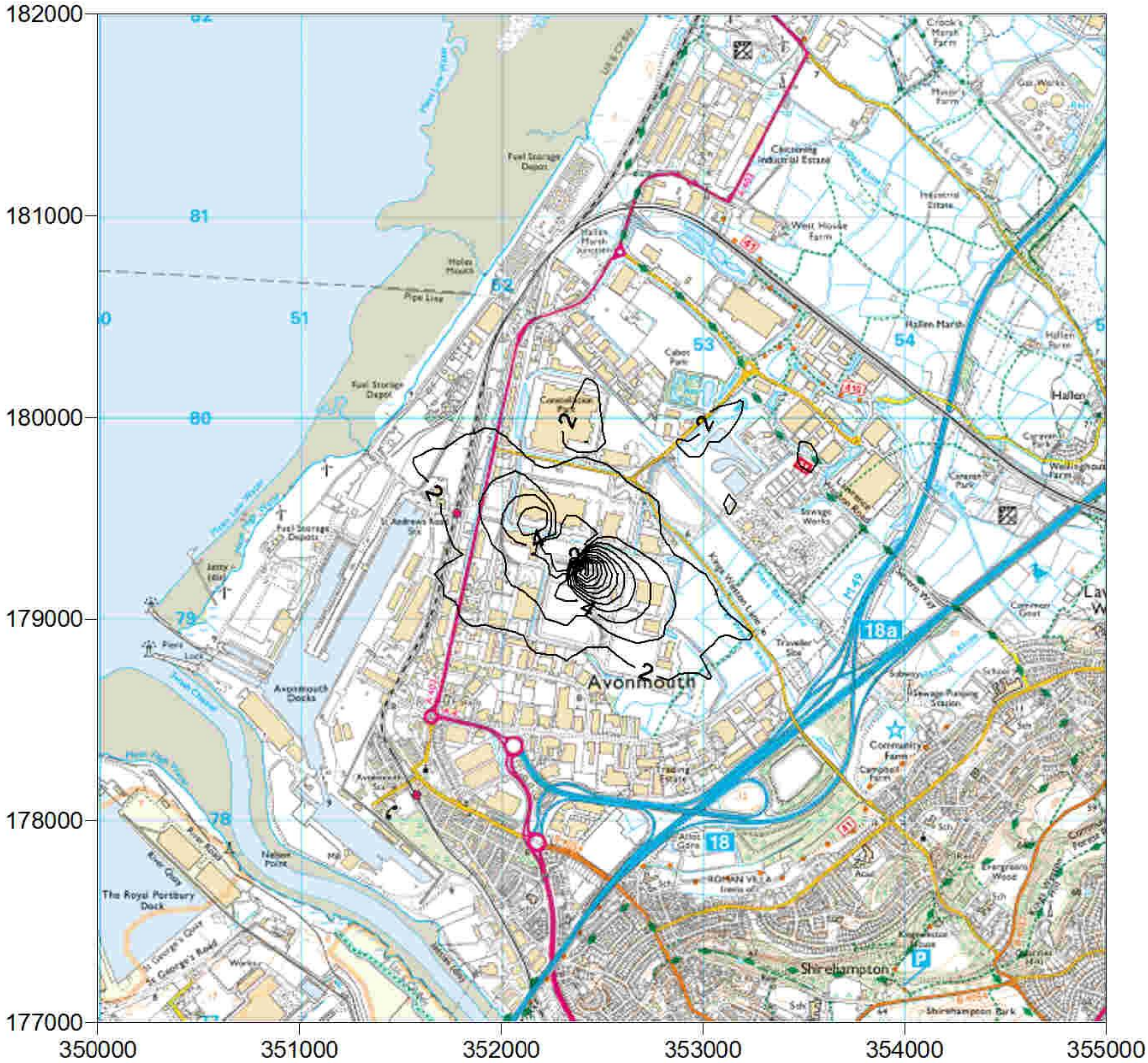
The maximum hourly average NO_2 PC was predicted to be approximately 20.48 µg m^{-3}, expressed as the 99.79th percentile value, equating to a little over 10 % of the 200 µg m^{-3} objective value. However, this assumes that up to 50 % of the NO_x released converts to NO_2 in the short-term, whereas the Environment Agency confirms that, for combustion processes where no more than 10 % of Nitrogen Oxides are emitted as Nitrogen Dioxide, a conservative conversion ratio of 35 % can be applied to the short-term averaging period.

Assuming that only 35 % of the NO_x converts to NO_2 in the short-term, the resultant maximum 99.79th percentile hourly average process contribution equates to 14.34 µg m^{-3} or approximately 7 % of the short-term air quality objective, and would therefore immediately be screened as insignificant.

Figure 9 over page plots the short-term NO_2 PC, with NO_2 equating to 35 % of total NO_x. As the PCs remain below 10 % of the AQS, none of the isopleths are highlighted in magenta, with contributions to all areas of the grid being insignificant.

Figure 9 99.79th Percentile Hourly Average Process Contribution of NO_x as NO_2 ($\mu g\ m^{-3}$); 2018 Meteorological Conditions



4.4 Sulphur Dioxide (SO_2)

The results from detailed modelling of Sulphur Dioxide associated with emissions from the Facility are presented in the following table.

Table 15 Results for Sulphur Dioxide

Statistic	Assessment Level	Averaging Period	Process Contribution ($\mu g\ m^{-3}$)	Percentage of the AQS
Annual PC	10	1hr	0.34	**3.4 %**
Annual PEC			6.48	68 %
Short-term PC 99.9% Average	266	15min	11.40	4 %
Short-term PC 99.73% Average	350	1hr	10.09	3 %
Short-term PC 99.18% Average	125	24hr	3.06	3 %

The annual average SO_2 process contribution was predicted to be 0.34 µg m^{-3}, or approximately 3.4 % of the annual limit value of 10 µg m^{-3} for the protection of ecosystems where lichens or bryophytes are present. Although not immediately screened as insignificant, the addition of the estimated local SO_2 background (6.63 µg m^{-3}) results in a PEC of approximately 6.48 µg m^{-3}, equating to 68 % of the environmental assessment level and therefore, even at this point of maximum process contribution, is not significant in relation to the EAL for the protection of sensitive ecosystems.

It is noted that the point of maximum impact reported, occurs approximately 105 metres to the east of the Facility stack, and is not an area that represents any sensitive ecological receptor. Additionally, the process contributions to each of the short-term human health assessment levels for Sulphur Dioxide remain well within 10 % of the respective AQS objective value and can therefore be screened as insignificant when applying the Environment Agency assessment methodology. Figures 10 – 12 plot the SO_2 dispersion characteristics for each relevant short-term averaging period. As the short-term PCs remain below 10 % of the AQS, none of the isopleths are highlighted in magenta, with contributions to all areas of the grid being insignificant.

Figure 10 99.9th Percentile 15-Minute Average Process Contribution of SO_2 (µg m^{-3}); 2020 Meteorological Conditions

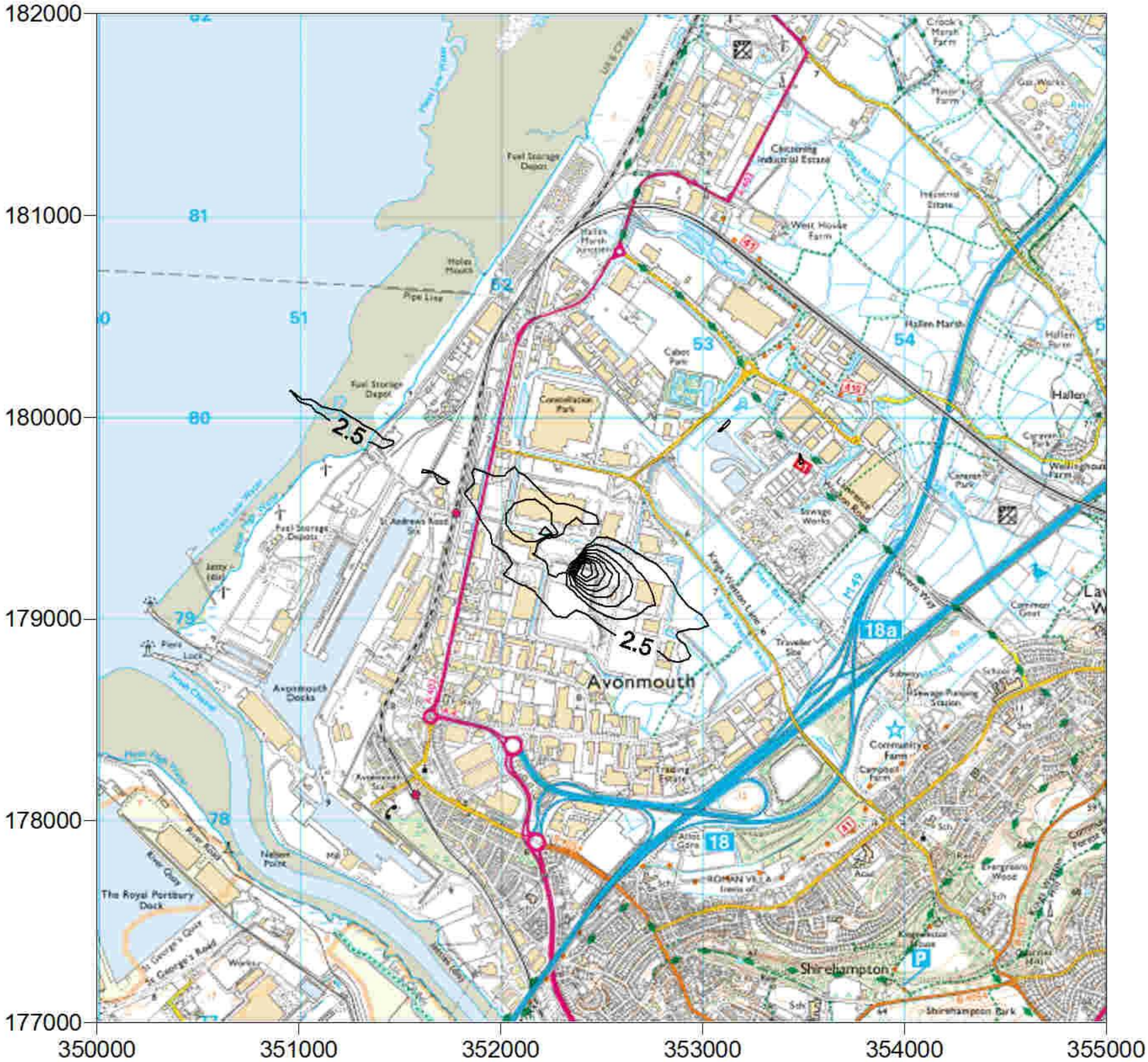


Figure 11 99.73rd Percentile Hourly Average Process Contribution of SO_2 (µg m^{-3}); 2018 Meteorological Conditions

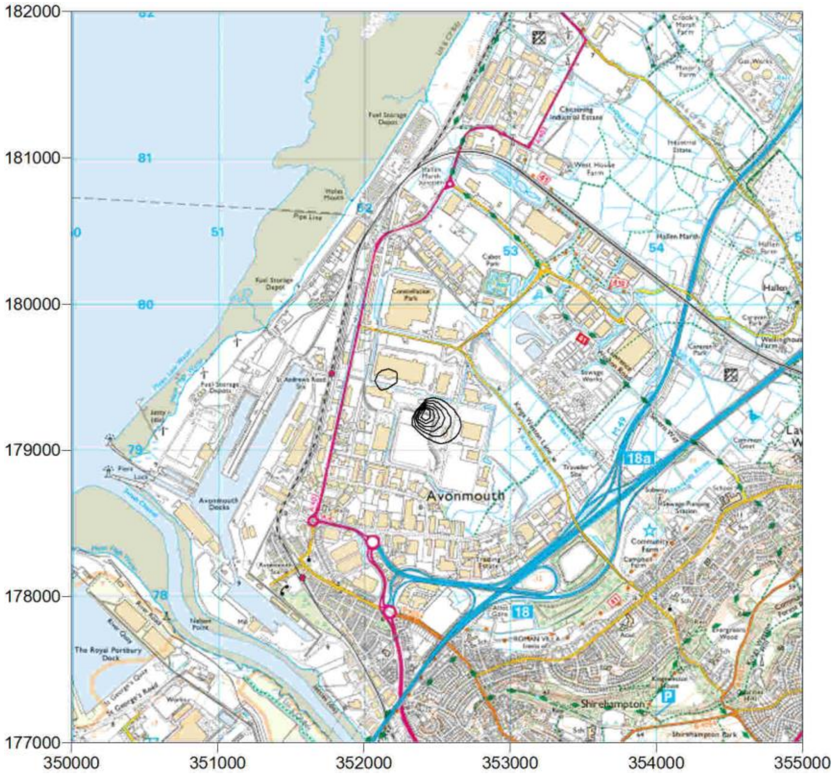


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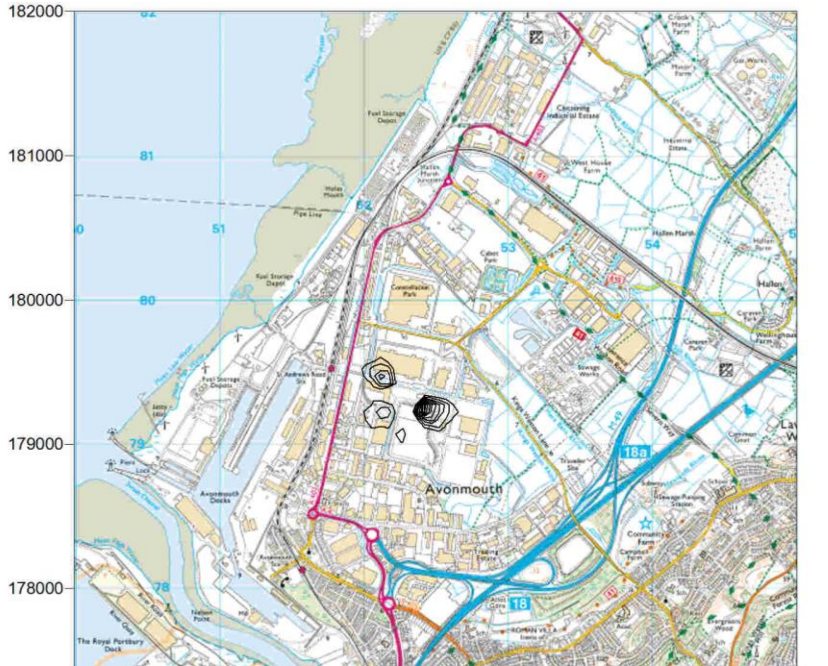
Figure 12 99.18th Percentile Daily Average Process Contribution of SO_2 (µg m^{-3}); 2018 Meteorological Conditions



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4.5 Carbon Monoxide (CO)

The results from detailed modelling of Carbon Monoxide are presented in Table 16.

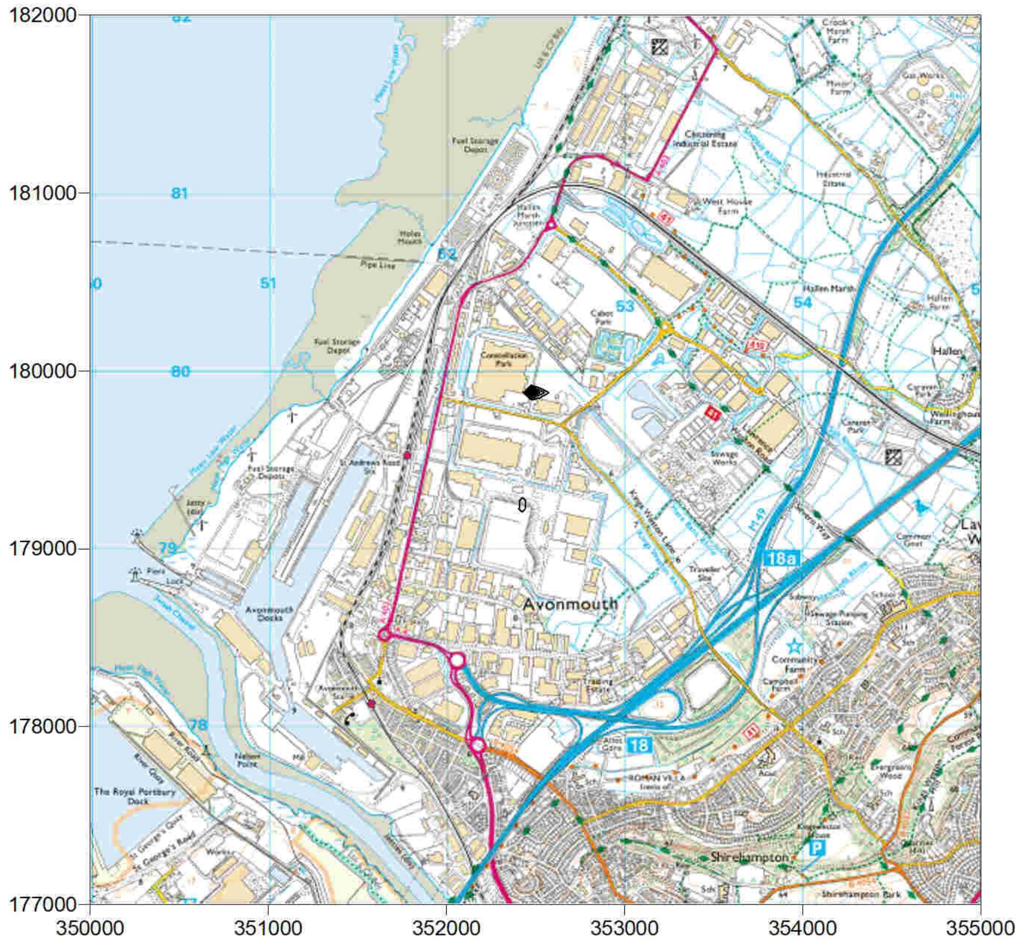
Table 16 Modelling Predictions for Carbon Monoxide

Statistic	Assessment Level (mg m^{-3})	Averaging Period	Process Contribution (mg m^{-3})	Percentage of the AQS
Short-term PC 100%	10	8hrs Max. Rolling	0.059	0.59 %
Short-term PC 100%	30	1hr (calculated from 8 hr)	0.084	0.28 %

Detailed modelling predicted that the maximum 8-hour rolling average ground-level process contribution for CO associated with emissions from the Facility would equate to approximately 0.6 % of the AQS objective value of 10 mg m^{-3}. When multiplied by 1.43, the hourly maximum can be calculated from the 8-hour maximum and equates to less than 0.3 % of the 2000 WHO air quality guideline for Europe (30 mg m^{-3} as an hourly average). The predicted PCs are considerably lower than the Environment Agency's 10 % insignificance threshold, and the results indicate that emissions of CO from the Facility are unlikely to have a significant impact on local air quality in the vicinity of the site. A plot of the 8-hour rolling process contribution isopleths is presented in Figure 13.

