ARUP

British Land

20 Triton Street

Laboratory Feasibility Emissions Study

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1. Introduction

Ove Arup and Partners Ltd (Arup) has been commissioned to prepare a laboratory feasibility emissions study for 20 Triton Street. The development proposal is for a new extract system that will serve fume cupboards installed on laboratory-enabled floors in the building. The location of 20 Triton Street is shown in Figure 1.

In order to support the laboratory operation, a fume extract system will be required, and this study will focus on the emissions via one flue at roof level.

This assessment outlines the relevant air quality standards (Section 2), outlines the methodology in detail (Section 4), and then determines the emission rates to minimise the short-term and long-term effect of emissions from the Proposed Development (Section 6).

1.1 Site information

The laboratory emissions will be discharged into the atmosphere via one at the roof level. Details of the extract fan were obtained from the design team.

The exact details of the laboratory operations are not yet known during the preparation of this report, which is based on currently available information provided by the project team.

The laboratory emissions will be designed to the standards defined in HSE guidance[1] for a containment level 2 laboratory. As defined in the HSE guidance a containment level 2 laboratory does not require HEPA filters (or similar filtration) to be added for input and extract air from the workplace.

1.2 Scope of assessment

The assessment has considered laboratory emissions from one stack associated with the laboratory. At the time of preparing this report, the exact pollutants used by the laboratory is unknown, therefore, the assessment has considered environmental standards for all pollutants defined by the Environment Agency to determine the maximum allowable emission of substances to the air from the stack in connection with the proposed laboratory use. These solvents can become airborne and directly lead to, or contribute to, adverse impacts on heath and the environment, by reacting with other air pollutants outdoors in the presence of sunlight to produce tropospheric ozone. Two commonly used solvents in laboratories have been chosen as representative pollutants in this study: benzene and formaldehyde.

[1] Health and Safety Executive, Management and operation of microbiological containment laboratories, Advisory Committee on Dangerous Pathogens, March 2019

Figure 1: Proposed Development Location

2. Air quality standards

This section sets out the relevant guidance and legislation associated with any emissions to air from the Proposed Development.

2.1 Environment Act 2021

The Environment Bill become an Act[2] (law) in November 2021. The Environment Act 2021 amends the Environment Act 1995[3] It also amends the Clean Air Act 1993[4] to give local authorities more power at reducing local pollution, particularly that from domestic burning. It also amends the Environmental Protection Act 1990[5] to reduce smoke from residential chimneys by extending the system of statutory nuisance to private dwellings.

The following sections of the Environment Act 1995[3] have been transposed into the Environment Act 2021:

For the Secretary of State to develop, implement and maintain an Air Quality Strategy. This includes the statutory duty, also under Part IV of the Environment Act 1995, for local authorities to undergo a process of local air quality management and declare an AQMA where pollutant concentrations exceed the national air quality objectives. Where an AQMA is declared, the local authority needs to produce an Air Quality Action Plan (AQAP) which outlines the strategy for improving air quality in these areas.

The Act will implement key parts of the government’s Clean Air Strategy and include targets for tackling air pollution in the UK.

Relevant to air quality:

- For the Secretary of State to publish a report reviewing the Air Quality Strategy every five years;
- For the Office for Environmental Protection to be established[6] to substitute the watchdog function previously exercised by the European Commission;
- For local authorities’ powers to be extended under the current Local Air Quality Management framework, including responsibilities to improve local air quality and to reduce public exposure to excessive levels of air pollution;
- For “air quality partners” to have a duty to share responsibility for dealing with local air pollution among public bodies; and
- Introduces a new power for the government to compel vehicle manufacturers to recall vehicles and non-road mobile machinery if they are found not to comply with the environmental standards that they are legally required to meet.

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[2] Environment Act 2021. Available at: https://www.legislation.gov.uk/ukpga/2021/30/contents/enacted. Accessed [Accessed November 2024].

[3] Environment Act 1995, Chapter 25, Part IV Air Quality

[4] Clean Air Act 1993. Available at: https://www.legislation.gov.uk/ukpga/1993/11/contents. [Accessed November 2024]

[5] Environmental Protection Act 1990. Available at: https://www.legislation.gov.uk/ukpga/1990/43/contents. [Accessed November 2024]

[6] Environment Act 2021. Chapter 2. The Office for Environmental Protection.

2.2 UK Environmental Assessment Levels

Environmental Assessment Levels (EALs) are defined by the Environment Agency[7] for a greater range of pollutants than covered by the Air Quality Standards Regulations 2010[8], in terms of annual average (long-term) levels and short-term average levels. If EALs are exceeded by emissions from a process, the operator may need to take further action in order to obtain a permit.

Formaldehyde and benzene have been chosen as representative pollutants in this study. The long and short-term EAL for formaldehyde and benzene is presented in Table 1.

Table 1: Environmental assessment level (EAL) for formaldehyde and benzene

Pollutant	Averaging period	EAL (µg/m^3)
Formaldehyde	Annual mean	5
	30 minute mean	100
Benzene	Annual mean	5*
	Daily	30
Note: *Benzene annual mean EAL is based on a limit value[9]		

The assessment has considered environmental standards for all pollutants defined by the Environment Agency to determine the maximum allowable emission of substances to the air from the stack in connection with the proposed laboratory use (see Appendix B).

2.3 Assessment criteria used in this study

Predicted formaldehyde and benzene process contributions will be compared with 10% of the relevant EALs, as presented in Table 2. The 10% has been selected to provide a robust limit which avoids risks of exceeding relevant EALs. The aim will be for the stack to have an impact on concentrations of less than 10% of the EAL.

Table 2: Assessment criteria for formaldehyde and benzene process contributions in this study

Averaging period	10% of EAL (µg/m^3)
Annual mean	0.5
Daily mean	3.0
30 minute mean	10.0

[7] Environment Agency (2024) Air emission risk assessment for your environmental permit [Available at: https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#environmental-standards-for-air-emissions]

[8] Air Quality Standards Regulations 2010. [Available at: https://www.legislation.gov.uk/uksi/2010/1001/contents/made]

[9] Environment Agency (2016) Air emission risk assessment for your environmental permit [Available at: https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#environmental-standards-for-air-emissions]

3. Planning, Policy and Guidance

3.1 National Policy

3.1.1 National Panning Policy Framework

The National Planning Policy Framework (NPPF)6F[1] was updated in December 2024 with the purpose of planning to achieve sustainable development. Paragraph 199 of the NPPF on air quality states that:

"Planning policies and decisions should sustain and contribute towards compliance with relevant limit values or national objectives for pollutants, taking into account the presence of Air Quality Management Areas and Clean Air Zones, and the cumulative impacts from individual sites in local areas. Opportunities to improve air quality or mitigate impacts should be identified, such as through traffic and travel management, and green infrastructure provision and enhancement. So far as possible these opportunities should be considered at the plan-making stage, to ensure a strategic approach and limit the need for issues to be reconsidered when determining individual applications. Planning decisions should ensure that any new development in Air Quality Management Areas and Clean Air Zones is consistent with the local air quality action plan."

In addition, paragraph 110 states that:

"The planning system should actively manage patterns of growth in support of these objectives. Significant development should be focused on locations which are or can be made sustainable, through limiting the need to travel and offering a genuine choice of transport modes. This can help to reduce congestion and emissions, and improve air quality and public health. However, opportunities to maximise sustainable transport solutions will vary between urban and rural areas, and this should be taken into account in both plan-making and decision-making."

Paragraph 187 discusses how planning policies and decisions should contribute to and enhance the natural and local environment. In relation to air quality, NPPF notes that this can be achieved by:

"e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans."

3.1.2 Planning Practice Guidance

National Planning Practice guidance (PPG) on various topics, including air quality was developed in order to support the NPPF. The guidance provides a concise outline as to how air quality should be considered in order to comply with the NPPF and states when air quality is considered relevant to a planning application. This includes factors such as the introduction of new point sources of air pollution, exposure of people to existing sources of air pollutants, and the potential to give rise to air quality impacts at nearby sensitive receptors.

3.2 Regional Policy

3.2.1 London Plan 2021

The London Plan 2021 forms part of the development strategy for the Greater London Authority (GLA) for the next 20-25 years, and integrates all economic, environmental, transport and social frameworks. This has been amended to be consistent with the NPPF.

Policy SI 1 Improving air quality states:

A. *"Development Plans, through relevant strategic, site-specific and area-based policies, should seek opportunities to identify and deliver further improvements to air quality and should not reduce air quality benefits that result from the Mayor's or borough's activities to improve air quality.*

B. *To tackle poor air quality, protect health and meet legal obligations the following criteria should be addressed*

   1. *Development proposals should not:*

      a. *Lead to further deterioration of existing poor air quality*

      b. *Create any new areas that exceed air quality limits, or delay the date at which compliance will be achieved in areas that are currently in exceedance in exceedance of legal limits*

      c. *Create unacceptable risk of high levels of exposure to poor air quality.*

   2. *In order to meet the requirements in Par 1, as a minimum:*

      a. *Development proposals must at least be air quality neutral*

      b. *Development proposals should use design solutions to prevent or minimise increased exposure to existing air pollution and make provision to address local problems of air quality in preference to pose-design or retro-fitted mitigation measures*

      c. *Major development proposals must be submitted with an Air Quality Assessment. Air quality assessments should know who the development will meet the requirements of B1*

      d. *Development proposals in Air Quality Focus Areas or that are likely to be used by large numbers of people particularly vulnerable to poor air quality, such as children or older people should demonstrate that design measures have been used to minimise exposure.*

C. *Masterplans and development briefs for large-scale development proposals subject to an Environmental Impact Assessment should consider how local air quality can be improved across the area of the proposal as part of an air quality positive approach. To achieve this a statement should be submitted demonstrating:*

   1. *how proposals have considered ways to maximise benefits to local air quality; and*

   2. *what measures or design features will be put in place to reduce exposure to pollution, and how they will achieve this.*

D. *In order to reduce the impact on air quality during the construction and demolition phase development proposals must demonstrate how they plan to comply with the Non-Road Mobile Machinery Low Emission Zone and reduce emissions from the demolition and construction of buildings following best practice guidance.*

E. *Development proposals should ensure that where emissions need to be reduced to meet the requirements of Air Quality Neutral or to make the impact of development on local air quality acceptable, this is done on-site. Where it can be demonstrated that emissions cannot be further reduced by on-site measures, off-site measures to improve local air quality may be acceptable, provided that equivalent air quality benefits can be demonstrated within the area affected by the development."*

Policy GG3 Creating a health city states:

"To improve Londoners' health and reduce health inequalities, those involved in planning and development must:

F. *Seek to improve London's air quality, reduce public exposure to poor air quality and minimise inequalities in levels of exposure to air pollution."*

3.2.2 London Environment Strategy

The London Environment Strategy (LES)[10] was published in May 2018 and sets out the Mayor's vision for London's environment in 2050. It is a strategy that brings together approaches from multiple aspects of London's environment in an integrated document. The key aim is to ensure that emissions and exposure to pollution are reduced and emphasises the importance of considering air quality very early in the design process. This assessment has fed into the design process to help minimise the short-term and long-term effect of formaldehyde emissions from the proposed development.