Outliers from the 100th percentile assessment are considered in detail in Section 6.

Figure 13 8-Hour Maximum Rolling Average Process Contribution of CO (mg m^{-3}); 2022 Meteorological Conditions



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4.6 Particulates (PM_{10})

The results from detailed modelling of particulates (PM_{10}) are provided in Table 17 and are presented in the context of the process contribution and the resultant predicted environmental concentration, taking into account the DEFRA estimated annual average background concentration for 2024 of 13.29 µg m^{-3}.

Table 17 Maximum Process Contribution for Particulates (PM_{10})

Statistic	Assessment Level	Averaging Period	Process Contribution (µg m^{-3})	Percentage of the AQS
Annual PC	40	Annual	0.0565	0.14 %
Annual PEC			13.35	33.37 %
Short-term PC 90.41%	50	24hr	0.22	0.44 %
Short-term PEC 90.41%			26.81	53.62 %

Detailed modelling predicted that the maximum annual average PC for particulates (PM_{10}) due to emissions from the Facility was likely to be less than 0.06 µg m^{-3}, or approximately 0.14 % of the AQS objective value, and can be screened as insignificant. The maximum daily average PC under normal operating conditions was predicted to be 0.22 µg m^{-3}, expressed as the 90.41 percentile value, equivalent to a value that is approximately 0.44 % of the 50 µg m^{-3} daily average objective value, and can also therefore also be screened as insignificant.

Plots of the long and short-term process contribution isopleths are presented in Figures 14 and 15.

Figure 14 Annual Average Process Contribution of Particulate Matter as PM_{10} (µg m^{-3}); 2019 Meteorological Conditions

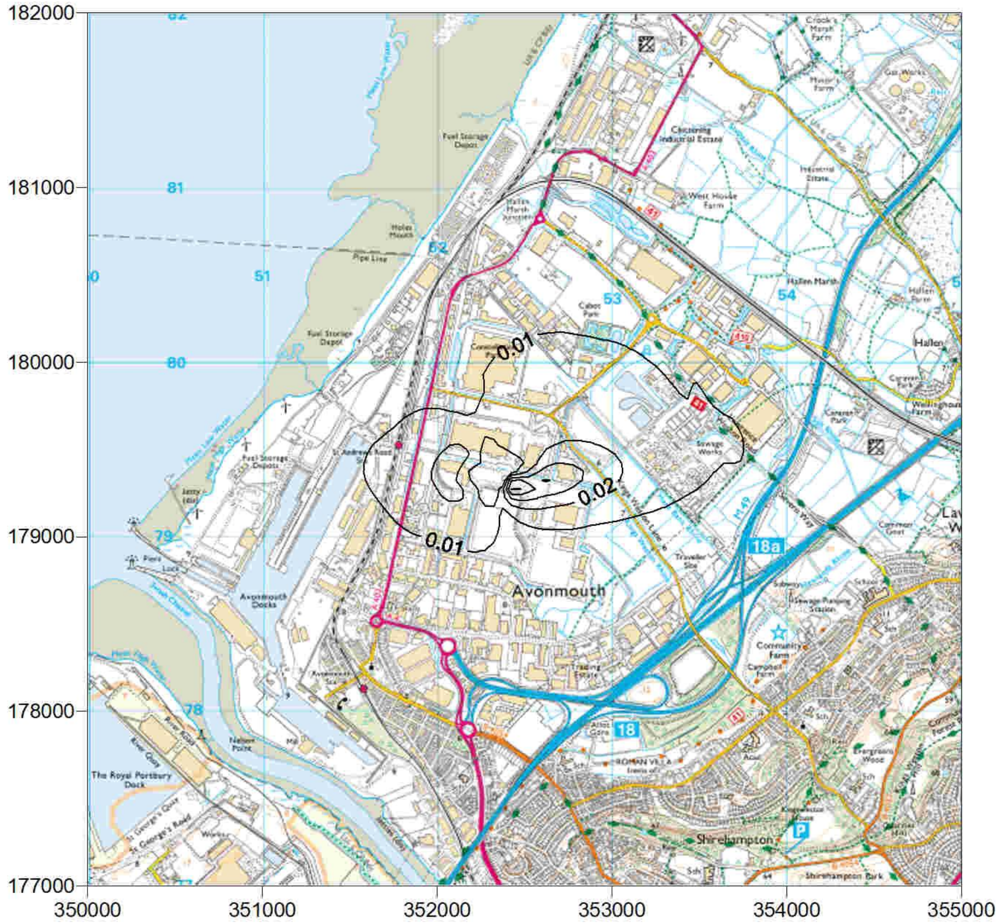
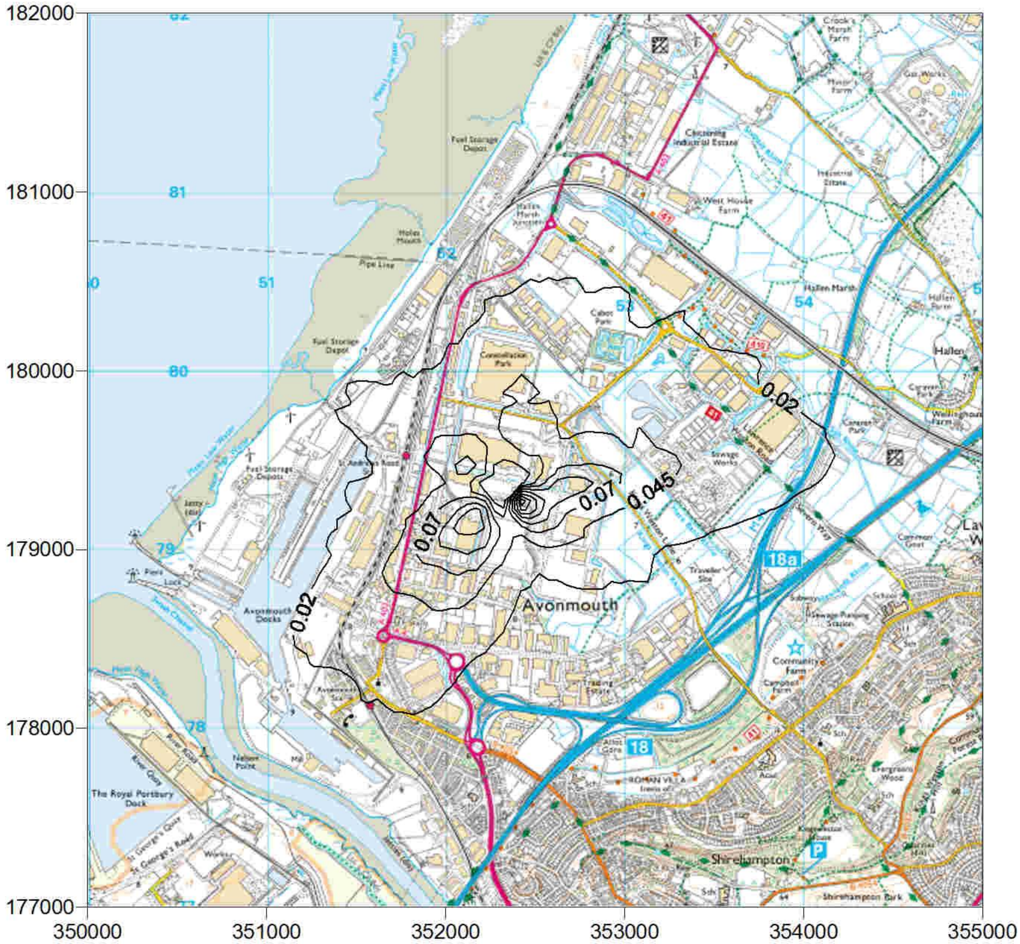


Figure 15 90.41st Percentile Daily Average Process Contribution of Particulate Matter as PM_{10} (µg m^{-3}); 2018 Meteorological Conditions



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4.7 Particulates ($PM_{2.5}$)

The Air Quality Standards Regulations 2010 (as amended) set a target of 20 µg m^{-3} $PM_{2.5}$ to be met by 2020. A new target[5] has recently been issued and ultimately requires a background level of 10 µg m^{-3} $PM_{2.5}$ to be met by 2040. Hence, both assessment levels, current and future are considered here.

Modelling was undertaken assuming that all of the particulate matter released from the Facility was $PM_{2.5}$, and so represents an absolute worst-case scenario. The assessment was based upon a worst-case assumption for emissions of particulates at a discharge value of 5 mg Nm^{-3}.

The results from the detailed modelling of particulates as $PM_{2.5}$ are reported in Table 18 and are presented in the context of the annual average PC and PEC Concentration, taking into account DEFRA's estimated annual average background concentration for 2024 of 8.08 µg m^{-3}.

Table 18 Modelling Predictions for Particulates ($PM_{2.5}$)

Statistic	Assessment Level	Averaging Period	Process Contribution (µg m^{-3})	Percentage of the AQS
Annual PC	20 (current)	Annual	0.0563	0.3 %
Annual PEC			8.13	40.66 %
Annual PC	10 (by 2040)	Annual	0.0563	0.6 %
Annual PEC			8.13	81.32 %

The results from modelling particulates, assuming that the total particulate emission is of $PM_{2.5}$, predicted that the maximum annual average PC associated with emissions from the Facility was likely to equate to 0.3 % of the current 20 µg m^{-3} target value, and 0.6 % of the future 20 µg m^{-3} target value. Contributions of $PM_{2.5}$ from the process can therefore be screened as insignificant in relation to Environment Agency guidance.

The annual average distribution of dispersion of $PM_{2.5}$ would be similar to that of PM_{10}, depicted in Figure 14.

Taking the background into consideration with the process contribution predicted by modelling, the maximum annual average predicted environmental concentration for $PM_{2.5}$ for the Facility was estimated to be approximately 8.13 µg m^{-3}. When compared against the future target value for $PM_{2.5}$, the PEC is approximately 81.32 % of the assessment level. However, with the vast majority of this concentration being made up of the existing background and the contribution from the Facility being insignificant, no further assessment against this target is required.

4.8 Volatile Organic Compounds (VOCs)

The results from detailed modelling of VOCs as Benzene are presented in Table 19.

Table 19 Maximum Process Contribution for VOCs as Benzene

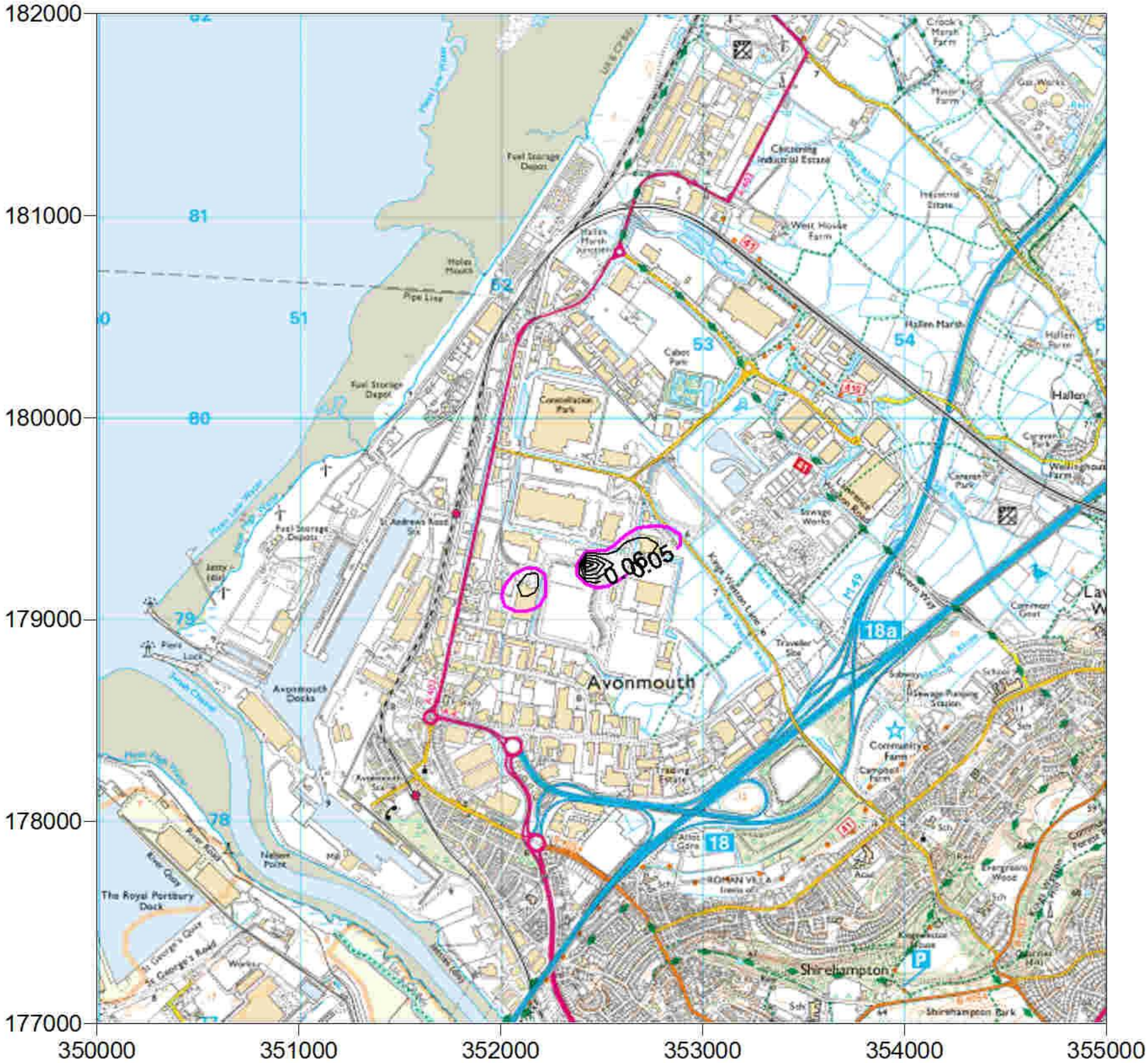
<table>
<tr><th>Pollutant</th><th>Statistic</th><th>Assessment Level</th><th>Averaging Period</th><th>Process Contribution (µg m^{-3})</th><th>Percentage of the AQS</th></tr>
<tr><td rowspan="5">Benzene</td><td>Annual PC</td><td rowspan="2">5</td><td rowspan="2">Annual</td><td>0.113</td><td>2.3 %</td></tr>
<tr><td>Annual PEC</td><td>0.331</td><td>6.6 %</td></tr>
<tr><td>Short-term PC 100%</td><td rowspan="2">30</td><td rowspan="2">24hr</td><td>4.036</td><td>13.5 %</td></tr>
<tr><td>Short-term PEC 100%</td><td>4.472</td><td>14.9 %</td></tr>
<tr><td>Revised ST Assessment Level (AQS – background x 2)</td><td>29.56</td><td>24hr</td><td>4.036</td><td>13.7 %</td></tr>
</table>

There are no assessment levels for total VOC emissions as they comprise a mixture of organic compounds, although Benzene and 1,3 Butadiene, which are both VOC species, do have air quality limit and objective values respectively associated with them. There is no information available about the proportion of Benzene or 1,3-Butadiene that may be present in the VOC emission from the Facility, although, each is likely to be a small percentage of the total. Therefore, and in line with Environment Agency guidance, as the individual composition of substances within the total VOC release is not known, the total VOC release has been treated as Benzene and is compared to the Benzene annual average limit value (5 µg m^{-3}) and the short-term assessment level (30 µg m^{-3}).

The model predicted a maximum annual average process contribution of approximately 0.113 µg m^{-3} for total VOC emissions from the Facility, which equates to approximately 2.3 % of the Benzene assessment level. Although not immediately screened as insignificant, the application of the relevant estimated background concentration in the area results in a PEC of approximately 6.6 % of the assessment level and, being less than 70 % of the total, is not considered to be a significant contribution.

A plot of the predicted distribution of VOCs is presented in Figure 16 and shows the point at which the annual average contribution to Benzene (magenta isopleth) would become insignificant.

Figure 16 Annual Average Process Contribution of VOC as Benzene (µg m^{-3}); 2019 Meteorological Conditions



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The short-term PC of total VOCs equates to approximately 13.5 % of the 24-hour average assessment level for Benzene but remains within 20 % of the EAL when considering either the PEC or the assessment of the PC against the revised short-term assessment level. As such and noting that Benzene will likely only form a small fraction of the total VOC release, the short-term impacts of potential Benzene release are deemed to not be significant.

4.9 Hydrogen Chloride (HCl)

The results from detailed modelling of HCl are presented in Table 20.

Table 20 Maximum Process Contribution for Hydrogen Chloride

Statistic	Assessment Level	Averaging Period	Process Contribution (µg m^{-3})	Percentage of the EAL
Short-term PC 100%	750	1hr	55.01	7 %

There is no Air Quality Standard for HCl and hence the assessment was based upon the Environment Agency short-term (1-hour) EAL. Detailed modelling predicted a maximum hourly average PC for HCl of approximately 55 µg m^{-3} (7 % of the 750 µg m^{-3} EAL). This maximum hourly average was reported for the 2022 meteorological conditions and, with the short-term process contributions remaining within the Environment Agency's 10 % assessment threshold, can be screened as insignificant.

It is noted however, that when modelling 2019 meteorological data the maximum hourly average was approximately 30 µg m^{-3} (4 % of the 750 µg m^{-3} EAL) and when modelling 2018, 2020 and 2021 meteorological conditions, the maximum hourly average process contributions were much lower, ranging from approximately 2.2 to 2.3 µg m^{-3} (0.3 % of the 750 µg m^{-3} EAL). The large variation in the short-term results and the location of the points of maximum contribution which occurred approximately 570 m to the north, close to the base of the Accolade Wines wind turbine in 2019 and 2022, in contrast to the point of maximum hourly impact in 2018, 2020 and 2021 which were all located approximately 105 m to the south-east of the stack, confirm the occasional influence of the wind turbine location on short-term averaging period contributions from the Grundon Facility.

Outliers from the 100th percentile assessment are considered in detail in Section 6.

4.10 Hydrogen Fluoride (HF)

The results from detailed modelling of Hydrogen Fluoride are presented in Table 21.

Table 21 Maximum Process Contribution for Hydrogen Fluoride

Statistic	Assessment Level	Averaging Period	Process Contribution (µg m^{-3})	Percentage of the EAL
Monthly average EAL	16	1hr	0.0113	0.07 %
Short-term PC 100%	160		9.17	6 %

Detailed modelling predicted that the maximum hourly average process contribution for HF associated with the emissions from the plant would be approximately 9.17 µg m^{-3}, or 6 % of the 160 µg m^{-3} EAL, and is therefore insignificant in relation to Environment Agency guidance. The corresponding annual average PC for HF was predicted to be 0.0113 µg m^{-3}. The longer-term assessment level is relevant to a monthly exposure period and hence, the annual average concentration is not directly comparable. However, the very small contribution of the annual PC to the monthly average EAL (0.07 %) suggests that the longer-term impacts of HF emissions would also be insignificant.

Similar to the predicted short-term process contributions of HCl, elevated short-term results were observed for 2022 and 2019 meteorological conditions with the point of maximum contribution occurring close to the base of the Accolade Wines wind turbine. Much lower maximum hourly process contributions were reported in 2018, 2020 and 2021 and occurred much closer to the Facility (approximately 105 m to the south-east of the stack) confirming the negative influence of the wind turbine that can sometimes occur.

Outliers from the 100th percentile assessment are considered in detail in Section 6.

Despite the occasionally elevated concentrations, the results indicate that emissions of HF are unlikely to have a significant impact on local air quality in the vicinity of the site. Accordingly, emissions of HF were screened out as insignificant and do not require further assessment.

4.11 Ammonia

The results from detailed modelling of Ammonia are presented in Table 22.

Table 22 Modelling Predictions for Ammonia

Statistic	Assessment Level	Averaging Period	Process Contribution (µg m^{-3})	Percentage of the EAL
Annual PC	180	1hr	0.1126	0.06 %
Short-term PC 100%	2,500		91.69	4 %

A similar phenomenon is seen in the 2019 and 2022 results as previously, with these higher points of short-term maximum contribution occurring in the vicinity of the Accolade Wines wind turbine. Modelling results for 2018, 2020 and 2021 were much lower and occurred closer to the Facility. Outliers from the 100^{th} percentile assessment are considered in detail in Section 6.

Despite this, detailed modelling predicted that the maximum annual average PC for Ammonia was approximately 0.11 µg m^{-3}, or 0.06 % of the long-term average EAL of 180 µg m^{-3}, and therefore immediately screens as insignificant. The maximum predicted hourly average process contribution for Ammonia associated with the emissions from the plant over five years' of modelled meteorological conditions would be approximately 91.7 µg m^{-3}, or about 4 % of the 2,500 µg m^{-3} EAL, and is therefore also insignificant in relation to Environment Agency guidance.

4.12 Cadmium and Thallium (Cd & Tl)

The results from detailed modelling of Cadmium and Thallium are reported in the following table and are presented on the basis that all of the emissions occur as Cadmium, due to there being no relevant assessment level for concentrations of Thallium.

Table 23 Maximum Process Contribution for Cadmium and Thallium

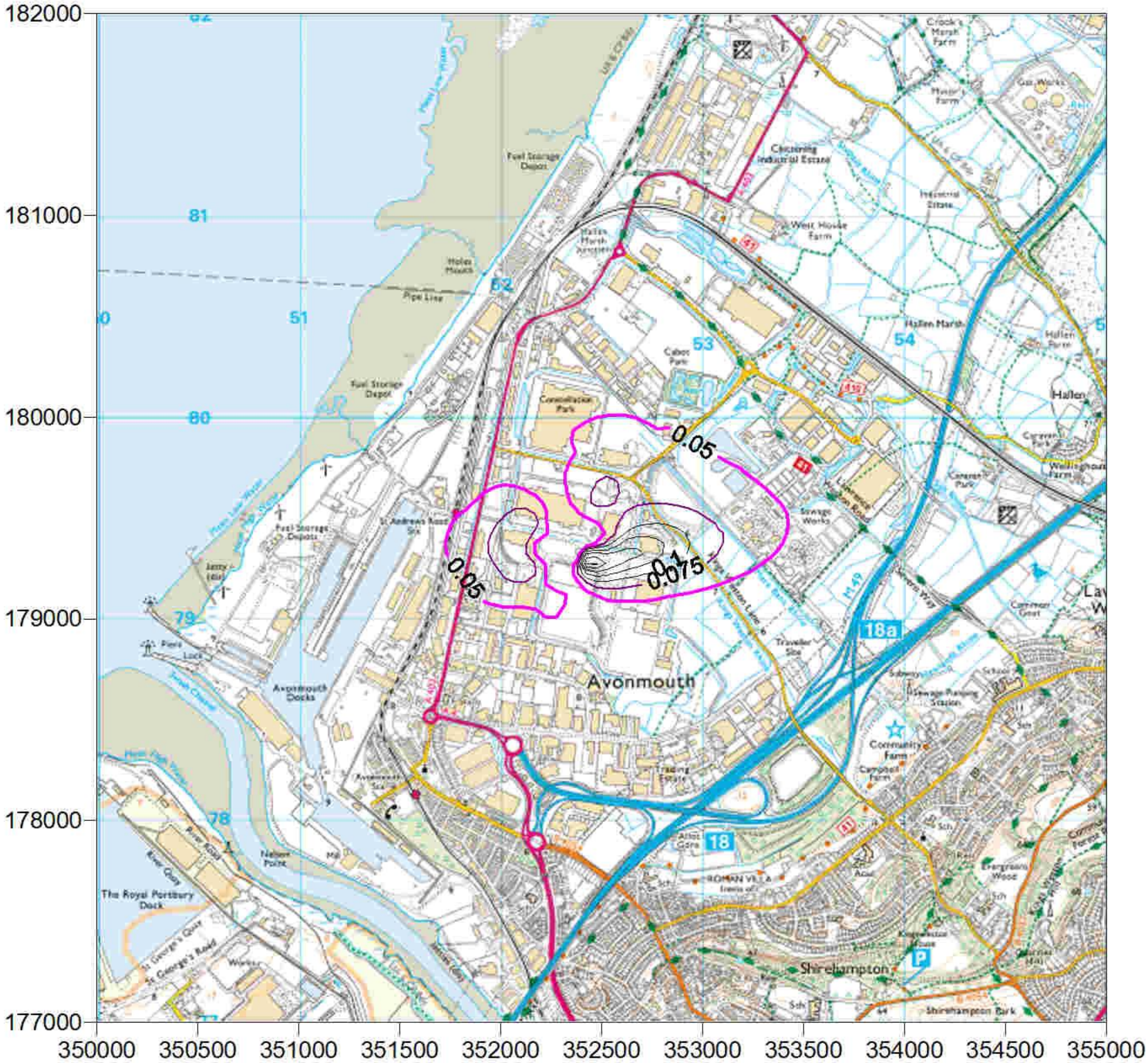
Pollutant	Statistic	Assessment Level	Averaging Period	Process Contribution (ng m^{-3})	Percentage of the EAL
Cadmium	Annual PC	5	1hr	0.225	**4.5 %**
	Annual PEC			0.355	7.1 %
	Short-term PC 100%	30	24hr	8.073	**26.9 %**

Cadmium has a target value of 5 ng m^{-3} as an annual average, and a short-term (24-hour average) EAL of 30 ng m^{-3}. By way of undertaking a conservative assessment, it was assumed that all of the combined Cadmium and Thallium emission (0.02 mg Nm^{-3}) would be discharged totally as Cadmium.

Detailed modelling predicted an annual average process contribution for Cadmium of approximately 0.225 ng m^{-3}, or about 4.5 % of the objective value. When a background concentration for Cadmium is added to the PC, the resultant PEC is approximately 7.1 % of the EAL and is not considered to be significant in relation to air quality impacts. The background concentration was measured as 0.13 ng m^{-3} at the Chilbolton monitoring station[11] in 2020. Chilbolton is located approximately 95 km to the east, south-east of Avonmouth and is the nearest and most representative heavy metals measurement station to the development.

Figure 17 over page presents the process contribution plot for Cadmium, in ng m^{-3}, with the 1 % point of insignificance (0.05 ng m^{-3}) shown.

Figure 17 Annual Average Process Contribution of Cadmium (ng m^{-3}); 2019 Meteorological Conditions. Magenta Isopleth Denotes the Point of Insignificance (1 % of the AQS)



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The short-term (24-hour) average process contribution of Cadmium was predicted to equate to approximately 27 % of the EAL. Being over 20 % of the short-term assessment level, the contribution would not screen at either the initial or secondary assessment stage. However, the emission limit value for Cadmium from incineration processes actually considers a combined release of Cadmium and Thallium. Therefore, assuming that the Cadmium release equates to 50 % of the total, the contribution from the process (approximately 4.04 ng m^{-3}) equates to approximately 13.5 % of the EAL, or 13.6 % of the short-term EAL minus twice the existing background. As such, with the PC remaining within 20 % of the revised short-term EAL, the overall potential impact of contributions of Cadmium are deemed to not be significant.

4.13 Mercury and its Compounds (Hg)

The results from detailed modelling of Mercury and its compounds are presented in the following table.

Table 24 Maximum Process Contribution for Mercury and its Compounds

Statistic	Assessment Level	Averaging Period	Process Contribution ($\mu g\ m^{-3}$)	Percentage of the EAL
Short-term PC 100%	0.06	24hr	0.0081	**13.45 %**
Short-term PEC 100%			0.0111	18.45 %
Revised ST Assessment Level (EAL – background x 2)	0.057		0.0081	14.16 %
Short-term PC 100%	0.6	1 hr	0.183	**30.56%**
Short-term PEC 100%			0.186	**31.06 %**
Revised ST Assessment Level (EAL – background x 2)	0.597		0.183	**30.72 %**

There is no air quality standard for Mercury and assessment levels were therefore based upon long-term (24-hour) and short-term (1-hour) environmental assessment levels.

The maximum 24-hour average PC for Mercury (0.0081 $\mu g\ m^{-3}$) equates to 13.45 % of the EAL and therefore does not immediately screen as insignificant. However, when considering the PC against a revised short-term assessment level of 0.057 $\mu g\ m^{-3}$ (the EAL minus twice the annual average background concentration), the contribution remains within 20 % of the revised EAL and is therefore confirmed as not having any significant impact.

The maximum hourly average PC for Mercury was predicted to be approximately 0.183 $\mu g\ m^{-3}$, equating to approximately 30.56 % of the new short-term EAL (0.6 $\mu g\ m^{-3}$). Being above 20 % of the assessment level, the contribution cannot be screened at either the initial or secondary assessment stage. However, both the process contribution and the PEC remain well within the EAL at the point of maximum contribution, which occurs close to the base of the Accolade Wines wind turbine and reduces quickly from this point, with only 9 of the gridded results equating to 10 % or more of the hourly average EAL. The most significant maximum hourly process contributions are reported for 2022 and 2019, with a clear influence from the local wind turbine. The maximum process contributions for other years were significantly lower than those reported for 2022 and 2019. As such, the short-term process contributions of Mercury are not considered likely to have any significant effect.

Outliers from the 100th percentile assessment are considered in detail in Section 6.

4.14 Group 3 Metals

The IED and associated BREF and BAT-Conclusions documents stipulate emission limits on Group 3 metals including Antimony (Sb), Arsenic (As), Lead (Pb), Chromium (Cr), Cobalt (Co), Copper (Cu), Manganese (Mn), Nickel (Ni), and Vanadium (V). The emission limit requires that the total emission (i.e. the sum) for all of these metals is below 0.3 mg Nm^{-3}, and this is the basis for the assessment.

The Environment Agency has issued guidance on metals impact assessment[12], which recommends a stepwise approach to the assessment of emissions of Group 3 metals. The guidance is based upon the presumption that the assessment is applicable for municipal waste (MSW) incineration and waste wood co-incineration facilities and is therefore appropriate for the Facility now proposed by Grundon, in Avonmouth.

The first step is based upon the assumption that each of the nine metal species is emitted at the IED emission limit value of 0.3 mg Nm^{-3} for Group 3 metals. The results from this initial screening assessment are presented over page.

Table 25 Maximum Annual Average Process Contribution for Group 3 Metals – Step 1 Screening

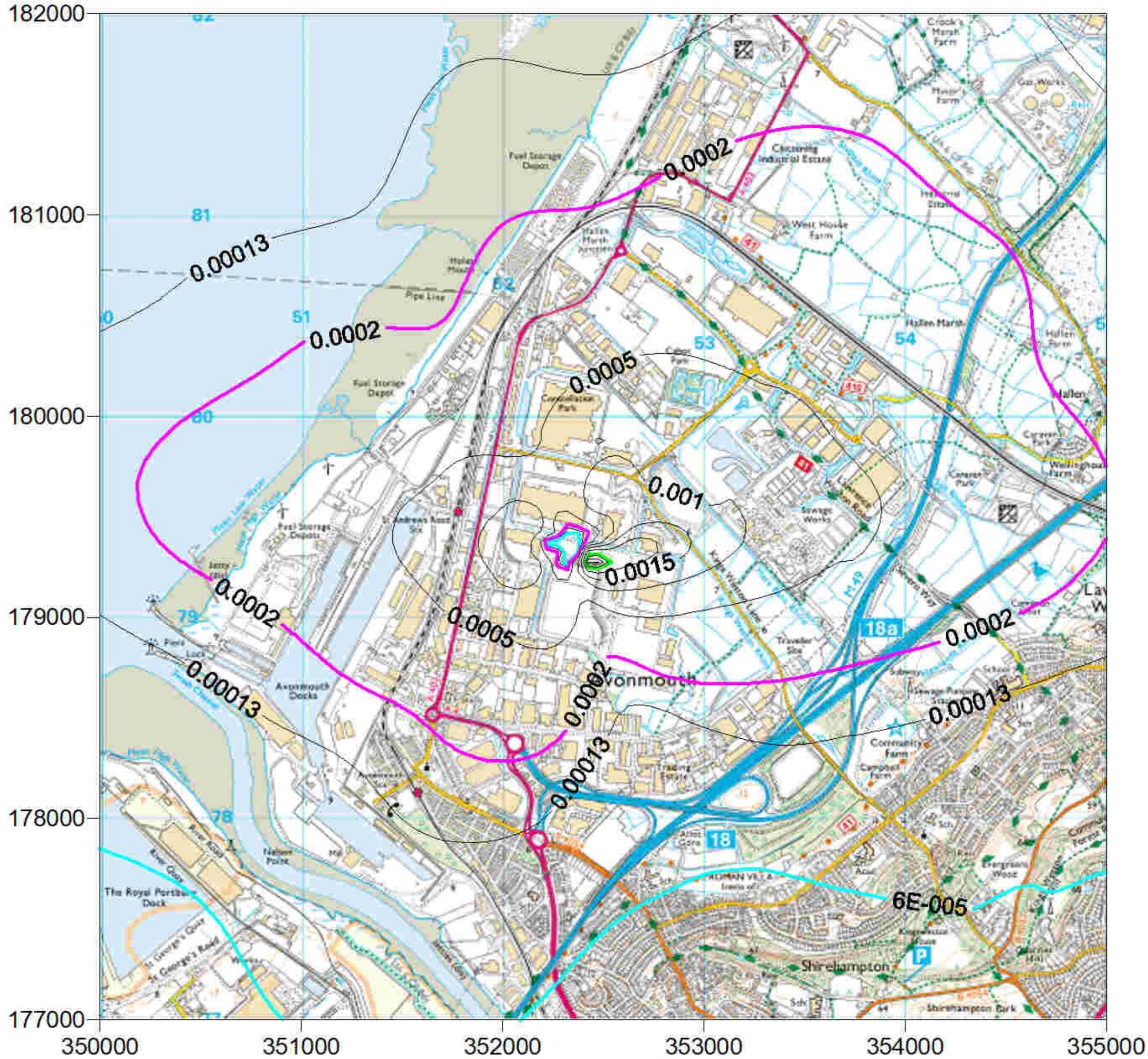
Metal	Assessment Level ($\mu g\ m^{-3}$)	Approximate Concentration ($\mu g\ m^{-3}$)	Percentage of the AQS/EAL
Antimony	5	0.0034	0.07 %
Arsenic	0.006	0.0034	**56 %**
Chromium$^{(VI)}$	0.00025	0.0034	**1,351 %**
Cobalt	0.2*	0.0034	**1.69 %**
Lead	0.25	0.0034	**1.35 %**
Manganese	0.15	0.0034	**2.25 %**
Nickel	0.02	0.0034	**17 %**

* In the absence of any current assessment level, the historic EAL is applied.[13]

Emissions of Arsenic and Chromium$^{(VI)}$, Cobalt, Lead, Manganese and Nickel are identified as being potentially significant by this initial screening assessment (values in bold text). It should be noted that the assessment assumes that all of the Chromium present in the emissions to atmosphere is present as Chromium$^{(VI)}$, therefore representing an absolute worst-case basis for the assessment.