3.2.3 London Local Air Quality Management Technical Guidance

The Defra Local Air Quality Management Technical Guidance (TG16)[11] provides guidance on air quality assessments for local authorities. This applies to all UK local authorities, however there is specific guidance for the London boroughs. The Local London Local Air Quality Management technical guidance (LLAQM.TG(16)) [12] applies only to London's 32 boroughs (and the City of London). Although the LLAQM.TG(16) technical guidance has many common elements with the updated national guidance (LAQM.TG(16)), it incorporates London-specific elements of the LAQM system.

These guidance documents are designed to support London authorities in carrying out their duties to review and assess air quality in their area. They provided best practice guidance for dispersion modelling which has been followed through this assessment.

3.3 Local Policy

3.3.1 Camden Local Plan

The Camden Local Plan[13] was adopted in July 2017 and is the basis for planning decisions and future development in Camden. Policy CC4, Air Quality states:

> *"The Council will ensure that the impact of development on air quality is mitigated and ensure that exposure to poor air quality is reduced in the borough.*
>
> *The Council will take into account the impact of air quality when assessing development proposals, through the consideration of both the exposure of occupants to air pollution and the effect of the development on air quality."*

The local plan also states that "all development likely to generate nuisance odours should install appropriate extraction equipment and other mitigation measures. These should be incorporated within the building where possible". These policies have been considered through the design process of this proposed development.

3.3.2 The Draft New Camden Local Plan

The council consulted on the Draft new Local Plan[14] from January to March 2024 which will be the basis for planning decisions and future development in Camden. An updated version of the Draft new Local Plan will be published for further consideration in Spring 2025. Policy A3 – Air Quality states:

A. The Council will expect development to contribute to improving air quality in Camden to protect public health. The Council will:

> *i. Require all development to be at least air quality neutral in accordance with the London Plan and associated guidance. An air quality positive approach is encouraged.*

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[10] Greater London Authority (2018) The London Environment Strategy

[11] Department for Environment Food and Rural Affairs (2018), Local Air Quality Management Technical Guidance (TG16).

[12] Greater London Authority (2016) London Local Air Quality Management Technical Guidance TG(16)

[13] Camden Council (2017) Camden Local Plan

[14] Draft New Camden Local Plan (2024)

ii. Require the following types of development to submit an Air Quality Assessment, where requested by the Council, the Air Quality Assessment must be supported by detailed air quality modelling:

a. All major developments;

b. Any development that introduces sensitive uses or occupiers into an area of poor air quality;

c. Development that involves significant demolition, construction and/or earthworks;

d. Any development that could have a significant impact on air quality, either directly or indirectly; or

e. Any development involving a biomass or gas Combined Heat Plant (including connections to existing networks where the increased capacity is not already covered in an existing Air Quality Assessment).

iii. Require all development to use design solutions to reduce exposure to existing poor air quality and address local problems of air pollution.

iv. Resist applications for sensitive uses (such as childcare, schools or accommodation for elderly people) in areas of particularly poor air quality.

v. Resist developments that introduce sensitive uses (e.g., housing) in locations of poor air quality, unless they are designed to substantially mitigate the impact.

vi. Require all development to demonstrate how they plan to meet the GLA emission standards for Non-Road-Mobile-Machinery. We will apply the emission standards for the Central Activities Zone across the whole borough.

vii. Require applicants to consider emergency backup power for development sites (in the operational phase) early in the design process. Non-combustion solutions are expected.

viii. Resist proposals for solid / wood burning heating or catering systems.

ix. Require applicants to give consideration to the actions identified in the Council's Air Quality Action Plan when designing and delivering development.

x. Require applications including commercial cooking to demonstrate how they will mitigate their impact on air quality.

3.4 Camden Planning Guidance on Air Quality

The Council prepared a supplementary planning document on Air Quality[15] to support the policies in the Camden Local Plan. This document details best practice for proposed developments and specifies the scope an air quality assessment should cover:

- Assess local air quality pollutants;
- Assess the current baseline situation in the vicinity of the Proposed Development; and
- Predict the future impact of operation.

3.4.1 Camden Clean Air Action Plan

The Council have prepared a two-part document[16] which sets out Camden's approach for improving air quality and protecting health from exposure to air pollution in Camden.

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[15] Camden Council (2021) Camden Planning Guidance on Air Quality

[16] Camden Clean Air Action Plan

The Camden Clean Air Strategy 2019-2034 sets out the strategic objectives for Camden, in which no person experiences poor health as a result of the air they breathe.

The Camden Clean Air Action Plan 2023-2026 describes the actions that Camden will take that we will take from 2023 to 2026. This follows on from the previous Camden Clean Air Action Plan 2019-2022.

4. Methodology

The overall approach to the air quality assessment comprises:

- A review of environmental standards for all pollutants defined by the Environment Agency to determine the maximum allowable emission of substances to the air from the stack in connection with the proposed laboratory use;
- An assessment of the potential changes in air quality arising from the operation of the laboratory at the Proposed Development; and
- Determination of the emission rates which will keep process contribution at less than 10%[17] of the relevant air quality standard, long-term and short-term EALs.

4.1 Methodology of operational assessment

The operational assessment inputs were as follows:

- information on the stack parameters and locations were obtained as detailed in Section 4.2.1;
- the study area and sensitive receptors likely to experience a significant change in pollution concentrations were identified as shown in Section 4.3;
- a dispersion-model was set-up and appropriate data to describe meteorological conditions in the vicinity of the Proposed Development as detailed in Section 4.3.2;
- a dispersion model was run with an emission of 1g/s from the stack; and
- the predicted process contributions from the dispersion model were used to determine suitable emission rates to minimise the short-term (daily, hourly and 30 minute-mean) and long-term (annual mean) effect of emissions from the Proposed Development, as described in Section 6.

4.1.1 Laboratory emissions

Laboratory emissions from the Proposed Development are planned to discharge via one stack placed three metres above roof level. The location and parameters of the stack are based on information from the design team.

Stack locations and parameters are included in Table 3. The location of the stack is shown in Figure 2.

Table 3: Modelling parameters of the stack

Parameter	Unit	Site parameter
Stacks	-	1
Location of point source	OS Coordinates (X,Y)	528940, 182301
Stack height	m (from ground level)	49.3m
Diameter of point source	m	0.31
Exit temperature	˚C	15
Exit velocity	m/s	10.6
Modelled emission rate	g/s	1.0
Modelled operating hours	-	24 hours, 365 days in year

[17] 10% is selected to provide a robust limit which avoids risks of exceeding air quality standard, odour threshold and short-term EAL.

In addition, in order to gain further understanding of the laboratory emission parameters from the Proposed Development, they have been compared with other typical laboratory stack parameters derived from six recent laboratory assessments conducted by Arup, presented in Table 4. The data below presents typical diameter and velocity used in stacks, in which are separated into strobic fan and standard stack sources. Strobic fans can be used to aid and increase dispersion of emissions sources, as they typically have a greater exit velocity than a standard stack and their design enables creation of an effective stack height, typically 5 – 15 m above their placement.

The laboratory emission parameters from the Proposed Development are within the typical model parameters for a site not using strobic fans.

Table 4: Typical laboratory stack model parameters

Parameter	Unit	Typical Parameters, Strobic Fans	Typical Parameters, Standard Stack
Diameter of point source	m	0.6 – 1.2	0.3 – 1
Exit temperature	˚C	15 – 21	
Exit velocity	m/s	10-32	1-15

Figure 2: Stack Location

4.2 Study area and receptors

Sensitive human and gridded receptors have been selected for the assessment.

4.2.1 Sensitive human receptors

Sensitive human receptors applicable to long-term and short-term locations have been considered at existing and proposed locations. Existing receptors include residential properties, schools, hospitals and locations relevant for short-term exposure, Proposed receptors include air intakes at on-site buildings. The sensitive human receptors closest to the modelled stack are detailed in Table 5 and shown in Figure 3.

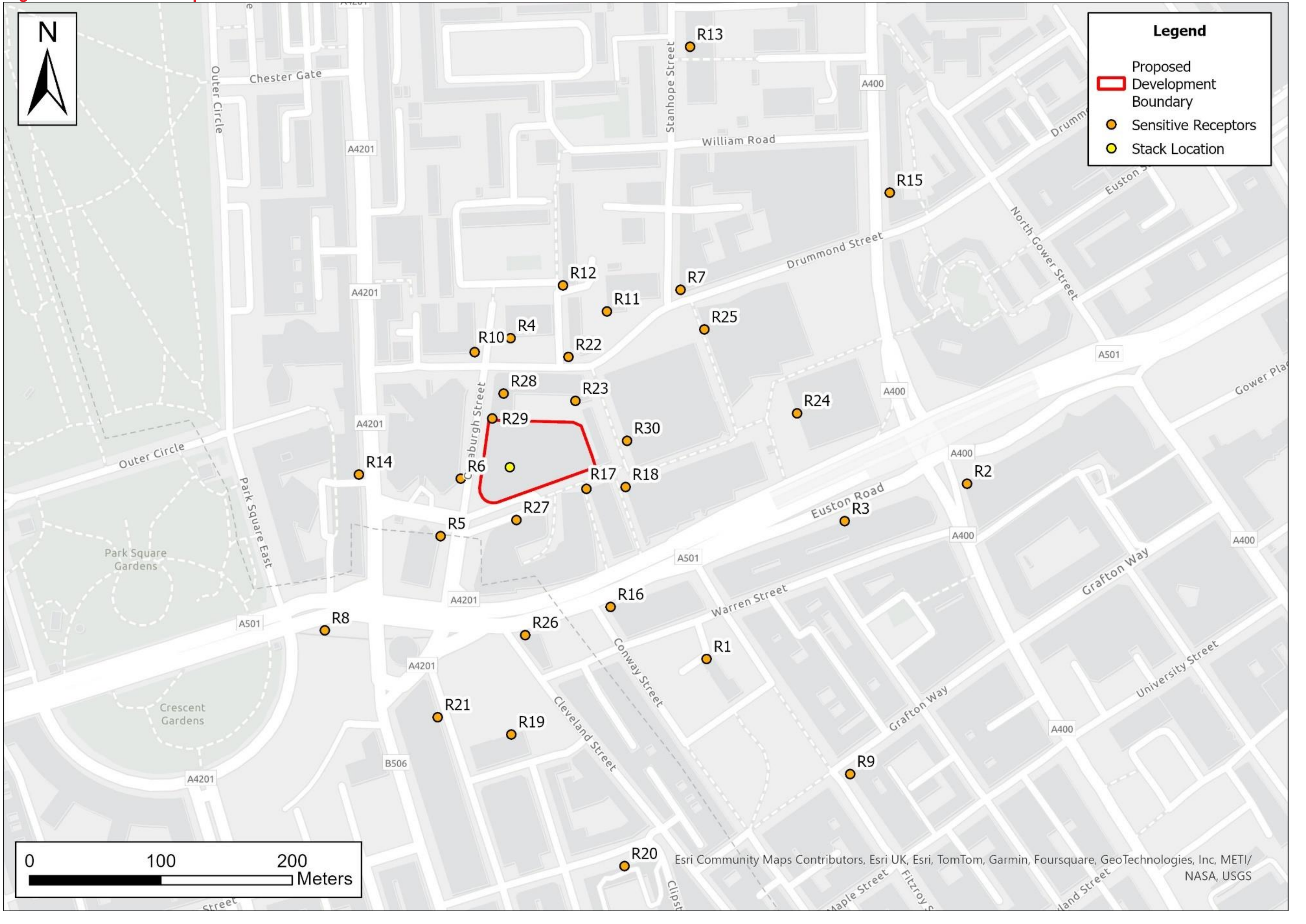
It is not required to model all receptors, worst case locations are selected and where receptors are further from the Proposed Development the concentrations will be lower due to the increased distance for dispersion to take place. As the flues are at height, a variety of heights were modelled on the façade of each receptor building to ensure the highest impact was captured.