Figure 18 presents the process contribution plot for Group three metals, in $\mu g\ m^{-3}$, with the 1 % point of insignificance for Arsenic (0.00006 $\mu g\ m^{-3}$ in turquoise), Nickel (0.0002 $\mu g\ m^{-3}$ in magenta), and Lead (0.0025 $\mu g\ m^{-3}$ in green). It should be remembered however, that the isopleths shown assume that the total concentration of Group 3 metals are emitted as individual species and as such, this first stage assessment presents a significant over-estimate of the actual impact of each metal compound.

Figure 18 Annual Average Process Contribution of Total Group Three Metals (µg m^{-3}); 2019 Meteorological Conditions. Isopleths Denote the Point of Insignificance (1 % of the AQS) for Arsenic, Nickel and Lead



Short-term process contributions are assessed using the same methodology, where short-term EALs are available, and results are presented in Table 26.

Table 26 Maximum Short-Term Process Contribution for Group 3 Metals – Step 1 Screening

Metal	Assessment Level (µg m^{-3})	Approximate Concentration (µg m^{-3})	Percentage of the AQS/EAL
Antimony	150 (1-hour mean)	2.75	1.83 %
Chromium(III)	2 (24-hour mean)	0.12	6.05 %
Copper	0.05 (24-hour mean)	0.12	**242 %**
Manganese	1,500 (1-hour mean)	2.75	0.18 %
Nickel	0.7 (1-hour mean)	2.75	**393 %**
Vanadium	1 (24-hour mean)	0.12	**12 %**

Where not initially screened as insignificant, the predicted environmental concentration of the metal species is calculated, applying measured background data from the nearest Heavy Metals Monitoring Network site, in this case from the Chilbolton Observatory. The Environment Agency guidance note specifies that, where the PEC is less than 100 % of the environmental standard, no further assessment is required. Where it is above 100 %, the assessment should proceed to Step 2. Table 27 presents the calculated PEC values for both long and short-term emissions where required.

Table 27 Predicted Environmental Concentrations of Group 3 Metals Where Long-Term PC is Greater Than 1 % and Short-Term PC is Greater Than 10 % of the EAL

Metal	Measured Background ($\mu g\ m^{-3}$)	Predicted Environmental Concentration ($\mu g\ m^{-3}$)	Percentage of the AQS/EAL
Arsenic	0.00076	0.0041	68.9 %
Chromium$^{(VI)}$	0.00096	0.0043	**1,735 %**
Cobalt	0.000048	0.0034	1.7 %
Copper (ST)	ST = (0.0035) x 2 = 0.007	0.1281	**256 %**
Lead	0.0036	0.0070	2.8 %
Manganese	0.003	0.0064	4.3 %
Nickel	0.00081	0.0042	20.9 %
Nickel (ST)	ST = (0.00081) x 2 = 0.00162	2.7521	**393 %**
Vanadium (ST)	ST = (0.00086) x 2 = 0.00172	0.123	12.3 %

The results in Table 27 demonstrate that, despite the worst-case PC not being immediately screened for a number of the Group 3 metals, the PEC does go on to screen for Arsenic, Cobalt, Lead, Manganese, Nickel, and the short-term contributions of Vanadium, leaving only Chromium$^{(VI)}$ and short-term contributions of Copper and Nickel which cannot be screened as insignificant in Step 1.

Environment Agency guidance then recommends that a second stage screening assessment should be carried out for those metals with a PC greater than 1 % and PEC greater than 100 % of the long-term assessment level, and this should be based on measured emissions data from currently operational MSW incineration and waste wood co-incineration plant. The Environment Agency has published a summary of measurements undertaken at facilities between 2007 and 2015, enabling the percentage contribution that each individual metal species makes to the total Group 3 metals contribution, to be used in calculating the likely release of each species from the modelled result. The calculated percentages specified in the guidance note are representative of the original BAT-AEL specified for Group 3 metals in the IED (0.5 mg Nm^{-3}). Due to the reduction in the BAT-AEL as specified in the BREF and BAT-Conclusions documents of 2019[6 and 7], the percentage contribution of the measured value has been recalculated in relation to the revised BAT-AEL. As the overall emission of Group 3 metals will reduce with the application of BAT, this likely represents a significant over-estimate of the contribution of each species, and would suggest an exceedance of the BAT-AEL if the Group 3 metals were to be summed. However, with no firm knowledge that individual metal species would be reduced proportionately through the application of best available techniques, the use of this conservative approach is considered to be reasonable.

Table 28 Percentage Contribution of Species for the Step 2 Assessment of Group 3 Metals

Measurement	Maximum (mg Nm^{-3})	Percentage Contribution to 0.5 mg Nm^{-3} ELV	Percentage Contribution to 0.3 mg Nm^{-3} ELV
Antimony	0.0115	2.3 %	3.8 %
Arsenic	0.025	5 %	8.3 %
Chromium$^{(VI)}$	0.00013	0.03 %	0.043 %
Cobalt	0.0056	1.1 %	1.9 %
Copper	0.029	5.8 %	9.7 %
Lead	0.0503	10.1 %	16.8 %
Manganese	0.060	12 %	20 %
Nickel	0.220	44 %	73.3 %
Vanadium	0.006	1.2 %	2 %

In the first instance, the Step 2 screening assessment should be based upon the maximum emissions and resultant percentage contributions as specified in the above table, and the measured data from the nearest Heavy Metals Monitoring Network site, in this case at the Chilbolton Observatory. A similar assessment of PC and PEC values should be applied as in Step 1. Therefore, the calculated maximum percentage contributions were applied to the total process contributions of 0.0034 µg m^{-3} for Chromium$^{(VI)}$, 0.1211 µg m^{-3} for Copper and 2.7505 µg m^{-3} for Nickel. Table 29 below reports both the PC and the resultant predicted environmental concentrations.

Table 29 Maximum Predicted Environmental Concentrations for Annual Average Chromium^{VI}, and Short-Term Copper and Nickel – Step 2 Screening

Metal	Assessment Level (µg m^{-3})	PC (µg m^{-3})	Percentage of the EAL	Background Concentration (µg m^{-3})	PEC (µg m^{-3})	Percentage of the EAL
Chromium$^{(VI)}$	0.00025	1.45 x 10^{-06}	0.58 %	0.00019*	0.00019	77 %
Copper (ST)	0.05	0.0117	**23.5 %**	0.0035	0.0187	37 %
Nickel (ST)	0.7	2.016	**288 %**	0.00081	2.0177	**288 %**

** Note: The background concentration of Chromium$^{(VI)}$ is assumed to equate to 20 % of the total Chromium background as measured at the Chilbolton Observatory in 2020 (0.00058 µg m^{-3}).*

As can be seen, the PC of Chromium$^{(VI)}$ is less than 1 % of the EAL when considered at this secondary screening stage. The resultant PEC, which includes a background concentration from Chromium$^{(VI)}$ estimated from total Chromium measured at the Chilbolton Observatory remains within 100 % of the relevant EAL. Therefore, and in accordance with the Environment Agency guidance note, the contributions of Chromium$^{(VI)}$ screen as insignificant when applying the Step 2 screening methodology.

Short-term contributions of Copper equate to more than 10 % of the EAL, but the PEC remains within 100 % of the EAL and therefore no further assessment is required. However, the short-term contributions of Nickel remain above 100 % of the assessment level when the Step 2 screening assessment is based upon the maximum measured emissions from the Environment Agency study. It is noted that the contribution of Nickel to the total Environment Agency measured emissions is high (73.3 %). However, the Environment Agency guidance note recognises that this includes outliers in the measurements. As such, it is reasonable to apply the mean contribution (5 %) of Nickel from the total measured results to the modelled concentration being assessed. Five percent of the total metals contribution would result in a revised PC of Nickel of 0.1375 µg m^{-3} as a maximum hourly average. The resultant PEC of 0.13915 µg m^{-3} equates to 19.88 % of the assessment level and therefore no further assessment is required.

4.15 Dioxins and Furans

The results from detailed modelling of Dioxins and Furans are presented in the following table.

Table 30 Maximum Process Contribution for Dioxins and Furans

Statistic	Averaging Period	Approximate Concentration (µg m^{-3})
Annual	1hr	4.50 x 10^{-10}
Short-term PC 100%		3.67 x 10^{-07}

There is a general concern within the population at large about the potential health effects associated with exposure to Dioxins and Furans in the emissions from industrial processes. However, there are no air quality standards or environmental assessment levels for Dioxins.

The maximum annual PC for Dioxins associated with emissions from the Facility, assuming a constant discharge at the permitted emission limit of 0.04 ng Nm^{-3} was approximately 0.45 fg m^{-3}, at the point of maximum process contribution, which is 105 metres to the east of the Facility stack. The maximum hourly average contribution was predicted to be approximately 37 fg m^{-3}. At such low levels, emissions of Dioxins from the Facility are not expected to significantly increase the airborne concentration or deposition rate of Dioxins and Furans over what may be currently experienced in the locality.

Outliers from the 100th percentile assessment are considered in detail in Section 6.

Further consideration of the potential impact of Dioxin and Furan releases is provided in a separate Dioxin and Furan Health Risk Assessment for the Facility[14].

4.16 PCBs and Dioxins and Furans

The maximum ELV specified in the BAT-Conclusions document for Poly Chlorinated Biphenyls (PCBs) is for a combined and total emission of PCBs and Dioxins and Furans, and is limited to 0.06 ng Nm^{-3}, or 1.5 times the Dioxin and Furan ELV. The assessment here assumes that the total permitted concentration is emitted as PCBs.

Table 31 Maximum Process Contribution of PCBs

Statistic	Assessment Level	Averaging Period	Process Contribution ($\mu g\ m^{-3}$)	Percentage of the EAL
Annual	0.2	1hr	6.75×10^{-10}	0.00000034 %
Short-term PC 100%	6		5.5×10^{-07}	0.000009 %

The results in Table 31 demonstrate that, even when assuming that the total permitted release of PCBs, Dioxins and Furans is emitted as PCBs only, the process contribution is a very small fraction of 1 % of the environmental assessment level and hence can be screened as insignificant.

By way of an additional assessment, specific to emissions of PCBs alone, reference is made to the original (August 2006) Waste Incineration BREF[15] which includes a table of measured emissions from some European municipal solid waste incineration plant, suggesting potentially higher releases of PCBs, although confirming that measured emissions of total PCBs are less than 0.005 mg Nm^{-3}. Pro-rating the impact of the modelled emissions (6×10^{-08} mg Nm^{-3}) to determine the impact of a discharge of 0.005 mg Nm^{-3} results in the process contributions reported in Table 32 below.

Table 32 Process Contribution of PCBs Emitted at 0.005 mg Nm^{-3}

Statistic	Assessment Level	Averaging Period	Process Contribution ($\mu g\ m^{-3}$)	Percentage of the EAL
Annual	0.2	1hr	5.63×10^{-05}	0.03 %
Short-term PC 100%	6		4.58×10^{-02}	0.76 %

Despite the significant increase in the modelled PCB emission when considering the historical data reported in the 2006 BREF[15], the process contribution remains a fraction of long and short-term assessment levels for PCBs and is immediately screened as insignificant at either averaging period. As such, no further assessment is required, with outliers from the 100th percentile assessment considered in detail in Section 6.

4.17 Polycyclic Aromatic Hydrocarbons (PAH as B[a]P)

Although measured discharges of total PAH identified in the 2019 BREF[6] reported concentrations of up to 0.05 mg Nm^{-3} (50,000 ng Nm^{-3}) from incineration processes, emissions of Benzo[a]Pyrene (B[a]P) were reported to a maximum of 0.001 mg Nm^{-3} (1,000 ng Nm^{-3}). B[a]P has an environmental assessment level of 0.25 ng m^{-3}. There is an additional European obligation to limit total ambient PAH to 1 ng m^{-3} as an annual average in the PM_{10} fraction. However, no information is available on the PAH content of any PM_{10} emissions that may be emitted from the Facility. Within this assessment therefore, the lower measured value has been applied and considers emissions of B[a]P, at 0.001 mg Nm^{-3}, rather than total PAH discharges.

The results from detailed modelling of Polycyclic Aromatic Hydrocarbons (as Benzo[a]Pyrene) are presented in the following table.

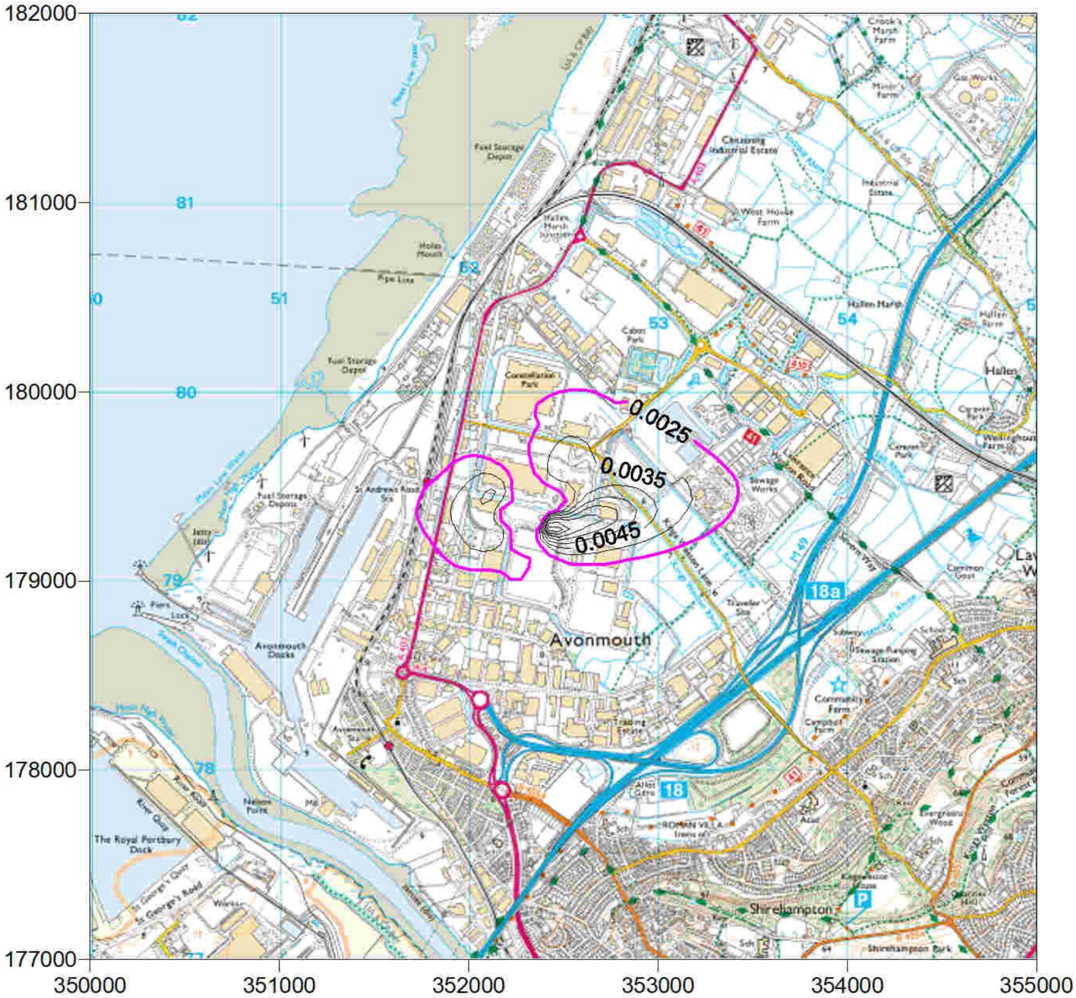
Table 33 Maximum Process Contribution for PAH as (B[a]P)

Statistic	Assessment Level (ng m^{-3})	Averaging Period	Approximate Concentration (ng m^{-3})	Percentage of the AQS
Annual (PC)	0.25	Annual	0.0113	**4.5 %**
Annual (PEC)			0.11	45 %

Detailed modelling predicts a maximum annual average process contribution for B[a]P of approximately 0.0113 ng m^{-3}, or about 4.5 % of the AQS objective. As such, the annual average PC is not immediately screened as insignificant. However, when calculating the PEC using data from DEFRA's interactive map of ambient air quality[16] which suggests an annual average B[a]P level around Avonmouth of less than 0.1 ng m^{-3}, the PEC equates to approximately 45 % of the AQS and is screened at the secondary assessment stage, as not significant.
Although background concentrations measured in central Bristol at the St. Pauls monitoring site report much higher PAH concentrations in the city centre, these elevated concentrations cover a relatively small area, and it is considered more appropriate to apply the background concentrations from the interactive mapping.