Table 5: Details of sensitive human receptors

ID	Name	Type	NGR (m)		Height (m)
			X	Y	
R1	Fitzrovia Hospital	Hospital	529093	182162	1.5, 9, 16.5
R2	University College Hospital	Hospital	529291	182296	1.5, 27, 52.5
R3	UCLH Clinical Microbiology and Virology Department	Hospital	529198	182267	1.5, 7.5, 13.5
R4	St Mary Magdalene, Regents Park	Church	528944	182406	1.5, 7.5, 13.5
R5	Holy Trinity Church	Church	528890	182256	1.5
R6	Melia White House	Hotel	528905	182300	1.5, 12, 24
R7	Schafer House	Hotel	529073	182443	1.5, 13, 24.5
R8	International Students House	Hotel	528802	182184	1.5, 5.5, 9.5
R9	YMCA Indian Student Hostel	Hotel	529202	182075	1.5, 9.5, 17.5
R10	Residential flats - Albany Street	Residential	528916	182396	1.5, 5.5, 9.5
R11	Westminster Kingsway College	Residential	529017	182427	1.5, 5.5, 9.5
R12	Residential flats - Munster Square	Residential	528983	182447	1.5, 5.5, 9.5
R13	Netley Primary School and Centre for Autism	School	529080	182628	1.5, 8, 14.5
R14	Albany Street	Residential	528828	182303	1.5, 6.5, 11
R15	Hampstead Road	Residential	529232	182517	1.5, 6.5, 11
R16	355 Euston Road	Commercial	529020	182202	1.5, 26, 52
R17	Regents Place 350 Euston Road	Commercial	529001	182292	1.5, 35.5, 69.5
R18	Regents Place 2 Triton Square	Commercial	529031	182293	1.5, 35.5, 65.5
R19	Royal National Orthopaedic Hospital	Hospital	528944	182105	1.5, 10.5, 19.5
R20	Holcroft Court	Residential	529030	182005	1.5, 9, 16.5
R21	Central Park Lodge	Residential	528888	182118	1.5, 9, 16.5

ID	Name	Type	NGR (m)		Height (m)
			X	Y	
R22	Residential flats - Longford Street	Residential	528988	182392	1.5, 15, 28.5
R23	Residential flats - Triton Square	Residential	528993	182359	1.5, 10.5, 19.5, 26
R24	Euston Tower	Commercial	529161	182349	1.5, 22, 44, 66, 88, 133
R25	Brock Street Offices	Commercial	529091	182413	1.5, 22, 44
R26	Birkbeck, University of London	School	528955	182181	1.5, 6, 11
R27	10 Triton Street Offices	Commercial	528948	182268	1.5, 22, 44
R28	One Osnaburgh Street	Residential	528938	182364	45, 60
R29	Two Osnaburgh Street	Residential	528929	182345	1.5, 12, 24
R30	1 Triton Square	Commercial	529032	182328	1.5, 26.5, 42

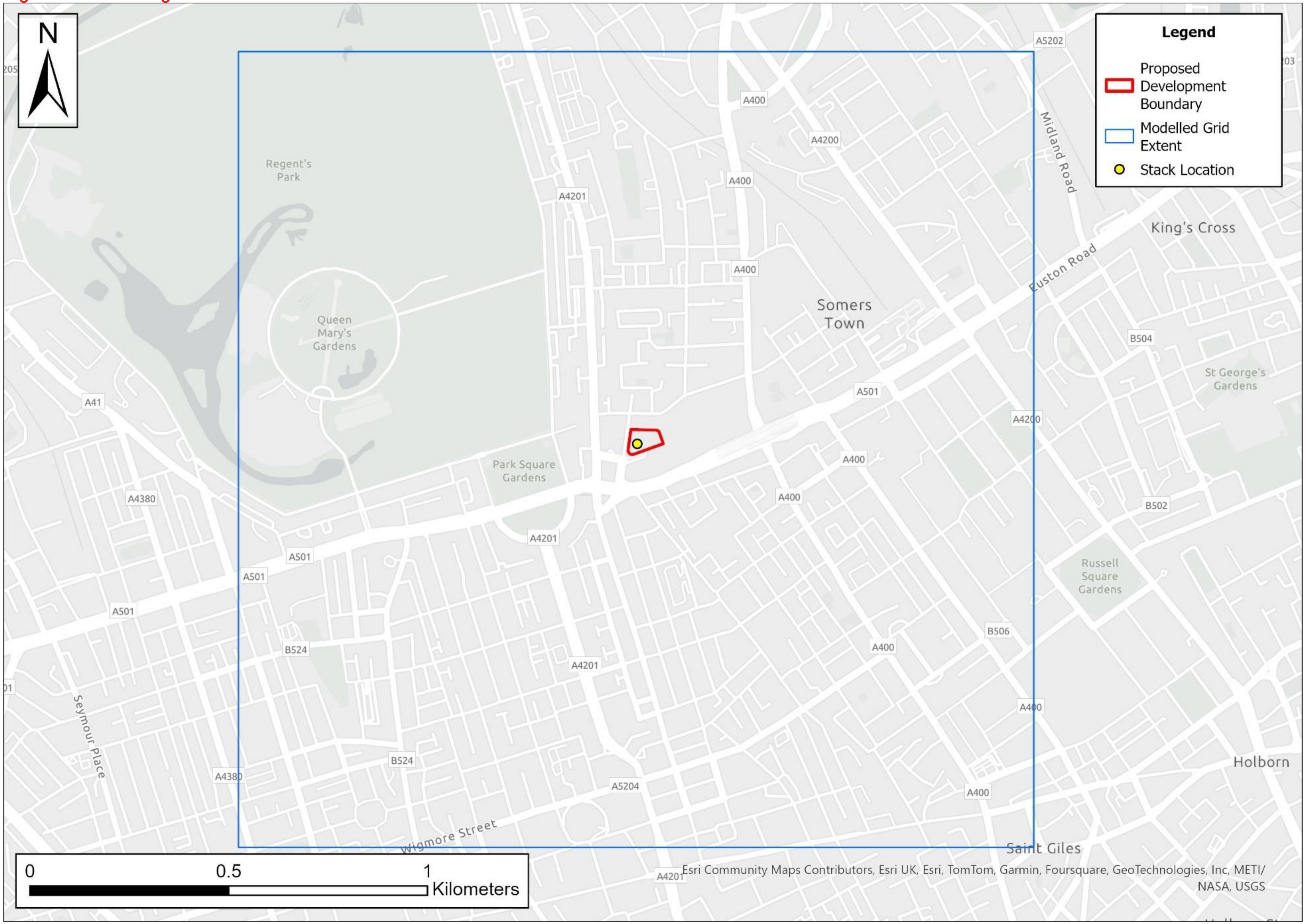
Figure 3: Sensitive receptors included in the assessment



Gridded domain

Process contributions were calculated at gridded receptors covering a 2km x 2km domain with 20m grid spacing. The modelled grid extent was (X,Y) to (X,Y) and the stack is located at the centre of the grid, presented in Figure 4. This method provides an assessment of potential impact across the entire study area, in particular to assess any short-term impacts. The gridded receptors were modelled at the representative inhalation height of a human (1.5m above ground level) and at roof level (43.3m).