Figure 19 below presents the process contribution plot for PAH as B[a]P, with the point at which the contributions become insignificant shown by the magenta-coloured contour.

Figure 19 Annual Average Process Contribution of PAH as B[a]P (ng m^{-3}); 2019 Meteorological Conditions. Magenta Isopleth Denotes the Point of Insignificance for B[a]P (1 % of the AQS)



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As noted above, PAH as B[a]P is measured in Bristol at St. Pauls. This monitoring station is located approximately 9 km to the south-east of the Facility, and is within the Bristol Air Quality Management Area. Measured levels of B[a]P recorded at the monitoring station during 2021 reported 0.21 ng m^{-3} B[a]P, equating to approximately 88 % of the EAL. This is significantly above the background suggested by the interactive map for the Avonmouth area, but is similar to the levels suggested by the interactive mapping for the Bristol city centre area. Therefore, it is considered likely that the levels of B[a]P around the Avonmouth industrial estate, which is not within any Air Quality Management Area, are likely to be similar to those levels proposed by the interactive map and have been applied in Table 33 at the top of the given range (0.1 ng m^{-3}).

4.18 Comparison Against Permitted Emissions

Recognising that the current application is for a variation to an existing Environmental Permit, a comparison can be made against the currently permitted emissions from the site process. Table 34 over page provides this assessment, considering previous modelling results (2012), and those now predicted.

Table 34 Comparison of Existing and Proposed Permit Conditions

Pollutant (µg m^{-3})	Averaging Period	2012 Modelling Result (30 m stack)	Re-Modelled with Wind Turbines (31.13 m stack)	Proposed Process Contributions (36.5 m stack)	Impact of Proposal
Oxides of Nitrogen - Ecological Assessment	Daily	42.9	160.4	48.4	Improvement
	Annual	5.1	7.9	1.4	Improvement
Nitrogen Dioxide	Hourly (99.79th %)	29.0	56.2	14.3	Improvement
	Annual	3.6	5.5	0.95	Improvement
Particulates (PM_{10})	Daily (90.41st %)	2.1	1.7	2.04	Improvement from original
	Annual	0.26	0.395	0.056	Improvement
Sulphur Dioxide	15-minute (99.9th %)	27.8	42.9	11.4	Improvement
	Hourly (99.73rd %)	20.7	39.7	10.1	Improvement
	Daily (99.18th %)	10.7	23.0	3.7	Improvement
	Annual	1.3	1.98	0.337	Improvement
Carbon Monoxide (mg m^{-3})	8-Hourly Rolling	0.017	0.11	0.059	Improvement from re-modelling
Hydrogen Chloride	Hourly	4.1	173.1	55.0	Improvement from re-modelling
Hydrogen Fluoride	Hourly	0.41	17.31	9.17	Improvement from re-modelling
	Daily	0.21	0.80	0.404	Improvement from re-modelling
	Weekly	0.08	0.29	0.062	Improvement
	Annual	0.03	0.04	0.011	Improvement
Cadmium and Thallium	Hourly	0.021	0.886	0.18	Improvement from re-modelling
	Annual	0.001	0.002	0.0002	Improvement
Mercury	Hourly	0.021	0.886	0.18	Improvement from re-modelling
	Annual	0.001	0.002	0.0002	Improvement
Group 3 Metals	Hourly	0.207	8.86	2.75	Improvement from re-modelling
	Annual	0.013	0.02	0.0034	Improvement
Dioxins and Furans	Annual	2.6×10^{-09}	3.92×10^{-09}	4.5×10^{-10}	Improvement

For the majority of pollutants and averaging periods, the amended discharge conditions, emissions, and increased stack height show an improvement, that is a reduced impact, from proposed process contributions when compared to the permitted operation.

For pollutants and averaging periods which did not demonstrate an improvement from the original (2012) modelling exercise, specifically when considering short-term impacts, re-modelling to include the as-built, existing, stack height and incorporating new features such as the local wind-turbines confirms that the new Facility will reduce the process contribution at the point of maximum impact, sometimes substantially, from the existing permitted installation should it operate in the current landscape.

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5. Impact of Short-Term Releases

In addition to the basic model parameters included in the study, consideration has been given to the potential for higher emission rates, through the modelling of short-term allowable emission levels, specified in the Industrial Emissions Directive. Although the daily emission limit values specified in the Directive are expected to be met for the vast majority of the time, the Directive does allow for transient increases in the emitted concentration of some pollutants and as such, a series of half-hourly average limit values are specified which have been modelled to estimate the maximum likely half-hourly average process contribution values.

Due to the transient nature of these permissible conditions, it is inappropriate to apply long-term averaging periods when considering the process contributions. It should be noted that if the Facility continually operated at the half-hourly limits presented in Table 35, the daily limits would be exceeded. The Facility is designed to achieve the daily limits specified in the BAT-Conclusions document[7], and as such would only operate at the shorter-term limits for short periods on rare occasions.

Table 35 Modelled Short-Term Emission Values

Pollutant Species	30-Minute Average Concentration (mg Nm^{-3})	Release Rate (g s^{-1})
NO_x	400	3.847
SO_2	200	1.924
CO	100	0.962
Particulate Matter (as PM_{10})	30	0.289
HCl	60	0.577
HF	4	0.038
Total / Volatile Organic Compounds (VOC)	20	0.192

The impact of short-term (30-minute) operational releases is considered in Table 36 with the likely process contributions from discharges at the maximum half-hourly limit values presented.

Table 36 Maximum Process Contributions During Short-Term (30-Minute ELV) Operating Conditions

Pollutant	Percentile	Short-Term PC (µg m^{-3})	Short-Term AQS / EAL	PC % AQS / EAL	Short-Term PEC (µg m^{-3})	*Short-Term AQS / EAL	PC % ST AQS / EAL
Hourly NO_2	99.79th	47.8	200	**24 %**	72.4	175	**27 %**
15-Minute SO_2	99.9th	75.9	266	**29 %**	88.8	253	**30 %**
Hourly SO_2	99.73rd	67.3	350	**19 %**	80.3	337	20 %
8-Hourly CO ~	100th	0.11	10	1.1 %	0.38	9.74	1.2 %
Hourly CO ~	100th	0.92	30	3.1 %	1.18	29.74	3.1 %
24-Hour PM_{10}	90.41st	1.33	50	2.7 %	27.92	23.41	5.7 %
Hourly HCl	100th	550.1	750	**73 %**	550.9	749	**73 %**
Hourly HF	100th	36.7	160	**23 %**	41.4	155	**24 %**
Hourly Benzene	100th	183.4	195#	**94 %**	183.8	194.56	**94 %**

Hourly process contribution of NO_2 is assumed to equate to 35 % of the total NO_x.
* The secondary short term assessment level is the AQS / EAL minus twice the background.
~ CO results are reported in mg m^{-3}.
# Although no hourly average EAL is currently available for Benzene this was, until recently specified as 195 µg m^{-3} and this has been applied in the Table 36 as the most appropriate assessment level for process contributions from the half-hourly ELV.

Outliers from the 100th percentile assessment are considered in detail in Section 6.

Although not always screened as insignificant when applying the standard assessment approach, each of the process contributions and predicted environmental concentrations remain within the relevant assessment level when discharging at the allowable half-hourly limit values and are therefore unlikely to result in an exceedance of the air quality standards or environmental assessment levels.

Figures 20 and 21 present the 2022 process contribution plots for short-term emissions of NO_2 and SO_2 when accounting for the allowable exceedances specified by the air quality standards. The magenta isopleths denote the point of insignificance, where the PC reaches 10 % of the assessment level, being 20 µg m^{-3} for NO_2 and 26.6 µg m^{-3} for SO_2, and the limited extent of the areas which cannot immediately be screened as insignificant is noted.

Figure 20 99.79th Percentile Hourly Average Process Contribution Due to Short-Term Releases of NO_2 (µg m^{-3}); 2022 Meteorological Conditions.

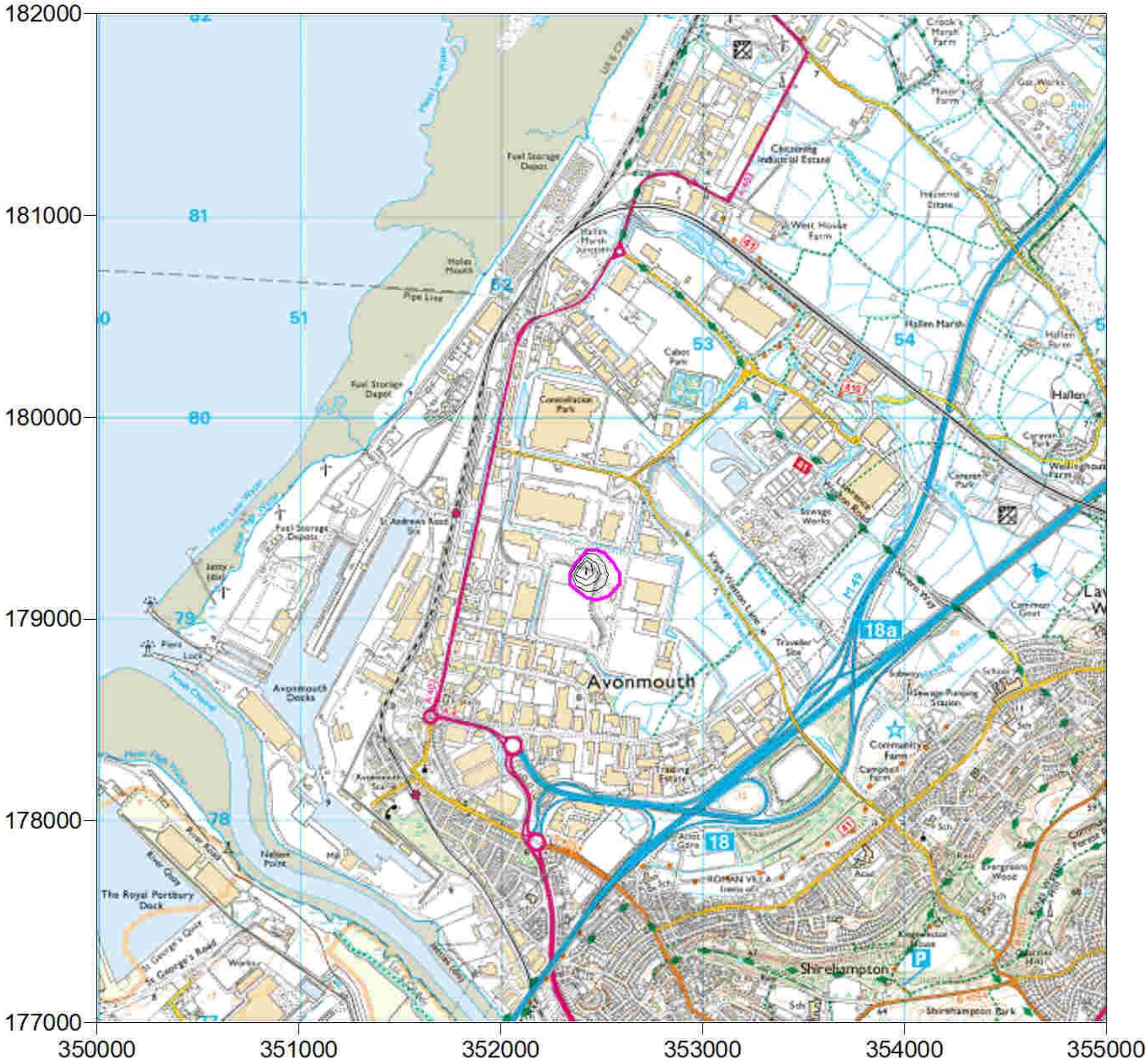

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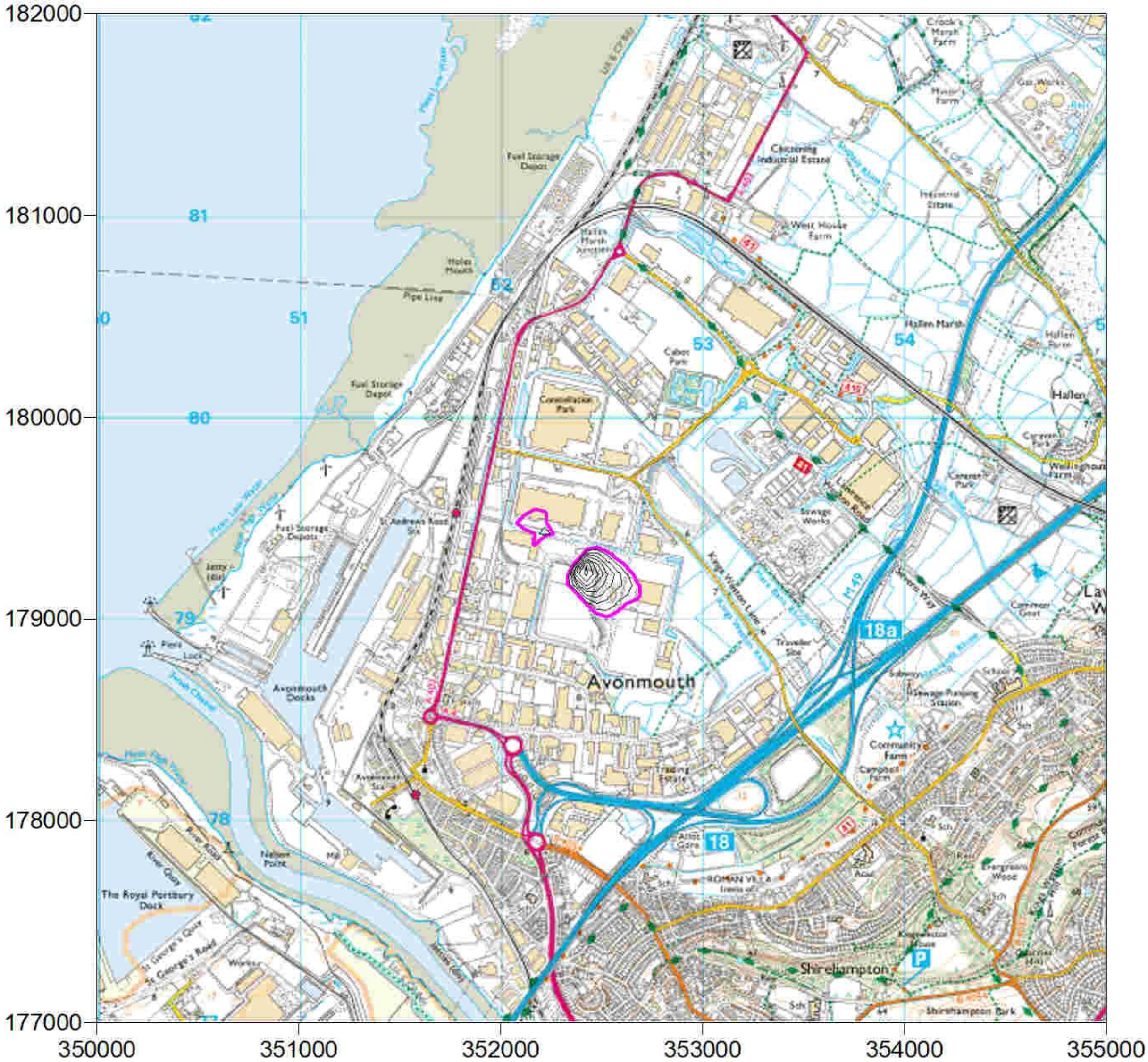
Figure 21 99.9th Percentile 15-Minute Average Process Contribution Due to Short-Term Releases of SO_2 (µg m^{-3}); 2022 Meteorological Conditions.



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6. Outlier Results

When modelling the 100th percentile average figures of each pollutant, the highest gridded results were substantially higher than the majority. The affected results varied in number, but each occurred in the vicinity of the Accolade Wines wind-turbine, located to the north of the Grundon stack.

Correspondence with CERC, the ADMS model producers, confirmed that the higher results were caused by a combination of a high thrust coefficient from the turbine and the location of the plume.