Figure 4: Modelled grid included in the assessment



4.2.2 Dispersion model set-up

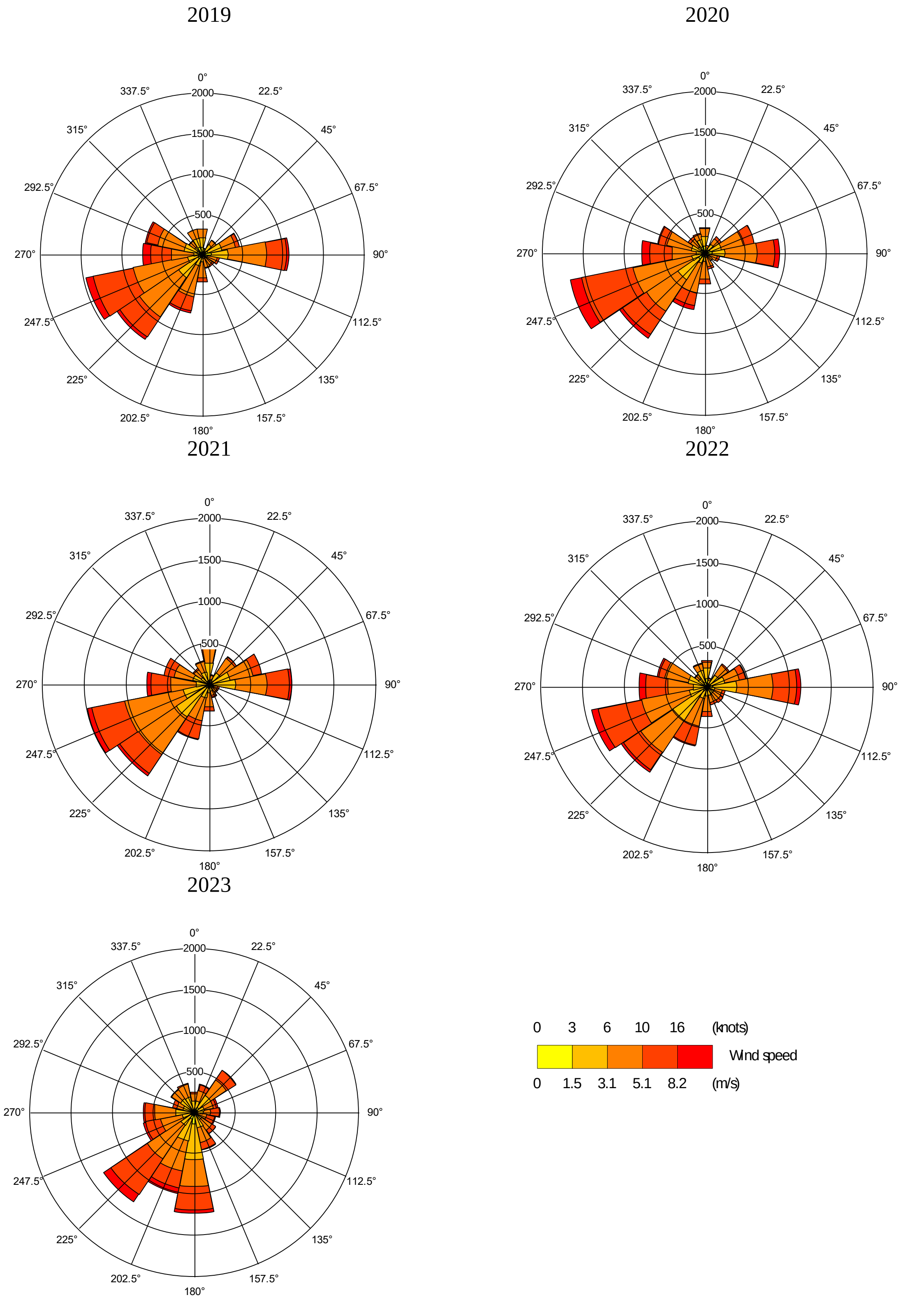
The ADMS 6 dispersion model (version 6.0.0.1) has been used for this study. This is the most up-to-date version of the model at the time of the assessment.

The ADMS model has been widely validated for point sources and is accepted by the industry as being 'fit-for-purpose' for air quality assessments of stack releases. The model incorporates the latest understanding of boundary layer meteorology and dispersion.

Meteorological data

To account for inter-annual variation in meteorological conditions five years of meteorological data have been used in this assessment. The model requires hourly sequential meteorological data as an input. Data from London City airport meteorological station for five years (1st January 2019 to 31st December 2023) was obtained for this assessment. Figure 5 presents the wind roses across the five years; it can be observed that the prevailing wind direction is from the south-west. The dataset included 99% of usable data for the dispersion model.

Figure 5: Windroses for London City Airport meteorological station (2019 to 2023)



Modelled buildings

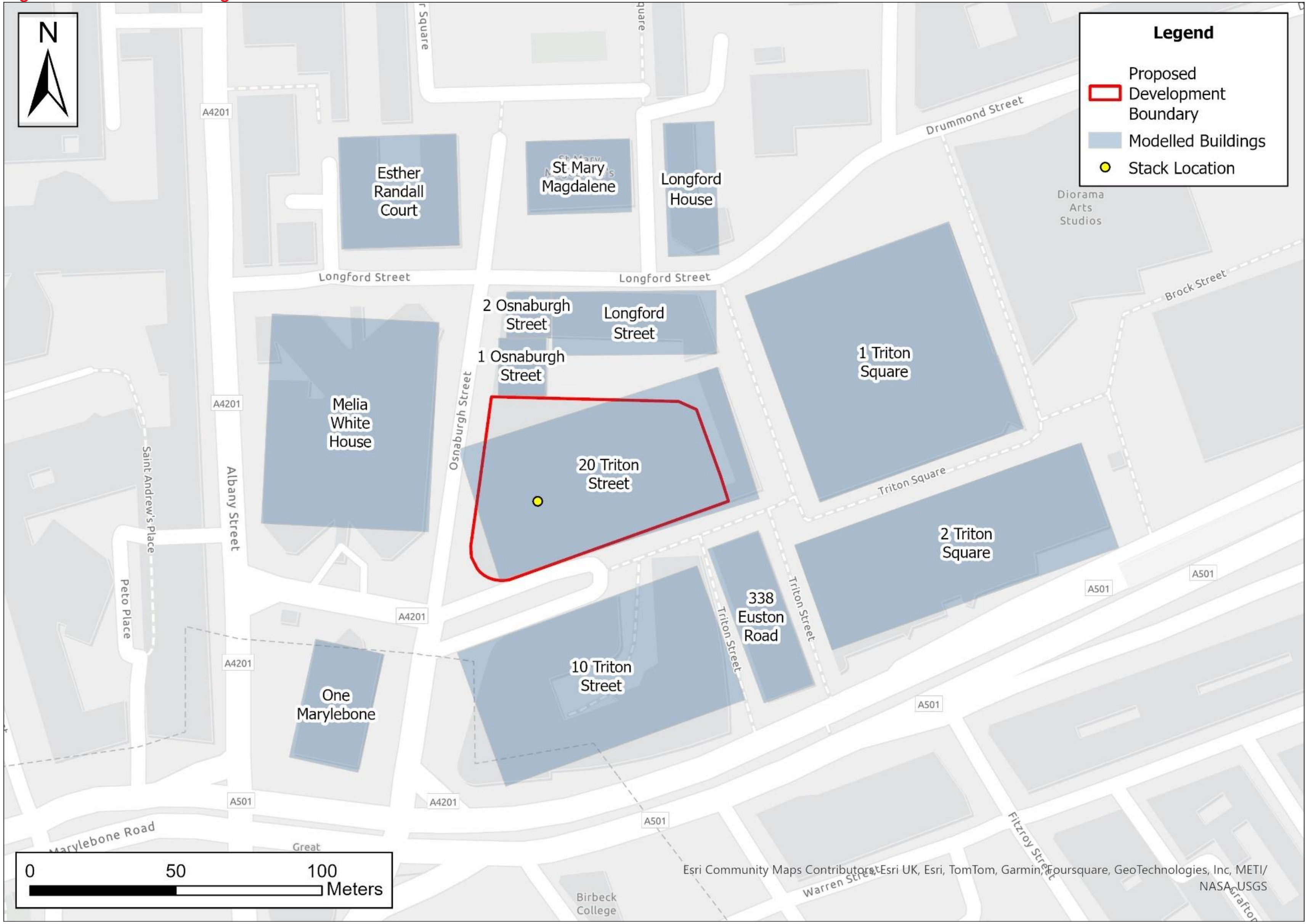
Buildings can have a significant effect on the dispersion of pollutants and can increase the maximum predicted ground level concentrations. The main effect of a building is to entrain pollutants into the cavity region in the immediate leeward side of the building, bringing them rapidly down to ground level. Therefore, buildings were included within the model. The buildings included in the assessment are presented in Table 6 and Figure 6.

The complex building geometry has been simplified to be included in the model, which only accepts rectangular or circular building shapes.

Table 6: Details of modelled buildings

Building Name	NGR (m)		Height (m)	Length (m)	Width (m)
	X	Y			
20 Triton Street	528967	182318	43	92.4	47.0
1 Triton Square	529062	182356	42	74.0	75.0
Longford Street	528976	182369	38	21.6	56.3
1 Osnaburgh Street	528940	182372	60	15.3	15.6
2 Osnaburgh Street	528938	182354	38	19.6	16.0
Melia White House	528879	182335	24	57.2	71.4
One Marylebone	528874	182248	12	24.0	41.2
10 Triton Street	528964	182248	42	48.0	86.8
338 Euston Road	529019	182269	61	55.6	18.1
2 Triton Square	529086	182293	33	103.8	37.8

Figure 6: Modelled Buildings



Other Modelled Parameters

The extent of mechanical turbulence (and hence, mixing) in the atmosphere is affected by the surface/ground over which the air is passing. Typical surface roughness values range from 0.0001m (for water or sandy deserts) to 1.5 (for cities, forests and industrial areas). In this assessment, the general land use in the Proposed Development can be described as "Large urban areas" with a corresponding surface roughness of 1.5m.

The minimum Monin-Obukhov length is a model parameter which describes the extent to which the urban heat island effect limits stable atmospheric conditions. A Monin-Obukhov length of 100m has been used in this dispersion modelling study. It is suggested in ADMS-6 guidance that this length is suitable for "Large urban areas >1 million". The same Monin-Obukhov length was used for the meteorological station site, which is considered representative.

4.2.3 Calculate emission rates

The predicted process contributions that come from a dispersion model emission of 1g/s, will likely be higher than the 10% of the relevant air quality standard and short-term EAL. Therefore, an adjustment will be needed to calculate what the controlled emission rate should be. The equation below shows the method used in this assessment to calculate the controlled emission rate needed to ensure the 10% targets are achieved to minimise the short-term and long-term effect of emissions from the Proposed Development.

$$C = ME * \frac{S}{MC}$$

C = controlled emission rate needed to achieve target

ME = Modelled emission rate

S = 10% of relevant air quality standard and short−term EAL

MC = Maximum modelled concentration at receptor for relevant averaging period

5. Operational assessment

5.1 Predicted process contribution

The dispersion model was run with emissions of 1g/s from the stack to determine the annual mean, and maximum daily, hourly and 30-minute mean contributions across the study area.

The maximum predicted process contributions of pollutants for the relevant averaging periods have been used to calculate the emission rates required to achieve 10% of relevant EALs. For each scenario, the short-term (Daily, hourly and 30-minute mean) and long-term (annual mean) impacts were compared to the EALs. The emission factor from the averaging period with the highest process contribution, and therefore worst air quality impacts was used to calculate the results.

At the time of preparing this report, the exact pollutants from the laboratories are unknown, therefore, the assessment has considered environmental standards for all pollutants defined by the Environment Agency to determine the maximum allowable emission of substances to the air from the stack in connection with the proposed laboratory use. The maximum allowable emission rate for the full list of pollutants is set out in Appendix B.

Maximum predicted process contributions for annual, hourly, daily and 30-minute means across the assessed receptors are below 10% of the EAL. At these levels it is considered any effects would be negligible and not significant at all human receptor locations.

It will be for the future occupant to carry out appropriate risk assessments and use the laboratory within the suitable design parameters for a containment level 2 laboratory as defined within the HSE guidance[18].

Representative pollutants: Benzene and Formaldehyde

This section represents the controlled emission rate required and the maximum predicted process contribution for two commonly used solvents in laboratories: benzene and formaldehyde. The controlled emission rate and maximum predicted process contribution for relevant EALs across all assessed receptors (both human and gridded receptors) are shown in Table 7 and Table 8.