In assessing one line of meteorological data where this occasional phenomenon occurred, CERC confirmed that the plume centreline happened to go almost straight through the Accolade Wines wind turbine at the hub height. At this time, the local wind speed behind the hub drops to almost zero due to the turbine removing almost all of the momentum from the upwind flow and, coupled with the increase in turbulence behind the hub from the operation of the turbine, results in the plume slowing down and spreading rapidly which increases the ground-level concentration suddenly.

CERC went on to say that *"We think the model is overdoing the slow-down for this case so we would advise not to consider this met line."*

CERC offered a number of options to remove the spurious data from the model runs, such as removing or adapting the meteorological data line that impacted the results, or considering the 99.9th percentile instead of the 100th which would remove the unreasonably high concentrations.

As an alternative, Envisage has provided below a summary of the results that are most significantly affected by this phenomenon and a plot that shows the occurrence of the elevated concentrations. This confirms that all of the elevated concentrations occur in the down-wind vicinity of the Accolade Wines wind turbine, thereby supporting the outcome of the CERC investigation.

The maximum 100th percentile average figures occurred when applying meteorological data from 2022. Although, as would be expected, different lines of meteorological data impact the different averaging periods, the same lines of meteorological conditions impacted the hourly maximums (hour 4,879); the 8-hour maximums (hour 4,897); and the 24-hour maximums (hour 4,896) for each pollutant species considered.

Table 37 below summarises the number of results predicted to not achieve insignificance when modelling the 100th percentile hourly average. It also specifies the point at which the process contributions from daily or half-hourly release rate modelling become insignificant and it is noted that these contributions also all occur in the vicinity of the Accolade Wines wind turbine.

The 'New Maximum' figures and grid references specified in Table 37 identify the point of maximum process contribution outside of the influence of the Accolade Wine wind turbine, and can be considered to be a more realistic maximum PC from the Facility. Contributions of TVOC are assessed against the hourly and 24-hour assessment levels for Benzene.

Other species and averaging periods screen as insignificant, although may also experience some elevated concentrations occurring down-wind of the wind turbine when modelling the 100th percentile. Pollutants assessed using lower percentile averages are not considered here.

Table 37 Summary of Outlier Results

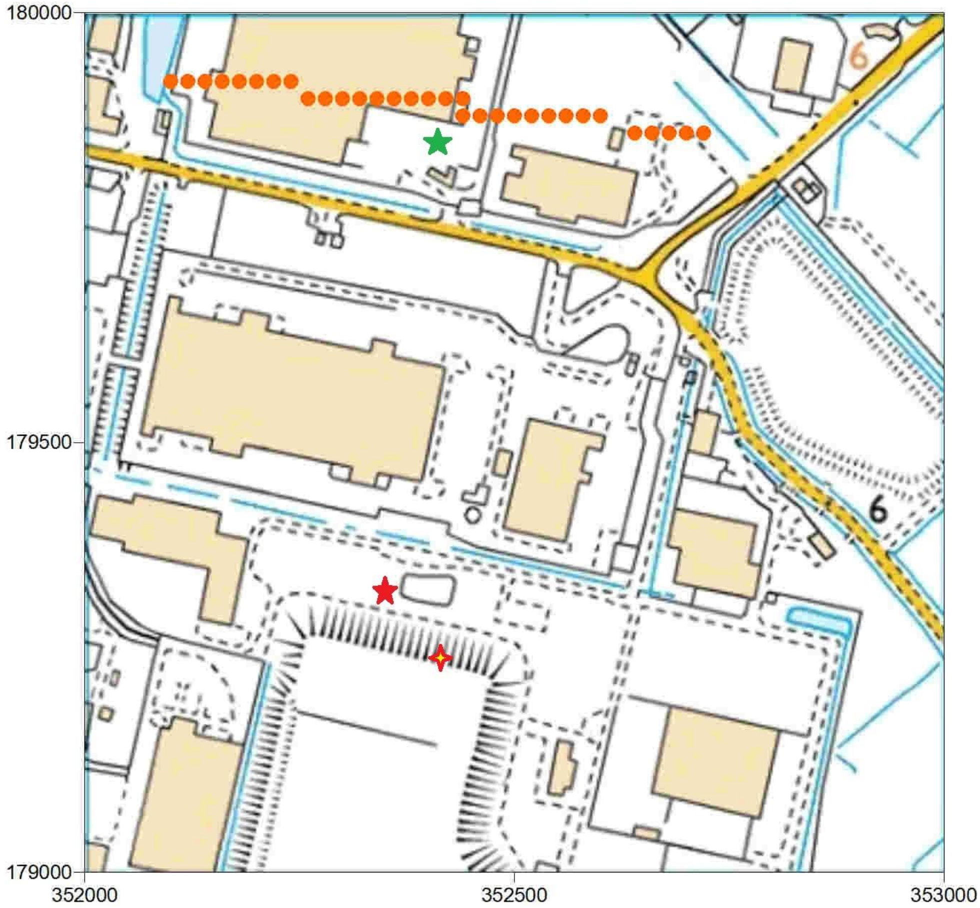
Half-Hourly Release Rates:								
Pollutant	**10 % of EAL**	**No. of Results Exceeding 10 %**	**Next Highest Concentration**	**X**	**Y**	**New Maximum**	**X**	**Y**
TVOC	19.5	32	18.87	352260	179920	7.24	352420	179240
HCl	75	27	70.41	352600	179880	21.72	352420	179240
HF	16	6	15.41	352340	179900	1.45	352420	179240
Daily Release Rates:								
Pollutant	**10 % of EAL**	**No. of Results Exceeding 10 %**	**Next Highest Concentration**	**X**	**Y**	**New Maximum**	**X**	**Y**
TVOC	3	2	2.86	352280	179900	1.39	352420	179280

The results from modelling the daily average release rate of other pollutants immediately screen as insignificant, although still include some outliers. Elevate concentrations of the 100th percentile hourly average Ammonia, HCl, HF, CO, Mercury and Dioxins and Furans / Dioxins and Furans and PCBs, and the maximum 8-hour average of CO all halve in value in the seven highest results. The location of each of these seven highest results occur in the location of the wind-turbine, at the same grid references as the maximum half-hourly outliers.

Figure 22 below shows the location of the 32 TVOC results that cannot immediately be screened as insignificant when compared against the hourly average assessment level for Benzene and when modelling the permissible half-hourly release rate of TVOC. All of the results that cannot be screened as insignificant occur in the immediate vicinity of the Accolade Wines wind turbine, which is marked with a green star. The elevated concentrations of all other pollutants also occur at a number of these same reference points, although TVOC has the maximum number of contributions that are not immediately screened. Therefore, the points impacted by all other pollutants are fewer in number, albeit occurring in the same overall location.

The location of the Facility stack is indicated with a red star in Figure 22 and the location of the highest predicted process contributions when modelling the half-hourly average release rates outside of the wind turbine's influence, is indicated by the coloured cross to the south-east of the stack.

Figure 22 Location of All Outlier Results



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With all 100th percentile contributions screening as insignificant outside of this small area, and with these elevated results clearly being impacted by what CERC describe as the model *'overdoing the slow-down'*, it is considered appropriate to simply discount these elevated concentrations in-lieu of removing or adapting the meteorological data line that is impacting the results, or considering the 99.9th percentile rather than the 100th percentile.

7. Air Quality Impact at Specific Receptors

The ADMS model was set up to calculate the impact of emissions at thirty specific receptors in the vicinity of the Facility. The locations of these receptors were shown in Figure 4 and represent locations where members of the general public may be present for extended periods of time, either through residence in a particular area, or as a result of their employment. The results have been assessed and, where the maximum pollutant contribution could not immediately be screened as insignificant, are summarised in the following table in order to assess the potential impact at the specific locations.

As Tables 38 and 39 only detail the results at receptors which do not immediately screen as insignificant, most of the human health receptors are not listed. However, for all pollutants at all locations other than those detailed below, the process contributions equate to less than 1 % of the long-term and less than 10 % of the short-term assessment level, and are therefore deemed to have an insignificant potential impact on air quality and human health.

Where impacts were screened when considering the maximum point of contribution throughout Section 4, process contributions at all of the nearby receptor locations will also be screened at the first stage of the assessment. Where this was not the case, the predicted environmental concentrations screened at the second stage for all receptors, with the PEC of all pollutants remaining within 70 % of the assessment level. Therefore, the proposal is not considered to have any significant impact at sensitive receptors.

Table 38 Results from Detailed Assessment for Specific Human Health Receptors 1 – 5

Pollutant	Statistic	1 Open Space off Zinc Road	2 Business to the E	3 Business to the SE	4 Business to the S	5 Business to the SW
Annual Average NO_2 (µg m^{-3}) Background Conc. = 12.33 µg m^{-3}	PC	0.828	0.641	Screened as insignificant	Screened as insignificant	0.528
	% AQS/EAL	**2%**	**2%**			**1%**
	PEC	13.15	12.97			12.85
	% AQS/EAL	33%	32%			32%
Annual Average TVOC as Benzene (µg m^{-3}) Background Conc. = 0.218 µg m^{-3}	PC	0.099	0.076	Screened as insignificant	Screened as insignificant	0.063
	% AQS/EAL	**2%**	**2%**			**1%**
	PEC	0.317	0.294			0.281
	% AQS/EAL	6%	6%			6%
Annual Average Cadmium (ng m^{-3}) Background Conc. = 0.13 ng m^{-3}	PC	0.197	0.153	0.065	0.052	0.126
	% AQS/EAL	**4%**	**3%**	**1.3%**	**1%**	**3%**
	PEC	0.327	0.283	0.195	0.182	0.256
	% AQS/EAL	7%	6%	4%	4%	5%
24-Hour Average Cadmium (ng m^{-3}) Background Conc. = 0.13 ng m^{-3}	PC	3.326	Screened as insignificant	Screened as insignificant	Screened as insignificant	Screened as insignificant
	% AQS/EAL	**11.09 %**				
	PEC	3.59				
	% AQS/EAL	12 %				
	PC as % revised ST EAL	11.2 %				
Annual Average Lead (µg m^{-3}) Background Conc. = 0.004 µg m^{-3}	PC	0.003	Screened as insignificant	Screened as insignificant	Screened as insignificant	Screened as insignificant
	% AQS/EAL	**1.2%**				
	PEC	0.007				
	% AQS/EAL	2.6%				
24-Hour Average Copper (µg m^{-3}) Background Conc. = 0.0035 µg m^{-3}	PC	0.0499	0.0118	0.0132	0.0111	0.0160
	% AQS/EAL	**99.78%**	**23.60%**	**26.40%**	**22.11%**	**32.03%**
	PEC	0.0569	0.0188	0.0202	0.0181	0.0230
	% AQS/EAL	**113.8%**	**37.6%**	**40.4%**	**36.1%**	**46.0%**
	% AQS/EAL where PC = 9.7 %	9.68%	2.29%	2.56%	2.14%	3.11%
Hourly Average Nickel (µg m^{-3}) Background Conc. = 0.00081 µg m^{-3}	PC	0.115	Screened as insignificant	Screened as insignificant	Screened as insignificant	Screened as insignificant
	% AQS/EAL	**16.48%**				
	PEC	0.116				
	% AQS/EAL	16.60%				
	PC as % revised ST EAL	16.52%				
Annual Average B[a]P (ng m^{-3}) Background Conc. = 0.1 ng m^{-3}	PC	0.010	0.008	0.0033	0.0026	0.006
	% AQS/EAL	**4%**	**3%**	**1.3%**	**1%**	**3%**
	PEC	0.110	0.108	0.103	0.103	0.106
	% AQS/EAL	44%	43%	41%	41%	43%

Table 39 Results from Detailed Assessment for Specific Human Health Receptors 6 - 9

Pollutant	Statistic	6 Business to the W	7 Business to the NW	8 Business to the SW	9 Mere Bank / Sewage Works
Annual Average Cadmium (ng m^{-3}) Background Concentration = 0.13 ng m^{-3}	PC	Screened as insignificant	Screened as insignificant	Screened as insignificant	0.060
	% AQS/EAL				**1.2%**
	PEC				0.190
	% AQS/EAL				4%
24-Hour Average Copper (µg m^{-3}) Background Conc. = 0.0035 µg m^{-3}	PC	0.0076	0.0067	0.0057	0.0063
	% AQS/EAL	15.21%	13.44%	11.33%	**12.68%**
	PEC	0.0146	0.0137	0.0127	0.0133
	% AQS/EAL	29.2%	27.4%	25.3%	**26.7%**
	% AQS/EAL where PC = 9.7 %	1.48%	1.30%	1.10%	1.23%
Annual Average B[a]P (ng m^{-3}) Background Conc. = 0.1 ng m^{-3}	PC	Screened as insignificant	Screened as insignificant	Screened as insignificant	0.003
	% AQS/EAL				**1.2%**
	PEC				0.103
	% AQS/EAL				41%

8. Air Quality Impact at Air Quality Monitoring Receptors

The ADMS model was also set up to calculate the impact of emissions at four nearby specific receptors where Bristol City Council undertakes air quality monitoring, or has done until recently. The location of these receptors was shown in Figure 4 as receptor numbers 31 to 34, and only receptor number 31 (the diffusion tube located on Third-Way in Avonmouth) is still monitored. The results of the maximum annual average process contribution to background concentrations of NO_2 at each of these locations are presented in Table 40 below.

Table 40 Results from Detailed Assessment for Nitrogen Dioxide at Nearby Air Quality Monitoring Locations

Receptor	Annual Average NO_2 PC ($\mu g\ m^{-3}$)	Percentage of the AQS/EAL	Background Concentration ($\mu g\ m^{-3}$)*	PEC ($\mu g\ m^{-3}$)	Percentage of the AQS/EAL
31	0.143	0.36 %	28.6	28.74	**72 %**
32	0.026	0.06 %	28.6	28.63	**72 %**
33	0.027	0.07 %	22.4	22.43	56 %
34	0.024	0.06 %	27.3	27.32	68 %

Measured background concentrations from 2019 are applied in the assessment in order to negate any influence from the Covid lock-down periods.

The results show that the increase in annual average NO_2 concentrations at each of the nearby monitoring sites is a fraction than 1 % of the AQS objective value, and is therefore immediately screened as insignificant. When considered in relation to the existing background, annual average NO_2 process contributions attributable to the operation of the Facility do not trigger any exceedance of the AQS objective value and nor do the contributions result in an overall predicted environmental concentration equating to more than 70 % of the AQS, where this is not already the case at these monitoring points.

9. Impact of Emissions on Nearby Ecological Receptors

Sixteen ecological receptor locations were incorporated into the ADMS model representing designated ecological habitats within a 10 km radius of the development site, and Sites of Nature Conservation Interest (SNCIs) or Bristol Wildlife Sites within 2 km of the site. Additionally, Receptor number 9 represents not only the Avonmouth Sewage Treatment Works but also the Mere Bank and Hoar Gout, an SNCI located to the north-east of the development site. The ecological habitats included in the assessment were listed in Table 5 and most were also shown in Figure 4.

9.1 Assessment Relative to Critical Level Values

Annual average process contributions of NO_x, Ammonia, SO_2 and HF were calculated for each of the ecological receptors using the ADMS model, and the predicted increases were compared against their respective critical level values as specified by the Environment Agency[4]. The critical levels are summarised in the following table.

Table 41 Critical Levels for NO_x, SO_2, NH_3 and HF

Pollutant	Averaging Period	Critical Level ($\mu g\ m^{-3}$)
Oxides of Nitrogen (NO_x as NO_2)	Annual	30
Oxides of Nitrogen (NO_x as NO_2)	24 hr	75
Sulphur Dioxide (Forests and Natural Vegetation)	Annual	10 - 20
Ammonia (Other Vegetation)	Annual	1 - 3
Hydrogen Fluoride	Daily	5
Hydrogen Fluoride	Weekly	0.5

Where a range exists for the critical levels (CLs) the more stringent (lowest) levels have been applied as appropriate to the Severn Estuary (SO_2) and Avon Gorge Woodlands (SO_2 and NH_3) national site network areas, with the higher CLs applied to other sites. The results from the critical levels assessment are presented in the tables below. As the environmental assessment level for ecological receptors considers NO_x as NO_2, the results provided are of total NO_x.