The calculated maximum allowable emission rate for formaldehyde and benzene was:

- 0.0109g/s for formaldehyde, which is equivalent to an annual total of 345kg per year or 39g per hour.
- 0.0109g/s for benzene, which is equivalent to an annual total of 289kg per year or 33g per hour.

The predicted impact for formaldehyde and benzene process contributions at selected receptors using five years of meteorological data are presented in Appendix A.

If the laboratory is intended to be used with emissions of other pollutants with more stringent limits or alter the containment level, these will need to be considered to identify the allowable emission rate, as provided in Appendix B.

Gridded Receptors

An assessment was undertaken with pollutant emissions of 1g/s from the stack to determine the annual mean, and 30-minute mean formaldehyde process contributions at gridded receptors at roof height (43.3m, Table 6) to provide a more conservative assessment, as concentrations will be higher at roof height. Formaldehyde has been assessed due to it having more stringent EALs than benzene (the two representative pollutants in this study). Initial modelling indicated that 2021 provided worst case results for annual mean, and 2020 provided worst case results for the 30-minute mean, therefore these contours have been provided as they represent the worst-case years. Contours are provided in Appendix C.

[18] Health and Safety Executive, Management and operation of microbiological containment laboratories, Advisory Committee on Dangerous Pathogens, March 2019

Table 7: Predicted process contribution of formaldehyde across all assessed receptors

Pollutant	Parameter	Annual mean	Year of maximum predicted impact	Maximum 30-minute mean (provided as the 100th percentile)	Year of maximum predicted impact
Formaldehyde	Controlled emission rate needed to achieve assessment criteria (g/s)	0.0109*	-	0.0138	-
	Maximum process contribution across human and gridded receptors (µg/m^3) using the controlled emission rate	0.5 (receptor R28 at 45m)	2023	10.0 (receptor R27 at 44m)	2019
*This emission factor is included for information only, as the lower emission rate is required to meet 10% of the EAL.					

Table 8: Predicted process contribution of benzene across all assessed receptors

Pollutant	Parameter	Annual mean	Year of maximum predicted impact	Daily mean (provided as the 100th percentile)	Year of maximum predicted impact
Benzene	Controlled emission rate needed to achieve assessment criteria (g/s)	0.0109*	-	0.0092	-
	Maximum process contribution across human and gridded receptors (µg/m^3) using the controlled emission rate	0.5 (receptor R28 at 45m)	2023	3.00 (receptor R27 at 44m)	2019
*This emission factor is included for information only, as the lower emission rate is required to meet 10% of the EAL.					

6. Summary and recommendations

The assessment has considered laboratory emissions from one stack associated with the proposed laboratory.

At the time of writing this report, the exact pollutants from the laboratories are unknown, therefore, the assessment has considered environmental standards for all pollutants defined by the Environment Agency to determine the maximum allowable emission of substances to air from the stack on connection with the proposed laboratory use. These solvents can become airborne and directly lead to, or contribute to, adverse impacts on health and the environment, by reacting with other air pollutants outdoors in the presence of sunlight to produce tropospheric ozone.

The assessment used dispersion modelling to determine the controlled emission rate of the stack for that would result in compliance with 10% of the EAL. At these levels, it is considered any effects would be negligible and not significant at all human receptor locations.

Two commonly used solvents in laboratories have been chosen as representative pollutants in this study: benzene and formaldehyde. The calculated maximum cumulative allowable emission rate for formaldehyde and benzene was:

- 0.0109g/s for formaldehyde, which is equivalent to an annual total of 345kg per year or 39g per hour.
- 0.0109g/s for benzene, which is equivalent to an annual total of 289kg per year or 33g per hour.

The predicted cumulative impact for formaldehyde and benzene process contributions at selected receptors using five years of meteorological data are presented in Appendix A.

Appendix B considers maximum allowable emission rates for the full list of pollutants defined by the Environment Agency, including those with more stringent environmental standards.

Appendix A

Predicted Process Contribution

A.1 Annual Mean Process Contribution

Table A.1: Predicted formaldehyde and benzene annual mean process contribution (µg/m^3), modelled using five years of meteorological data

ID	X	Y	Height (m)	Formaldehyde annual mean process contribution (µg/m^3)					Benzene annual mean process contribution (µg/m^3)				
				2019	2020	2021	2022	2023	2019	2020	2021	2022	2023
R1	529093	182162	1.5	0.019	0.017	0.017	0.017	0.016	0.016	0.014	0.014	0.014	0.014
R1	529093	182162	9.0	0.020	0.018	0.017	0.017	0.017	0.017	0.015	0.015	0.014	0.014
R1	529093	182162	16.5	0.020	0.017	0.017	0.017	0.016	0.016	0.014	0.015	0.014	0.014
R2	529291	182296	1.5	0.012	0.012	0.012	0.013	0.012	0.010	0.010	0.010	0.011	0.010
R2	529291	182296	27.0	0.011	0.011	0.011	0.012	0.011	0.009	0.009	0.009	0.010	0.009
R2	529291	182296	52.5	0.009	0.009	0.009	0.009	0.009	0.007	0.007	0.007	0.008	0.007
R3	529198	182267	1.5	0.018	0.016	0.016	0.018	0.013	0.015	0.013	0.014	0.015	0.011
R3	529198	182267	7.5	0.018	0.016	0.017	0.019	0.013	0.015	0.013	0.014	0.016	0.011
R3	529198	182267	13.5	0.019	0.017	0.018	0.020	0.014	0.016	0.014	0.015	0.017	0.012
R4	528944	182407	1.5	0.021	0.021	0.020	0.024	0.058	0.018	0.018	0.017	0.020	0.049
R5	528890	182256	1.5	0.048	0.050	0.054	0.050	0.051	0.040	0.042	0.045	0.042	0.043
R6	528905	182300	1.5	0.107	0.101	0.104	0.109	0.105	0.090	0.085	0.088	0.092	0.088
R6	528905	182300	12.0	0.107	0.101	0.104	0.109	0.105	0.090	0.085	0.088	0.092	0.088
R6	528905	182300	24.0	0.108	0.102	0.104	0.110	0.105	0.091	0.085	0.088	0.092	0.088

ID	X	Y	Height (m)	Formaldehyde annual mean process contribution (µg/m^3)					Benzene annual mean process contribution (µg/m^3)				
				2019	2020	2021	2022	2023	2019	2020	2021	2022	2023
R7	529073	182443	1.5	0.056	0.055	0.054	0.054	0.052	0.047	0.046	0.046	0.046	0.043
R7	529073	182443	13.0	0.057	0.057	0.057	0.056	0.049	0.048	0.048	0.048	0.047	0.041
R7	529073	182443	24.5	0.072	0.071	0.073	0.071	0.054	0.060	0.060	0.062	0.060	0.045
R8	528802	182184	1.5	0.015	0.018	0.021	0.018	0.022	0.013	0.015	0.017	0.015	0.018
R8	528802	182184	5.5	0.015	0.018	0.021	0.018	0.022	0.013	0.015	0.017	0.015	0.019
R8	528802	182184	9.5	0.016	0.018	0.021	0.018	0.022	0.013	0.015	0.018	0.015	0.019
R9	529202	182075	1.5	0.012	0.010	0.010	0.010	0.009	0.010	0.009	0.008	0.008	0.007
R9	529202	182075	9.5	0.012	0.010	0.010	0.010	0.009	0.010	0.009	0.008	0.008	0.007
R9	529202	182075	17.5	0.012	0.010	0.010	0.010	0.009	0.010	0.008	0.008	0.008	0.007
R10	528916	182396	1.5	0.031	0.028	0.025	0.031	0.049	0.026	0.024	0.021	0.026	0.041
R10	528916	182396	5.5	0.031	0.028	0.025	0.031	0.049	0.026	0.024	0.021	0.026	0.042
R10	528916	182396	9.5	0.031	0.029	0.025	0.031	0.050	0.026	0.024	0.021	0.026	0.042
R11	529017	182427	1.5	0.063	0.064	0.067	0.066	0.080	0.053	0.054	0.056	0.055	0.067
R11	529017	182427	5.5	0.064	0.065	0.068	0.066	0.081	0.054	0.054	0.057	0.056	0.068
R11	529017	182427	9.5	0.066	0.067	0.070	0.068	0.083	0.056	0.056	0.059	0.057	0.070
R12	528984	182447	1.5	0.017	0.018	0.015	0.018	0.054	0.014	0.015	0.013	0.015	0.045
R12	528984	182447	5.5	0.017	0.019	0.015	0.018	0.055	0.015	0.016	0.013	0.015	0.046

ID	X	Y	Height (m)	Formaldehyde annual mean process contribution (μg/m^3)					Benzene annual mean process contribution (μg/m^3)				
				2019	2020	2021	2022	2023	2019	2020	2021	2022	2023
R12	528984	182447	9.5	0.019	0.020	0.017	0.020	0.057	0.016	0.017	0.014	0.017	0.048
R13	529080	182628	1.5	0.014	0.013	0.013	0.014	0.024	0.011	0.011	0.011	0.012	0.020
R13	529080	182628	8.0	0.013	0.013	0.013	0.014	0.024	0.011	0.011	0.011	0.012	0.020
R13	529080	182628	14.5	0.013	0.013	0.012	0.014	0.024	0.011	0.011	0.010	0.011	0.020
R14	528828	182303	1.5	0.035	0.031	0.031	0.036	0.015	0.030	0.026	0.026	0.030	0.013
R14	528828	182303	6.5	0.036	0.031	0.032	0.036	0.015	0.030	0.026	0.027	0.030	0.013
R14	528828	182303	11.0	0.038	0.033	0.033	0.038	0.016	0.032	0.027	0.028	0.032	0.013
R15	529232	182517	1.5	0.033	0.033	0.035	0.032	0.019	0.028	0.028	0.030	0.027	0.016
R15	529232	182517	6.5	0.033	0.033	0.035	0.032	0.019	0.028	0.028	0.029	0.027	0.016
R15	529232	182517	11.0	0.033	0.033	0.035	0.032	0.019	0.027	0.027	0.029	0.027	0.016
R16	529020	182202	1.5	0.028	0.024	0.025	0.025	0.027	0.024	0.020	0.021	0.021	0.022
R16	529020	182202	26.0	0.038	0.032	0.035	0.034	0.039	0.032	0.027	0.029	0.029	0.032
R16	529020	182202	52.0	0.047	0.040	0.039	0.042	0.048	0.039	0.034	0.033	0.035	0.040
R17	529001	182292	1.5	0.154	0.149	0.158	0.161	0.173	0.129	0.125	0.132	0.135	0.145
R17	529001	182292	35.5	0.213	0.202	0.211	0.219	0.210	0.179	0.169	0.177	0.184	0.176
R17	529001	182292	69.5	0.009	0.009	0.008	0.009	0.007	0.008	0.007	0.006	0.007	0.006
R18	529031	182293	1.5	0.117	0.112	0.121	0.122	0.098	0.098	0.094	0.101	0.103	0.082

ID	X	Y	Height (m)	Formaldehyde annual mean process contribution (µg/m^3)					Benzene annual mean process contribution (µg/m^3)				
				2019	2020	2021	2022	2023	2019	2020	2021	2022	2023
R18	529031	182293	33.5	0.158	0.150	0.160	0.165	0.130	0.133	0.126	0.135	0.139	0.109
R18	529031	182293	65.5	0.030	0.027	0.028	0.031	0.024	0.025	0.023	0.024	0.026	0.020
R19	528944	182105	1.5	0.011	0.011	0.015	0.011	0.012	0.009	0.009	0.012	0.009	0.010
R19	528944	182105	10.5	0.012	0.011	0.015	0.012	0.012	0.010	0.010	0.013	0.010	0.010
R19	528944	182105	19.5	0.014	0.013	0.017	0.014	0.013	0.011	0.011	0.014	0.011	0.011
R20	529030	182005	1.5	0.012	0.011	0.012	0.011	0.010	0.010	0.009	0.010	0.009	0.008
R20	529030	182005	9.0	0.012	0.011	0.012	0.011	0.010	0.010	0.009	0.010	0.009	0.008
R20	529030	182005	16.5	0.012	0.011	0.012	0.011	0.010	0.010	0.009	0.010	0.009	0.008
R21	528888	182118	1.5	0.009	0.009	0.011	0.009	0.019	0.007	0.007	0.009	0.008	0.016
R21	528888	182118	9.0	0.009	0.009	0.011	0.010	0.019	0.008	0.008	0.009	0.008	0.016
R21	528888	182118	16.5	0.010	0.011	0.012	0.011	0.019	0.009	0.009	0.010	0.009	0.016
R22	528988	182392	1.5	0.068	0.069	0.071	0.070	0.102	0.057	0.058	0.059	0.059	0.086
R22	528988	182392	15.0	0.070	0.071	0.073	0.072	0.105	0.059	0.060	0.061	0.061	0.089
R22	528988	182392	28.5	0.098	0.098	0.100	0.101	0.142	0.082	0.082	0.084	0.085	0.120
R23	528993	182359	1.5	0.133	0.134	0.141	0.137	0.149	0.112	0.112	0.118	0.115	0.125
R23	528993	182359	10.5	0.133	0.134	0.141	0.137	0.149	0.112	0.112	0.119	0.115	0.125
R23	528993	182359	19.5	0.136	0.136	0.144	0.139	0.151	0.114	0.115	0.121	0.117	0.127

ID	X	Y	Height (m)	Formaldehyde annual mean process contribution (µg/m^3)					Benzene annual mean process contribution (µg/m^3)				
				2019	2020	2021	2022	2023	2019	2020	2021	2022	2023
R23	528993	182359	26.0	0.149	0.150	0.158	0.152	0.164	0.125	0.126	0.132	0.128	0.138
R24	529162	182349	1.5	0.013	0.015	0.014	0.014	0.016	0.011	0.013	0.012	0.012	0.013
R24	529162	182349	22.0	0.021	0.024	0.022	0.021	0.023	0.018	0.020	0.019	0.018	0.019
R24	529162	182349	44.0	0.029	0.031	0.029	0.028	0.025	0.024	0.026	0.024	0.023	0.021
R24	529162	182349	66.0	0.021	0.023	0.022	0.020	0.018	0.018	0.019	0.018	0.017	0.015
R24	529162	182349	88.0	0.007	0.008	0.007	0.007	0.006	0.006	0.006	0.006	0.006	0.005
R24	529162	182349	133.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R25	529091	182413	1.5	0.061	0.061	0.064	0.059	0.043	0.051	0.051	0.054	0.050	0.036
R25	529091	182413	22.0	0.082	0.081	0.087	0.078	0.054	0.068	0.068	0.073	0.066	0.045
R25	529091	182413	44.0	0.084	0.085	0.091	0.082	0.046	0.071	0.071	0.076	0.069	0.038
R26	528955	182181	1.5	0.023	0.021	0.025	0.022	0.027	0.019	0.017	0.021	0.019	0.023
R26	528955	182181	6.0	0.023	0.021	0.025	0.023	0.027	0.019	0.017	0.021	0.019	0.023
R26	528955	182181	11.0	0.024	0.021	0.026	0.023	0.028	0.020	0.018	0.022	0.020	0.024
R27	528948	182268	1.5	0.132	0.127	0.135	0.138	0.155	0.111	0.107	0.113	0.116	0.130
R27	528948	182268	22.0	0.132	0.127	0.135	0.139	0.155	0.111	0.107	0.113	0.116	0.130
R27	528948	182268	44.0	0.212	0.184	0.270	0.207	0.216	0.178	0.155	0.227	0.174	0.181
R28	528938	182364	45.0	0.135	0.146	0.120	0.142	0.500	0.113	0.122	0.101	0.119	0.420

ID	X	Y	Height (m)	Formaldehyde annual mean process contribution (µg/m^3)					Benzene annual mean process contribution (µg/m^3)				
				2019	2020	2021	2022	2023	2019	2020	2021	2022	2023
R28	528938	182364	60.0	0.036	0.036	0.029	0.035	0.121	0.030	0.030	0.024	0.030	0.102
R29	528929	182345	1.5	0.149	0.141	0.146	0.152	0.171	0.125	0.118	0.122	0.128	0.144
R29	528929	182345	12.0	0.149	0.141	0.146	0.152	0.171	0.125	0.118	0.122	0.128	0.144
R29	528929	182345	24.0	0.149	0.141	0.146	0.153	0.172	0.125	0.119	0.122	0.128	0.144
R30	529032	182328	1.5	0.125	0.123	0.129	0.129	0.101	0.105	0.103	0.108	0.108	0.085
R30	529032	182328	26.5	0.150	0.151	0.154	0.153	0.119	0.126	0.127	0.129	0.129	0.100
R30	529032	182328	42.0	0.258	0.269	0.266	0.257	0.206	0.217	0.226	0.224	0.216	0.173

A.2 Daily Mean Process Contribution

Table A.2: Predicted benzene daily mean process contribution (µg/m^3), modelled using five years of meteorological data

ID	X	Y	Height (m)	Benzene daily mean process contribution (µg/m^3)				
				2019	2020	2021	2022	2023
R1	529093	182162	1.5	0.171	0.161	0.150	0.142	0.142
R1	529093	182162	9.0	0.175	0.167	0.151	0.135	0.144
R1	529093	182162	16.5	0.163	0.162	0.147	0.128	0.138
R2	529291	182296	1.5	0.063	0.080	0.064	0.086	0.084
R2	529291	182296	27.0	0.060	0.078	0.064	0.080	0.079
R2	529291	182296	52.5	0.048	0.059	0.051	0.061	0.061
R3	529198	182267	1.5	0.122	0.105	0.126	0.146	0.122
R3	529198	182267	7.5	0.126	0.109	0.129	0.151	0.125
R3	529198	182267	13.5	0.135	0.116	0.135	0.163	0.134
R4	528944	182407	1.5	0.117	0.164	0.186	0.144	0.201
R5	528890	182256	1.5	0.176	0.182	0.209	0.167	0.169
R6	528905	182300	1.5	0.214	0.261	0.228	0.216	0.214
R6	528905	182300	12.0	0.214	0.261	0.228	0.216	0.214
R6	528905	182300	24.0	0.241	0.263	0.228	0.270	0.214

ID	X	Y	Height (m)	Benzene daily mean process contribution (µg/m^3)				
				2019	2020	2021	2022	2023
R7	529073	182443	1.5	0.183	0.247	0.186	0.186	0.198
R7	529073	182443	13.0	0.168	0.247	0.190	0.189	0.187
R7	529073	182443	24.5	0.212	0.326	0.252	0.290	0.216
R8	528802	182184	1.5	0.138	0.166	0.196	0.134	0.155
R8	528802	182184	5.5	0.138	0.166	0.196	0.135	0.155
R8	528802	182184	9.5	0.138	0.168	0.198	0.136	0.155
R9	529202	182075	1.5	0.092	0.095	0.076	0.077	0.071
R9	529202	182075	9.5	0.092	0.094	0.075	0.077	0.071
R9	529202	182075	17.5	0.090	0.092	0.073	0.076	0.070
R10	528916	182396	1.5	0.137	0.153	0.171	0.138	0.176
R10	528916	182396	5.5	0.138	0.153	0.172	0.138	0.176
R10	528916	182396	9.5	0.140	0.154	0.173	0.139	0.179
R11	529017	182427	1.5	0.178	0.246	0.174	0.201	0.220
R11	529017	182427	5.5	0.181	0.248	0.176	0.204	0.221
R11	529017	182427	9.5	0.188	0.255	0.182	0.212	0.224
R12	528984	182447	1.5	0.126	0.136	0.180	0.141	0.200
R12	528984	182447	5.5	0.129	0.136	0.182	0.144	0.202

ID	X	Y	Height (m)	Benzene daily mean process contribution (µg/m³)				
				2019	2020	2021	2022	2023
R12	528984	182447	9.5	0.136	0.137	0.185	0.153	0.207
R13	529080	182628	1.5	0.070	0.083	0.085	0.071	0.119
R13	529080	182628	8.0	0.070	0.083	0.084	0.071	0.119
R13	529080	182628	14.5	0.069	0.081	0.083	0.070	0.117
R14	528828	182303	1.5	0.239	0.247	0.197	0.206	0.176
R14	528828	182303	6.5	0.245	0.253	0.201	0.210	0.177
R14	528828	182303	11.0	0.256	0.264	0.210	0.219	0.182
R15	529232	182517	1.5	0.127	0.140	0.119	0.151	0.068
R15	529232	182517	6.5	0.126	0.140	0.119	0.151	0.068
R15	529232	182517	11.0	0.125	0.139	0.118	0.150	0.067
R16	529020	182202	1.5	0.176	0.230	0.183	0.180	0.164
R16	529020	182202	26.0	0.236	0.278	0.298	0.271	0.248
R16	529020	182202	52.0	0.472	0.825	0.438	0.535	0.526
R17	529001	182292	1.5	0.252	0.300	0.225	0.249	0.248
R17	529001	182292	35.5	0.511	0.471	0.477	0.522	0.447
R17	529001	182292	69.5	0.196	0.145	0.078	0.090	0.102
R18	529031	182293	1.5	0.206	0.202	0.200	0.198	0.187