Table 42 Critical Levels Assessment for NO_x and SO_2

Ecological Receptor Name	Annual NO_x PC ($\mu g\ m^{-3}$)	Percentage of Critical Level	Daily NO_x PC ($\mu g\ m^{-3}$)	Percentage of Critical Level	Annual SO_2 PC ($\mu g\ m^{-3}$)	Percentage of Critical Level
Mere Bank / Hoar Gout	0.359	**1.2 %**	2.536	3.4 %	0.0898	0.4 %
Severn Estuary 1	0.127	0.4 %	1.716	2.3 %	0.0317	0.3 %
Severn Estuary 2	0.141	0.5 %	1.792	2.4 %	0.0353	0.4 %
Severn Estuary 3	0.036	0.1 %	0.544	0.7 %	0.0090	0.1 %
Severn Estuary 4	0.121	0.4 %	0.816	1.1 %	0.0301	0.3 %
Avon Gorge Woodlands 1	0.008	0.03 %	0.391	0.5 %	0.0021	0.02 %
Avon Gorge Woodlands 2	0.004	0.01 %	0.200	0.3 %	0.0011	0.01 %
Hallen Marsh Junction	0.144	0.5 %	1.007	1.3 %	0.0360	0.2 %
St Andrews Road Rhine	0.371	**1.2 %**	4.713	6.3 %	0.0927	0.5 %
Salt Rhine and Moorhouse Rhine	0.159	0.5 %	1.157	1.5 %	0.0398	0.2 %
Gloucester Road Railway Siding	0.070	0.2 %	0.947	1.3 %	0.0175	0.1 %
Fields along the M5	0.122	0.4 %	0.841	1.1 %	0.0306	0.2 %
Kings Weston Lane Rhine	0.600	**2.0 %**	3.400	4.5 %	0.1499	0.7 %
Lawrence Weston Road Rhines	0.264	0.9 %	1.542	2.1 %	0.0660	0.3 %
Long Cross Tip	0.073	0.2 %	0.886	1.2 %	0.0183	0.09 %
Lawrence Weston Bowl	0.051	0.2 %	0.935	1.2 %	0.0127	0.06 %
Barracks Lane Rhine Complex	0.036	0.1 %	1.400	1.9 %	0.0089	0.04 %

As can be seen in the above table and with the exception of Mere Bank / Hoar Gout, St Andrews Road Rhine and Kings Weston Lane Rhine, the annual average process contributions of NO_x (as NO_2) at each of the receptors considered are less than 1 % of the 30 µg m^{-3} CL for NO_x. The daily process contributions of NO_x (as NO_2) and the annual average contributions of SO_2 screen as insignificant at all reported receptors.

The three sensitive ecological receptors at which process contributions of long-term NO_x are not immediately screened as insignificant are all SNCIs. Contributions equate to between 1.2 and 2 % of the assessment levels and as such can be screened from further study in accordance with the Environment Agency guidance[4] which states that, where both the short and long-term process contributions remain within 100 % of the relevant environmental standard, they can be screened as insignificant.

The corresponding values for Ammonia and Hydrogen Fluoride are detailed in Table 43 below:

Table 43 Critical Levels Assessment for NH_3 and HF

Ecological Receptor Name	Annual NH_3 PC (µg m^{-3})	Percentage of Critical Level	Daily HF PC (µg m^{-3})	Percentage of Critical Level	Weekly HF PC (µg m^{-3})	Percentage of Critical Level
Mere Bank / Hoar Gout	0.0299	1.0 %	0.0211	0.4 %	0.0088	1.8 %
Severn Estuary 1	0.0106	0.4 %	0.0143	0.3 %	0.0060	1.2 %
Severn Estuary 2	0.0118	0.4 %	0.0149	0.3 %	0.0076	1.5 %
Severn Estuary 3	0.0030	0.1 %	0.0045	0.1 %	0.0019	0.4 %
Severn Estuary 4	0.0100	0.3 %	0.0068	0.1 %	0.0045	0.9 %
Avon Gorge Woodlands 1	0.0007	0.07 %	0.0033	0.07 %	0.0007	0.1 %
Avon Gorge Woodlands 2	0.0004	0.04 %	0.0017	0.03 %	0.0003	0.1 %
Hallen Marsh Junction	0.0120	0.4 %	0.0084	0.2 %	0.0057	1.1 %
St Andrews Road Rhine	0.0309	**1.0 %**	0.0393	0.8 %	0.0166	3.3 %
Salt Rhine and Moorhouse Rhine	0.0133	0.4 %	0.0096	0.2 %	0.0035	0.7 %
Gloucester Road Railway Siding	0.0058	0.2 %	0.0079	0.2 %	0.0031	0.6 %
Fields along the M5	0.0102	0.3 %	0.0070	0.1 %	0.0030	0.6 %
Kings Weston Lane Rhine	0.0500	**1.7 %**	0.0283	0.6 %	0.0140	2.8 %
Lawrence Weston Road Rhines	0.0220	0.7 %	0.0129	0.3 %	0.0073	1.5 %
Long Cross Tip	0.0061	0.2 %	0.0074	0.1 %	0.0025	0.5 %
Lawrence Weston Bowl	0.0042	0.1 %	0.0078	0.2 %	0.0026	0.5 %
Barracks Lane Rhine Complex	0.0030	0.1 %	0.0117	0.2 %	0.0026	0.5 %

With the exception of the contribution of Ammonia at St Andrews Road Rhine which is marginally over 1 %, and the 1.7 % contribution of annual average Ammonia at Kings Weston Lane Rhine, process contributions at each of the reported ecological receptors are less than 1 % of the 3 µg m^{-3} critical level for ecological protection from Ammonia (1 µg m^{-3} when considering the Avon Gorge Woodlands), and can be screened out as insignificant. However, as above, although exceeding 1 %, the process contribution of NH_3 at the two SNCIs remain within 100 % of the assessment level and therefore can still be screened as insignificant. The daily and weekly average process contributions of Hydrogen Fluoride at all sites remain within 10 % of the short-term CLs and hence are also screened as insignificant.

It should also be borne in mind that all of the reported results are based upon a series of worst-case assumptions, including continual discharge at the emission limit values that the site will be required to work to and as such, may overestimate their significance by an appreciable margin. Accordingly, the impact of emissions from the Facility on nearby ecological habitats, in relation to critical level values, will be very low and will have an insignificant impact on sensitive species at these locations.

9.2 Assessment Relative to Site-Specific Critical Load Values

Sensitive ecological receptors may also be sensitive to nutrient Nitrogen and acid deposition, and where relevant, an assessment has been made of the potential for deposition to occur. Information on site specific critical loads and background levels of nutrient Nitrogen and acid deposition were obtained from the APIS website.[17] The Severn Estuary is specified on the APIS website as not being sensitive to acid deposition.

The following deposition velocities were applied to the study to calculate the levels of deposition from the release point:

Dry deposition of:	Grassland Velocity (m s^{-1})	Forest Velocity (m s^{-1})
NO_2	0.0015	0.003
NH_3	0.02	0.03
SO_2	0.012	0.024
HCl	0.025	0.06

In the absence of a stated dry deposition velocity for HF, deposition was modelled and assumes that HF is a reactive gas.

The model was run to include outputs for dry deposition based on the relevant deposition factors specified above, for each site, whereby only the Avon Gorge Woodlands SAC was considered to be a forest receptor, and all others were modelled as grassland receptors. Wet deposition was also modelled and applied the default washout coefficients: A = 0.0001 and B = 0.64.

The following methods were applied when calculating total nutrient Nitrogen and acid deposition rates.

Nitrogen Based Species

Levels of NO_x dry deposition were multiplied by 0.7 in order to represent the deposited level of NO_2, as NO does not deposit in any significant quantity. The resultant µg m^{-2} s^{-1} figures were multiplied by 95.9 to calculate the contributions to nutrient Nitrogen deposition. Levels of nutrient Nitrogen from Ammonia releases were calculated by multiplying the dry deposited Ammonia level reported from the modelling exercise by 260, before the contributions from NO_2 and NH_3 releases were summed to provide a total kg N ha^{-1} $year^{-1}$ nutrient Nitrogen deposition loading.

When calculating the Nitrogen based component of acid deposition, the µg m^{-2} s^{-1} dry deposition figures were multiplied by 6.84 (NO_2) and 18.5 (NH_3) to calculate individual contributions of Nitrogen based species to acid deposition, before the figures were summed to provide a total keq ha^{-1} $year^{-1}$ Nitrogen based acid loading.

Sulphur and Hydrogen Based Species

Similar to the calculation of acid deposition from Nitrogen species, the dry deposition levels of SO_2 reported by the model in µg m^{-2} s^{-1} were multiplied by 9.84. Due to their higher levels of solubility, levels of total (wet and dry) deposition of HCl and HF were multiplied by 8.63 and 15.77 respectively to calculate those species' contributions to acid deposition. Finally, the Sulphur and Hydrogen based deposition rates were summed to provide a total S and H keq ha^{-1} $year^{-1}$ acid loading.

The total concentrations of pollutant substances were applied to the deposition calculations and thus results can be considered to represent a worst-case.

The results in Table 44 relate to the maximum annual average nutrient Nitrogen deposition at nearby designated ecological habitats and SNCIs, associated with emissions of NO_2 and NH_3 from the Facility.

Table 44 Results from Detailed Modelling of Nitrogen Deposition in Relation to the Site-Specific Critical Load

Ecological Receptor Name	N Deposition (kgN/ha/yr)	% Lower Critical Load (10 kgN/ha/yr)	% Higher Critical Load (20 kgN/ha/yr)
Mere Bank / Hoar Gout	0.1918	**1.9 %**	0.96 %
Severn Estuary 1	0.0678	0.7 %	0.34 %
Severn Estuary 2	0.0754	0.8 %	0.38 %
Severn Estuary 3	0.0193	0.2 %	0.10 %
Severn Estuary 4	0.0644	0.6 %	0.32 %
Avon Gorge Woodlands 1	0.0072	0.1 %	0.04 %
Avon Gorge Woodlands 2	0.0037	0.04 %	0.02 %
Hallen Marsh Junction *	0.0770	**1.5 %**	0.77 %
St Andrews Road Rhine	0.1981	**2.0 %**	0.99 %
Salt Rhine and Moorhouse Rhine	0.0851	0.9 %	0.43 %
Gloucester Road Railway Siding	0.0374	0.4 %	0.19 %
Fields along the M5	0.0653	0.7 %	0.33 %
Kings Weston Lane Rhine	0.3203	**3.2 %**	**1.60 %**
Lawrence Weston Road Rhines	0.1411	**1.4 %**	0.71 %
Long Cross Tip	0.0391	0.4 %	0.20 %
Lawrence Weston Bowl	0.0272	0.3 %	0.14 %
Barracks Lane Rhine Complex	0.0191	0.2 %	0.10 %

* Receptor Number 41 (Hallen Marsh Junction) has more stringent critical loads ranging from 5 – 10.

The results in Table 44 confirm that, for the most part, contributions of nutrient Nitrogen to the local sensitive ecological receptors remain within 1 % of both the lower and the higher ends of the critical load range and hence are immediately screened as insignificant. Where contributions equate to more than 1 % of the lower range of the critical loads (Mere Bank / Hoar Gout; Hallen Marsh Junction; St Andrews Road Rhine; Kings Weston Land Rhine and Lawrence Western Road Rhines), these generally remain within 1 % of the upper range of the critical loads for the site. The one exception to this is the contribution to the Kings Weston Lane Rhine, where the Facility is predicted to contribute up to 1.6 % of the CL for nutrient Nitrogen deposition. Although the existing background level of nutrient Nitrogen deposition is reported to be approximately 12.8 kgN ha^{-1} $year^{-1}$, or 64 % of the upper CL, the small additional process contributions can still be screened as they remain within 100 % of the critical load and, as a locally designated ecological receptor (SNCI), this is sufficient to demonstrate that contributions to the Kings Weston Lane Rhine will not be significant.

It should be noted that exceedance of a critical load is not a quantitative estimate of damage to a particular habitat but instead represents the potential for damage to occur. Accordingly, and noting that the incremental increase in Nitrogen deposition attributable to emissions of NO_x and NH_3 from the Facility is very small at all receptors, it is unlikely to have a measurable effect on the integrity of the any of the ecological habitat sites considered.

The results for the associated acid deposition are summarised in Table 45 over page.

In line with the method for calculating exceedances of the acidity critical load function guidance provided on the APIS website[17], the first stage in the assessment considers the contribution of the predicted environmental concentration of Nitrogen based acid deposition to the CLminN assessment level as, only if the PEC is greater than CLminN will the additional Nitrogen deposition from the source contribute to acidity. Nitrogen deposition considers contributions from NO_x and Ammonia and where the PEC is more than 100 % of the CLminN, the total acid deposition is subsequently assessed against the CLmaxN assessment level. Where the PEC from Nitrogen based sources is less than 100 %, the assessment of acid deposition considers only contributions from the Sulphur and Hydrogen based species (SO_2, HCl, and HF).

Contributions from NO_x, Ammonia and SO_2 consider levels of dry deposition only, whereas for contributions of HCl and HF, total deposition rates are applied.

Table 45 Results from Detailed Modelling of Acid Deposition in Relation to Site-Specific Critical Loads

Habitat	N Based Acid Deposition	CLMin N	N Based Background	PEC	Is PEC > CLminN	S & H Based Acid Deposition	Total Acid Deposition (N, S and H)	Lowest CLmaxN or S	PC as % CLmaxN / S
	(keq/ha/yr)					(keq/ha/yr)			
Mere Bank / Hoar Gout	0.01365	1.071	0.91	0.924	No	0.0157	0.0293	4	0.73%
Avon Gorge Woodlands 1	0.00051	0.856	1.73	1.731	Yes	0.0007	0.0013	4.856	0.03%
Avon Gorge Woodlands 2	0.00026	0.856	1.83	1.830	Yes	0.0004	0.0006	4.856	0.01%
Hallen Marsh Junction	0.00548	1.071	0.92	0.925	No	0.0063	0.0118	4	0.29%
St Andrews Road Rhine	0.01410	1.071	0.91	0.924	No	0.0161	0.0302	4	0.76%
Gloucester Road Railway Siding	0.00266	1.071		0.003	No	0.0030	0.0057	4	0.14%
Fields along the M5	0.00465	1.071	0.97	0.975	No	0.0053	0.0100	4	0.25%
Long Cross Tip	0.00278	1.071	0.94	0.943	No	0.0031	0.0059	4	0.15%
Lawrence Weston Bowl	0.00193	1.071	0.94	0.942	No	0.0022	0.0041	4	0.10%
Barracks Lane Rhine Complex	0.00136	0.928	0.94	0.941	Yes	0.0015	0.0029	4.928	0.06%

Data is not provided for the Severn Estuary as it is not sensitive to acid deposition.

Predicted environmental concentrations of Nitrogen based acid deposition (keq ha^{-1} yr^{-1}) exceed the CLminN at only three of the ten sensitive ecological receptors under consideration, being the two Avon Gorge Woodlands sites and at the Barracks Lane Rhine Complex. At each of the other sites for which an acid critical load is specified, the Nitrogen based acid PECs remain within the CLminN and hence only Sulphur is considered in the second half of the assessment, as the small levels of Nitrogen are not expected to contribute to the acidity levels. The remainder of the ecological receptors are either not sensitive to acid deposition (Severn Estuary), or no comparable acid critical load is specified on the UK APIS website.

When considering the relevant total acid deposition rates, either as Nitrogen, Sulphur and Hydrogen based species at Avon Gorge Woodlands and the Barracks Lane Rhine Complex , or when considering contributions from Sulphur and Hydrogen based species only at all other receptor locations, the process contributions to acid remain within 1 % of the relevant maximum critical load at all sites and the potential impact from the Facility is therefore screened as insignificant.

10. Cumulative Impact with Other Recent Developments and Proposals

Although the potential impacts of the Facility are effectively screened as insignificant or are deemed to not be significant at the secondary assessment stage, it is important to consider the impact in conjunction with other operations in the vicinity that might also impact on air quality locally. Although existing facilities are naturally considered through the incorporation of a background level, which will include contributions from those sites which are already operational, where new plant are proposed, are under construction or have only recently been commissioned, it is likely that the contributions from those plant will not be included in the existing background data, and thus a cumulative impact assessment must consider the likely overall impact of the future operations.

The air quality assessment prepared for submission with the planning application considered six new, or recently approved activities in the Avonmouth area. Two of these applications (GEPII Limited and EL (Avonmouth) Limited considered the development of gas fired engines, each of which was scheduled to operate for less than 20 % of the year. Phase 8 of the Access 18 development and the Flogas pipeline were considered for their impacts on traffic emissions only, and at the time of preparing the air quality assessment for the planning submission, no quantitative data was found to be available for developments at either the Veolia resource recovery facility, nor the Viridor resource recovery centre, both based in Avonmouth. As such, a partly qualitative assessment was made on the likely cumulative impact of the newer developments around the Avonmouth area at the planning stage.

Due to the recent issue (September 2022) of the Environmental Permit to Viridor for their Avonmouth Resource Recovery Centre, and the relatively recent (March 2020) increase in permitted capacity of the Suez Recycling and Recovery UK Limited Severnside Energy Recovery Centre (SERC), data on the emissions from these plant have now been obtained[18 and 19], and have been considered in combination with the emissions from the Facility now proposed by Grundon. The input details for the two installations now considered cumulatively with the Facility are detailed over page. The highest buildings associated with both the Viridor and Suez plants were also included in the modelling exercise and each was associated as the main building to the relevant site stack(s).

Contributions of Carbon Monoxide, particulate matter and PCBs were immediately screened as insignificant in the initial Grundon Facility assessment and hence have not been included here. Similarly, no cumulative assessment is provided for Dioxins and Furans which have no air quality or environmental assessment level.

Table 46 Cumulative Assessment Input Data

Parameter	Viridor	Suez Line 1	Suez Line 2
Height of Release (m)	90	118	118
Diameter (m)	2.48	1.76	1.76
Location (x,y)	353862,181627	353802,182718	353804,182720
Flue-Gas Temperature (ºC)	140	152	154
Flue-Gas Moisture Content (%)	15.69	20.7	18.7
Flue-Gas Oxygen Content (% dry)	8.0	8.7	8.0
Volumetric Flowrate (Actual) (m^3 s^{-1})	93.10	63.13	73.02
Volumetric Flowrate (STP, dry, 11 % O_2) (m^3 s^{-1})	67.54	39.56	49.37
Flue-Gas Velocity (m s^{-1})	19.27	25.95	30.02
Mass Releases (g s^{-1})	**Viridor**	**Suez Line 1**	**Suez Line 2**
Oxides of Nitrogen	13.508	7.911	9.875
Sulphur Dioxide	3.377	1.978	2.469
Ammonia	0.675	0.396	0.494
Hydrogen Chloride	0.675	0.396	0.494
Hydrogen Fluoride	0.068	0.079	0.099
VOCs (as Benzene)	0.675	0.396	0.494
Cadmium and Thallium	0.003	0.00198	0.00247
Mercury	0.003	0.00198	0.00247
Lead (for heavy metals)	0.034	0.01978	0.0247
PAH (as B[a]P)	0.0000135	0.0000042	0.0000052

Having regard to the meteorological conditions that resulted in the maximum process contributions when modelling the Grundon Facility in isolation, meteorological conditions from 2018; 2019 and 2022 were modelled during the cumulative assessment.

The results of the cumulative impact assessment are presented in the following table.

Table 47 Human Health Assessment of Maximum Cumulative Process Contributions

Pollutant	Averaging Period and Units	Maximum Cumulative Contribution	Assessment Level	Percentage of Assessment Level	PEC (PC plus Local Background)	Percentage of Assessment Level	Revised ST Assessment Level*	PC as Percentage of Revised EAL
Nitrogen Dioxide	Annual µg m^{-3} (NO_2 = 70 % NO_x)	1.38	40	**3.4%**	13.71	34%	-	-
	99.79 % Hourly µg m^{-3} (NO_2 = 50 % NO_x)	21.24	200	**10.6%**	45.89	22.9%	175	12.1%
	99.79 % Hourly µg m^{-3} (NO_2 = 35 % NO_x)	14.87	200	7%	39.52	19.8%	175	8.5%
Sulphur Dioxide	99.9 % 15-Min µg m^{-3}	11.85	266	4%	24.81	9.3%	253	4.7%
	99.73 % Hourly µg m^{-3}	10.51	350	3%	23.47	6.7%	337	3.1%
	99.18 % Daily µg m^{-3}	5.42	125	4%	18.38	14.7%	112	4.8%
Ammonia	Annual µg m^{-3}	0.14	180	0.08%	2.96	2%	-	-
	Hourly µg m^{-3}	4.094	2500	0.2%	10.00	0.4%	2494	0.2%
Hydrogen Chloride	Hourly µg m^{-3}	2.457	750	0.3%	3.28	0.4%	749	0.3%
Hydrogen Fluoride	Annual µg m^{-3} (monthly assessment)	0.014	16	0.09%	2.35	15%	-	-
	Hourly µg m^{-3}	0.409	160	0.3%	5.11	3.2%	155	0.3%
Benzene	Annual µg m^{-3}	0.137	5	**2.7%**	0.355	7.1%	-	-
	Daily µg m^{-3}	1.848	30	6.2%	0.446	1.5%	29.56	6.3%
Cadmium	Annual ng m^{-3}	0.436	5	**8.7%**	0.566	11.3%	-	-
	Daily ng m^{-3}	5.59	30	**18.6%**	5.85	19.5%	29.74	18.8%
Mercury	Daily µg m^{-3}	0.0056	0.06	9.32%	0.0086	14.3%	0.0597	9.4%
	Hourly µg m^{-3}	0.0103	0.6	1.72%	0.0133	2.22%	0.597	1.73%
Lead	Annual µg m^{-3}	0.005	0.25	**2.0%**	0.009	3.4%	-	-
PAH as B[a]P	Annual ng m^{-3}	0.013	0.25	**5.1%**	0.11	45%	-	-
	Hourly ng m^{-3}	0.409	6	6.8%	0.200	3.3%	5.80	7.1%

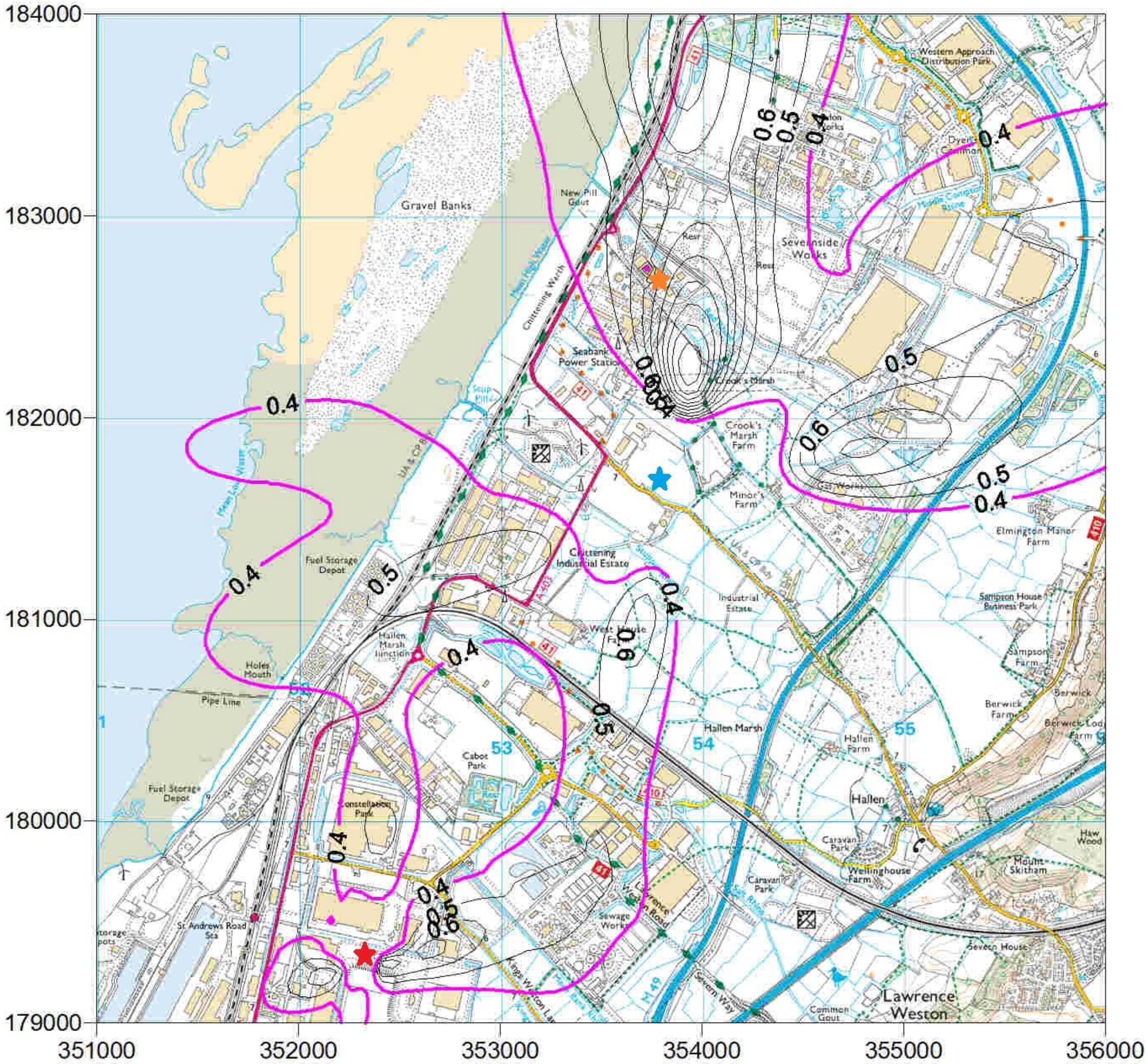
* As previously, the revised short-term assessment level for the second stage assessment is calculated as the air quality standard objective value or environmental assessment level, minus twice the long-term background concentration.

As detailed in Section 2.5, the modelled grids applied when considering the Grundon site in isolation and when modelled cumulatively with other local developments vary and hence the assessment results are not directly comparable. The most significant effect of this slight difference in locations can be seen when considering the maximum (100^{th} percentile) averaging periods, the cumulative results of which are lower than when modelling the Grundon facility in isolation. This reduction in the process contributions with a slight movement of the result location confirms the very limited extent of any elevated concentrations.

The cumulative process contributions of Nitrogen Dioxide, annual average contributions of volatile organic compounds assumed to be 100 % Benzene, contributions of Cadmium and Thallium when considered to comprise solely Cadmium, Lead, and PAH (as B[a]P) do not necessarily immediately screen as insignificant. However, all contributions are confirmed to not be significant when considered at the secondary assessment stage and therefore, there is no significant impact predicted to human health receptors in the area local to the three installations, through their cumulative effect.

Figure 23 depicts the 2022 cumulative annual average process contribution plot of NO_2 across the local area. It is noted that the gridded area of the cumulative modelling is different to that which has been considered when modelling the Grundon Facility in isolation. In Figure 23, the Grundon Facility is located in the south-western area of the grid, and for clarity, the approximate location of the modelled processes has each been indicated with a star.

Figure 23 Cumulative Annual Average Process Contribution of NO_2 (µg m^{-3}); 2022 Meteorological Conditions.



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Red star = Grundon Facility;
Blue star = Viridor Facility;
Orange star = Suez Facility.

When considering the potential impact on the national site network areas of the Severn Estuary and the Avon Gorge Woodland, the following cumulative contributions to the site critical levels are predicted.

Table 48 Critical Levels Assessment of Cumulative Impact

Ecological Receptor Name	Annual NO_X PC (µg m^{-3})	Percentage of Critical Level	Daily NO_X PC (µg m^{-3})	Percentage of Critical Level	Annual SO_2 PC (µg m^{-3})	Percentage of Critical Level
Severn Estuary 1	0.559	**1.9 %**	3.77	5.0 %	0.140	**1.4 %**
Severn Estuary 2	0.667	**2.2 %**	5.07	6.8 %	0.167	**1.7 %**
Severn Estuary 3	0.241	0.8 %	3.11	4.1 %	0.060	0.6 %
Severn Estuary 4	0.735	**2.4 %**	7.15	9.5 %	0.184	**1.8 %**
Avon Gorge Woodlands 1	0.087	0.3 %	2.00	2.7 %	0.022	0.2 %
Avon Gorge Woodlands 2	0.055	0.2 %	1.12	1.5 %	0.014	0.1 %
Ecological Receptor Name	**Annual NH_3 PC (µg m^{-3})**	**Percentage of Critical Level**	**Daily HF PC (µg m^{-3})**	**Percentage of Critical Level**	**Weekly HF PC (µg m^{-3})**	**Percentage of Critical Level**
Severn Estuary 1	0.0316	**1.1 %**	0.0278	0.6 %	0.0157	3.1 %
Severn Estuary 2	0.0361	**1.2 %**	0.0322	0.6 %	0.0230	4.6 %
Severn Estuary 3	0.0130	0.4 %	0.0246	0.5 %	0.0081	1.6 %
Severn Estuary 4	0.0411	**1.4 %**	0.0403	0.8 %	0.0222	4.4 %
Avon Gorge Woodlands 1	0.0046	0.5 %	0.0151	0.3 %	0.0033	0.7 %
Avon Gorge Woodlands 2	0.0029	0.3 %	0.0085	0.2 %	0.0019	0.4 %

Although cumulative contributions are not immediately screened as insignificant at all of the modelled points across the Severn Estuary, the addition of background concentrations of NO_x (17.5 µg m^{-3}), SO_2 (1.6 µg m^{-3}) and Ammonia (1.4 µg m^{-3}) confirm that the predicted environmental concentrations of all pollutants remain within 70 % of their critical level, being 61 %, 18 % and 48 % for NO_x, SO_2 and NH_3 respectively at the receptor named Severn Estuary 4, and are therefore considered to not be significant.

When considering the potential contribution to nutrient Nitrogen critical loads, cumulative contributions are again not screened at three of the four modelled points representing the Severn Estuary.

Table 49 Results from Detailed Modelling of Nitrogen Deposition in Relation to the Site-Specific Critical Load

Ecological Receptor Name	N Deposition (kgN/ha/yr)	% Lower Critical Load (10 kgN/ha/yr)	% Higher Critical Load (20 kgN/ha/yr)
Severn Estuary 1	0.2206	**2.2 %**	**1.1 %**
Severn Estuary 2	0.2546	**2.5 %**	**1.3 %**
Severn Estuary 3	0.0919	0.92 %	0.46 %
Severn Estuary 4	0.2876	**2.9 %**	**1.4 %**
Avon Gorge Woodlands 1	0.0532	0.53 %	0.27 %
Avon Gorge Woodlands 2	0.0335	0.34 %	0.17 %

However, with an existing nutrient Nitrogen deposition level of 12.94 kgN ha^{-1} yr^{-1}, the overall predicted environmental concentration (13.23 kgN ha^{-1} yr^{-1}) equates to 66 % of the higher critical load and is therefore unlikely to have any significant effect on the sensitive ecological site.

When assessing the potential impact of cumulative acid deposition on to the Avon Gorge Woodland, the contributions immediately screen as insignificant.

Table 50 Results from Cumulative Modelling of Acid Deposition in Relation to Site-Specific Critical Loads

Habitat	N Based Acid Deposition	CLMin N	N Based Background	PEC	Is PEC > CLminN	S & H Based Acid Deposition	Total Acid Deposition (N, S and H)	Lowest CLmaxN or S	PC as % CLmaxN / S
	(keq/ha/yr)					(keq/ha/yr)			
Avon Gorge Woodlands 1	0.0038	0.856	1.73	1.734	Yes	0.0077	0.0115	4.856	0.24 %
Avon Gorge Woodlands 2	0.0024	0.856	1.83	1.832	Yes	0.0049	0.0073	4.856	0.15 %

The small increase in the overall contributions of pollution will also have limited impact on the predicted impacts at local ecological sites, which all previously screened as insignificant.

In summary therefore, it is concluded that the additions from the Facility remain acceptable whether considered in isolation or in combination with existing and planned processes.

11. Conclusions

Detailed atmospheric dispersion modelling has been undertaken of emissions to atmosphere from a Facility to be operated by Grundon, on Zinc Road of the Avonmouth industrial estate. Modelling of the emissions from the Facility was undertaken for a scenario that represents normal operating conditions while operating at maximum output and discharging emissions to atmosphere via a 36.5-metre-high stack. Short-term (half-hourly) emissions were also modelled and reported. Emissions were based upon the achievable limits for new plant, as specified in the BAT-Conclusions document, with half-hourly limits drawn from the Industrial Emissions Directive.

The modelling was undertaken using ADMS Version 6 and incorporated various sensitivity analyses in order to ensure that the model presented a reasonable worst-case assessment. Hourly average meteorological data for the Bristol Airport measurement station for the years 2018 to 2022 were used to determine maximum process contributions across a 5 km x 5 km receptor grid with 20-metre grid spacing, as well as specified nearby receptor locations.

The model predicted that process contributions for all modelled pollutants would be well below the objective limits defined within the UK Air Quality Standards Regulations, or relevant environmental assessment levels recommended by the Environment Agency, with all impacts either screening as insignificant or being deemed to not be significant at the secondary assessment stage or when applying more detailed analysis.

Annual average process contributions of Nitrogen Dioxide were not screened as insignificant across all locations of the modelled grid, with the model predicting a maximum NO_2 process contribution (being 70 % of NO_x) of 0.95 µg m^{-3}, equating to approximately 2.4 % of the AQS. Coupled with the existing estimated background concentration (12.33 µg m^{-3}) the resultant PEC of 13.27 µg m^{-3} equates to approximately 33 % of the AQS and, remaining within 70 % of the assessment level, is not considered to have a significant impact on air quality.

It is noted that the area in the vicinity of the Facility would not generally be considered to be a sensitive human health receptor area for annual average contributions, and at all modelled human health receptors, the impact on levels of Nitrogen Dioxide is also screened either at the initial or secondary assessment stage. Similarly, all other pollutants screen when considering either the process contribution or the overall predicted environmental concentration and their potential effects on human health.

Contributions at three of the modelled sensitive ecological receptors are also not immediately screened as insignificant. However, each of the affected sites are SNCIs and Environment Agency guidance states that, where both the short and long-term process contributions remain within 100 % of the relevant environmental standard for locally designated ecological areas, they can be screened as insignificant. As this is the case at each of the SNCIs, the Facility is deemed not to have any significant potential effect on these sites. Contributions of pollutants in air and nutrient Nitrogen and acid deposition to both the Severn Estuary and Avon Gorge Woodlands national site network areas are so small as to be screened as insignificant.

Short-term process contributions and predicted environmental concentrations also remained within their stated Environmental Quality Standards when discharging at the allowable half-hourly limit values and were therefore screened as not significant, although the contributions of several pollutants do exceed the 20 % screening criteria for short-term assessment levels.

An assessment of the cumulative impact of emissions from the Facility along with the Viridor Avonmouth Resource Recovery Centre, and the Suez Recycling and Recovery UK Limited Severnside Energy Recovery Centre, both of which are located in the vicinity, did not fundamentally change the conclusions of the assessment undertaken for the Grundon Facility in isolation. Despite the concentration and point of maximum impact changing in the cumulative assessment, impacts that could not be screened as insignificant were ultimately shown to not be significant.

The overall conclusion from detailed modelling of emissions from the Facility to be operated by Grundon was that the potential impact on local air quality is likely to be small, generally being screened as insignificant and will not therefore have any significant impact on the health of people living and working nearby, or on the surrounding environment.

12. References

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