ID	X	Y	Height (m)	Benzene daily mean process contribution (µg/m³)				
				2019	2020	2021	2022	2023
R18	529031	182293	33.5	0.341	0.327	0.363	0.406	0.368
R18	529031	182293	65.5	0.217	0.158	0.181	0.220	0.198
R19	528944	182105	1.5	0.128	0.136	0.142	0.136	0.096
R19	528944	182105	10.5	0.129	0.141	0.143	0.140	0.096
R19	528944	182105	19.5	0.129	0.160	0.174	0.148	0.094
R20	529030	182005	1.5	0.153	0.221	0.112	0.133	0.095
R20	529030	182005	9.0	0.153	0.221	0.111	0.133	0.094
R20	529030	182005	16.5	0.153	0.220	0.110	0.132	0.093
R21	528888	182118	1.5	0.095	0.093	0.123	0.139	0.153
R21	528888	182118	9.0	0.098	0.093	0.124	0.142	0.151
R21	528888	182118	16.5	0.108	0.109	0.126	0.148	0.147
R22	528988	182392	1.5	0.186	0.236	0.191	0.195	0.235
R22	528988	182392	15.0	0.190	0.250	0.191	0.201	0.250
R22	528988	182392	28.5	0.288	0.370	0.298	0.317	0.338
R23	528993	182359	1.5	0.250	0.300	0.217	0.210	0.241
R23	528993	182359	10.5	0.250	0.300	0.217	0.210	0.241
R23	528993	182359	19.5	0.250	0.301	0.218	0.211	0.241

ID	X	Y	Height (m)	Benzene daily mean process contribution (µg/m^3)				
				2019	2020	2021	2022	2023
R23	528993	182359	26.0	0.276	0.306	0.225	0.236	0.259
R24	529162	182349	1.5	0.069	0.078	0.071	0.066	0.106
R24	529162	182349	22.0	0.091	0.116	0.106	0.097	0.145
R24	529162	182349	44.0	0.121	0.126	0.146	0.145	0.155
R24	529162	182349	66.0	0.094	0.096	0.111	0.113	0.109
R24	529162	182349	88.0	0.032	0.033	0.036	0.028	0.034
R24	529162	182349	133.0	0.008	0.006	0.004	0.004	0.004
R25	529091	182413	1.5	0.176	0.204	0.178	0.201	0.150
R25	529091	182413	22.0	0.222	0.244	0.255	0.256	0.191
R25	529091	182413	44.0	0.378	0.400	0.343	0.440	0.205
R26	528955	182181	1.5	0.206	0.230	0.183	0.170	0.169
R26	528955	182181	6.0	0.208	0.231	0.184	0.172	0.170
R26	528955	182181	11.0	0.216	0.232	0.190	0.180	0.175
R27	528948	182268	1.5	0.241	0.276	0.225	0.249	0.241
R27	528948	182268	22.0	0.241	0.276	0.225	0.250	0.244
R27	528948	182268	44.0	3.000	2.669	2.584	2.191	2.222
R28	528938	182364	45.0	1.219	1.469	2.171	1.087	2.249

ID	X	Y	Height (m)	Benzene daily mean process contribution (µg/m³)				
				2019	2020	2021	2022	2023
R28	528938	182364	60.0	0.268	0.390	0.584	0.269	0.577
R29	528929	182345	1.5	0.243	0.300	0.240	0.259	0.248
R29	528929	182345	12.0	0.243	0.305	0.240	0.259	0.248
R29	528929	182345	24.0	0.243	0.346	0.240	0.259	0.249
R30	529032	182328	1.5	0.210	0.239	0.217	0.215	0.193
R30	529032	182328	26.5	0.239	0.262	0.241	0.253	0.216
R30	529032	182328	42.0	0.646	0.668	0.779	0.626	0.727

A.3 30-minute Mean Process Contribution

Table A.3 Predicted formaldehyde 30-minute mean process contribution (µg/m3), modelled using five years of meteorological data

ID	X	Y	Height (m)	Formaldehyde 30-minute mean process contribution (µg/m^3)				
				2019	2020	2021	2022	2023
R1	529093	182162	1.5	0.876	0.798	0.611	0.598	0.525
R1	529093	182162	9.0	0.888	0.789	0.612	0.603	0.585
R1	529093	182162	16.5	0.747	0.759	0.647	0.616	0.610
R2	529291	182296	1.5	0.514	0.431	0.443	0.584	0.505
R2	529291	182296	27.0	0.535	0.481	0.469	0.533	0.518
R2	529291	182296	52.5	0.472	0.473	0.474	0.472	0.472
R3	529198	182267	1.5	0.721	0.693	0.613	0.626	0.525
R3	529198	182267	7.5	0.724	0.692	0.613	0.627	0.553
R3	529198	182267	13.5	0.730	0.688	0.611	0.726	0.617
R4	528944	182407	1.5	0.801	1.068	0.492	0.502	0.698
R5	528890	182256	1.5	0.950	0.980	0.939	0.949	0.766
R6	528905	182300	1.5	0.761	0.772	0.798	0.779	0.633
R6	528905	182300	12.0	0.762	0.793	0.805	0.790	0.633
R6	528905	182300	24.0	1.028	1.226	1.083	1.199	0.633

ID	X	Y	Height (m)	Formaldehyde 30-minute mean process contribution ($\mu g/m^3$)				
				2019	2020	2021	2022	2023
R7	529073	182443	1.5	0.678	0.962	0.814	0.699	0.742
R7	529073	182443	13.0	0.811	0.964	0.840	0.718	0.754
R7	529073	182443	24.5	1.269	1.118	1.011	1.118	1.210
R8	528802	182184	1.5	0.846	0.688	0.552	0.730	0.793
R8	528802	182184	5.5	0.847	0.690	0.558	0.736	0.796
R8	528802	182184	9.5	0.848	0.693	0.570	0.747	0.802
R9	529202	182075	1.5	0.512	0.525	0.522	0.515	0.503
R9	529202	182075	9.5	0.507	0.519	0.516	0.509	0.498
R9	529202	182075	17.5	0.494	0.505	0.502	0.496	0.487
R10	528916	182396	1.5	0.755	1.083	0.525	0.503	0.689
R10	528916	182396	5.5	0.767	1.092	0.525	0.503	0.702
R10	528916	182396	9.5	0.792	1.109	0.525	0.520	0.727
R11	529017	182427	1.5	0.794	0.847	0.554	0.724	0.818
R11	529017	182427	5.5	0.794	0.845	0.567	0.724	0.820
R11	529017	182427	9.5	0.795	0.841	0.595	0.724	0.823
R12	528984	182447	1.5	0.828	0.929	0.474	0.708	0.846
R12	528984	182447	5.5	0.828	0.930	0.476	0.719	0.848

ID	X	Y	Height (m)	Formaldehyde 30-minute mean process contribution (µg/m^3)				
				2019	2020	2021	2022	2023
R12	528984	182447	9.5	0.827	0.933	0.483	0.740	0.853
R13	529080	182628	1.5	0.418	0.470	0.470	0.417	0.468
R13	529080	182628	8.0	0.415	0.466	0.466	0.415	0.465
R13	529080	182628	14.5	0.408	0.458	0.458	0.408	0.457
R14	528828	182303	1.5	0.863	0.997	0.992	0.986	0.587
R14	528828	182303	6.5	0.875	1.001	1.001	0.994	0.601
R14	528828	182303	11.0	0.898	1.009	1.017	1.007	0.629
R15	529232	182517	1.5	0.637	0.648	0.497	0.504	0.519
R15	529232	182517	6.5	0.645	0.650	0.496	0.503	0.517
R15	529232	182517	11.0	0.659	0.652	0.493	0.501	0.515
R16	529020	182202	1.5	0.543	0.708	0.525	0.748	0.693
R16	529020	182202	26.0	0.920	1.265	0.725	0.932	0.851
R16	529020	182202	52.0	3.406	3.312	3.426	3.420	3.350
R17	529001	182292	1.5	0.761	0.771	0.798	0.779	0.633
R17	529001	182292	35.5	2.245	2.118	1.783	1.975	1.662
R17	529001	182292	69.5	3.097	1.801	1.346	1.390	0.960
R18	529031	182293	1.5	0.761	0.771	0.798	0.779	0.560

ID	X	Y	Height (m)	Formaldehyde 30-minute mean process contribution (µg/m^3)				
				2019	2020	2021	2022	2023
R18	529031	182293	33.5	1.606	1.603	1.505	1.499	1.196
R18	529031	182293	65.5	1.946	1.368	1.263	1.253	1.976
R19	528944	182105	1.5	0.607	0.568	0.705	0.555	0.529
R19	528944	182105	10.5	0.623	0.620	0.708	0.614	0.589
R19	528944	182105	19.5	0.754	0.729	0.733	0.767	0.744
R20	529030	182005	1.5	0.847	0.510	0.477	0.501	0.492
R20	529030	182005	9.0	0.851	0.507	0.475	0.498	0.490
R20	529030	182005	16.5	0.852	0.499	0.469	0.492	0.483
R21	528888	182118	1.5	0.832	0.907	0.476	0.637	0.656
R21	528888	182118	9.0	0.836	0.946	0.524	0.630	0.726
R21	528888	182118	16.5	0.833	1.028	0.657	0.680	0.877
R22	528988	182392	1.5	0.761	0.925	0.798	0.779	0.706
R22	528988	182392	15.0	0.871	0.985	0.798	0.779	0.874
R22	528988	182392	28.5	1.109	1.133	0.872	0.934	1.356
R23	528993	182359	1.5	0.761	0.771	0.798	0.779	0.633
R23	528993	182359	10.5	0.761	0.802	0.798	0.779	0.633
R23	528993	182359	19.5	0.866	1.049	0.798	0.779	0.792

ID	X	Y	Height (m)	Formaldehyde 30-minute mean process contribution (µg/m^3)				
				2019	2020	2021	2022	2023
R23	528993	182359	26.0	1.013	1.583	1.226	0.918	1.112
R24	529162	182349	1.5	0.664	0.718	0.621	0.652	0.458
R24	529162	182349	22.0	0.682	0.718	0.632	0.644	0.609
R24	529162	182349	44.0	1.183	1.183	0.993	1.119	1.158
R24	529162	182349	66.0	1.018	0.936	0.675	1.039	0.964
R24	529162	182349	88.0	0.248	0.266	0.209	0.211	0.181
R24	529162	182349	133.0	0.092	0.123	0.081	0.091	0.058
R25	529091	182413	1.5	0.601	0.980	0.822	0.583	0.590
R25	529091	182413	22.0	0.919	0.991	0.901	0.667	0.735
R25	529091	182413	44.0	1.648	1.478	1.468	1.418	1.480
R26	528955	182181	1.5	0.844	0.572	0.608	0.854	0.564
R26	528955	182181	6.0	0.857	0.572	0.625	0.867	0.575
R26	528955	182181	11.0	0.887	0.572	0.673	0.897	0.601
R27	528948	182268	1.5	0.761	0.771	0.798	0.779	0.633
R27	528948	182268	22.0	0.761	0.771	0.798	1.267	1.046
R27	528948	182268	44.0	7.938	7.372	6.741	7.066	6.684
R28	528938	182364	45.0	6.584	6.782	6.684	7.105	7.786

ID	X	Y	Height (m)	Formaldehyde 30-minute mean process contribution ($\mu g/m^3$)				
				2019	2020	2021	2022	2023
R28	528938	182364	60.0	2.874	3.480	1.780	1.974	7.302
R29	528929	182345	1.5	0.761	0.771	0.798	0.779	0.633
R29	528929	182345	12.0	0.761	0.771	0.798	0.779	0.633
R29	528929	182345	24.0	1.025	1.440	0.798	0.779	0.830
R30	529032	182328	1.5	0.761	0.771	0.798	0.779	0.572
R30	529032	182328	26.5	1.119	1.143	0.976	1.077	0.815
R30	529032	182328	42.0	3.262	3.262	2.936	2.913	3.118

Appendix B

Maximum Allowable Emission Rates

Table B.1 provides maximum allowable emission rates for additional pollutants defined by the Environment Agency[7], including those with more stringent environmental standards than the representative pollutants formaldehyde and benzene used in this assessment. Maximum emission rates are defined for short-term (daily, hourly and 30-minute mean) and long-term (annual mean) averaging times. A small number of pollutants have other uncommon averaging times (15-minute, 8-hour, weekly and monthly means). These averaging times have not been considered in the study, however these pollutants are represented by the other short and long-term averaging times modelled.

Table B.1: Calculated maximum allowable emission rates for environmental standards defined by the Environment Agency

Pollutant	Target Type	Time Period	Target Value ($\mu g/m^3$)	Controlled Emission Rate needed to achieve assessment criteria for compliance with 10% of EAL	
				g/s	kg/yr
1, 3-butadiene	EAL	daily mean	2.25	0.000688	22
1,3-butadiene	Objective	annual mean	2.25	0.005	155
1,2,4-trichlorobenzene	EAL	annual mean	76	0.166	5240
1,2,4-trichlorobenzene	EAL	hourly mean	2280	0.343	10804
1-propanol	EAL	annual mean	5000	10.931	344705
1-propanol	EAL	hourly mean	62500	9.392	296174
2-propanol	EAL	annual mean	9990	21.839	688720
2-propanol	EAL	hourly mean	125000	18.783	592348
Acetaldehyde	EAL	annual mean	370	0.809	25508
Acetaldehyde	EAL	hourly mean	9200	1.382	43597
Acetic acid	EAL	annual mean	250	0.547	17235
Acetic acid	EAL	hourly mean	3700	0.556	17534
Acetic anhydride	EAL	annual mean	1	0.0022	69
Acetic anhydride	EAL	hourly mean	40	0.006	190
Acetone	EAL	annual mean	18100	39.568	1247831
Acetone	EAL	hourly mean	362000	54.396	1715440
Acetonitrile	EAL	annual mean	680	1.487	46880
Acetonitrile	EAL	hourly mean	10200	1.533	48336
Acrylamide	EAL	annual mean	0.05	0.00011	3
Acrylic acid	EAL	annual mean	300	0.656	20682
Acrylic acid	EAL	hourly mean	6000	0.902	28433
Acrylonitrile	EAL	annual mean	8.8	0.019	607
Acrylonitrile	EAL	hourly mean	264	0.040	1251

Pollutant	Target Type	Time Period	Target Value ($\mu g/m^3$)	Controlled Emission Rate needed to achieve assessment criteria for compliance with 10% of EAL	
				g/s	kg/yr
Allyl alcohol	EAL	annual mean	48	0.105	3309
Allyl alcohol	EAL	hourly mean	970	0.146	4597
Ammonia	EAL	annual mean	180	0.393	12409
Ammonia	EAL	hourly mean	2500	0.376	11847
Aniline	EAL	annual mean	8	0.017	552
Aniline	EAL	hourly mean	240	0.036	1137
Antimony and compounds (as antimony) except antimony trisulphide and antimony trioxide	EAL	annual mean	5	0.011	345
Antimony and compounds (as antimony) except antimony trisulphide and antimony trioxide	EAL	hourly mean	150	0.023	711
Arsenic	Target Value	annual mean	0.006	0.000013	0.41
Arsine	EAL	annual mean	1.6	0.003	110
Arsine	EAL	hourly mean	48	0.007	227
Benzene	Limit Value	annual mean	5	0.0109	345
Benzene	EAL	daily mean	30	0.0092	289
Benzylchloride	EAL	annual mean	5.2	0.011	358
Benzylchloride	EAL	hourly mean	158	0.024	749
Beryllium (total in the PM10 fraction)	EAL	annual mean	0.0002	0.0000004	0.014
Boron trifluoride	EAL	hourly mean	280	0.042	1327
Bromine	EAL	hourly mean	70	0.011	332
Bromomethane	EAL	annual mean	200	0.437	13788
Bromomethane	EAL	hourly mean	5900	0.887	27959
Butane	EAL	annual mean	14500	31.698	999644
Butane	EAL	hourly mean	181000	27.198	857720
Cadmium	Target Value	annual mean	0.005	0.000011	0.34
Cadmium	EAL	daily mean	0.03	0.000009	0.29
Carbon disulphide	EAL	annual mean	64	0.140	4412
Carbon disulphide	EAL	daily mean	100	0.031	965

Pollutant	Target Type	Time Period	Target Value (µg/m³)	Controlled Emission Rate needed to achieve assessment criteria for compliance with 10% of EAL	
				g/s	kg/yr
Carbon monoxide	EAL	hourly mean	30000	4.508	142164
Carbon tetrachloride	EAL	annual mean	130	0.284	8962
Carbon tetrachloride	EAL	hourly mean	3900	0.586	18481
Chlorine	EAL	hourly mean	290	0.044	1374
Chloroform	EAL	daily mean	100	0.031	965
Chromium (III) and its compounds (as chromium)	EAL	daily mean	2	0.0006	19
Chromium VI	EAL	annual mean	0.00025	0.0000005	0.017
Copper and its compounds (as copper)	EAL	daily mean	0.05	0.000015	0.48
Dibutyl phthalate	EAL	annual mean	50	0.109	3447
Dibutyl phthalate	EAL	hourly mean	1000	0.150	4739
Diethyl ether	EAL	annual mean	12300	26.889	847974
Diethyl ether	EAL	hourly mean	154000	23.141	729773
Diethyl ketone	EAL	annual mean	7160	15.652	493617
Diethyl ketone	EAL	hourly mean	89500	13.449	424121
Diisobutyl phthalate	EAL	annual mean	50	0.109	3447
Diisobutyl phthalate	EAL	hourly mean	1500	0.225	7108
Diisopropyl ether	EAL	annual mean	10600	23.173	730774
Diisopropyl ether	EAL	hourly mean	131000	19.685	620781
Dimethyl sulphate	EAL	annual mean	0.52	0.0011	36
Dimethyl sulphate	EAL	hourly mean	15.6	0.0023	74
Dimethylformamide	EAL	annual mean	300	0.656	20682
Dimethylformamide	EAL	hourly mean	6100	0.917	28907
Dioxane	EAL	annual mean	910	1.989	62736
Dioxane	EAL	hourly mean	36600	5.500	173440
Ethyl acrylate	EAL	annual mean	210	0.459	14478
Ethyl acrylate	EAL	hourly mean	6200	0.932	29380
Ethylbenzene	EAL	annual mean	4410	9.641	304030
Ethylbenzene	EAL	hourly mean	55200	8.295	261581

Pollutant	Target Type	Time Period	Target Value ($\mu g/m^3$)	Controlled Emission Rate needed to achieve assessment criteria for compliance with 10% of EAL	
				g/s	kg/yr
Ethylene dibromide	EAL	annual mean	7.8	0.017	538
Ethylene dibromide	EAL	hourly mean	234	0.035	1109
Ethylene dichloride	EAL	annual mean	3	0.007	207
Ethylene oxide	EAL	annual mean	0.002	0.000004	0.14
Formaldehyde	EAL	annual mean	5	0.0109	345
Formaldehyde	EAL	30-minute mean	100	0.0138	434
Hydrazine	EAL	annual mean	0.06	0.00013	4
Hydrazine	EAL	hourly mean	2.6	0.0004	12
Hydrogen bromide	EAL	hourly mean	700	0.105	3317
Hydrogen chloride	EAL	hourly mean	750	0.113	3554
Hydrogen cyanide	EAL	daily mean	2	0.0006	19
Hydrogen fluoride	EAL	hourly mean	160	0.024	758
Hydrogen iodide	EAL	hourly mean	520	0.078	2464
Hydrogen sulphide	EAL	annual mean	140	0.306	9652
Hydrogen sulphide	EAL	daily mean	150	0.046	1447
Lead	Limit Value	annual mean	0.5	0.0011	34
Lead	Objective	annual mean	0.25	0.0005	17
Manganese and compounds (as manganese)	EAL	annual mean	0.15	0.0003	10
Manganese and compounds (as manganese)	EAL	hourly mean	1500	0.225	7108
Mercury and its inorganic compounds (as mercury)	EAL	hourly mean	0.6	0.00009	2.8
Mercury and its inorganic compounds (as mercury)	EAL	daily mean	0.06	0.000018	0.58
Methanol	EAL	annual mean	2660	5.815	183383
Methanol	EAL	hourly mean	33300	5.004	157802
Methyl chloride (chloromethane)	EAL	daily mean	18	0.006	174
Methyl chloroform	EAL	daily mean	5000	1.530	48234
Methyl ethyl ketone	EAL	annual mean	6000	13.117	413646
Methyl ethyl ketone	EAL	hourly mean	89900	13.509	426017

Pollutant	Target Type	Time Period	Target Value (µg/m^3)	Controlled Emission Rate needed to achieve assessment criteria for compliance with 10% of EAL	
				g/s	kg/yr
Methyl propyl ketone	EAL	annual mean	7160	15.652	493617
Methyl propyl ketone	EAL	hourly mean	89500	13.449	424121
Methylene chloride (dichloromethane)	EAL	annual mean	770	1.683	53085
Methylene chloride (dichloromethane)	EAL	daily mean	2100	0.642	20258
Mono-ethanolamine (MEA)	EAL	hourly mean	400	0.060	1896
Mono-ethanolamine (MEA)	EAL	daily mean	100	0.031	965
Naphthalene	EAL	daily mean	3	0.0009	29
N-hexane	EAL	annual mean	720	1.574	49637
N-hexane	EAL	hourly mean	21600	3.246	102358
Nickel	Target Value	annual mean	0.02	0.00004	1.4
Nickel and its compounds, except nickel hydride (as nickel)	EAL	hourly mean	0.7	0.00011	3.3
Nitric acid	EAL	annual mean	52	0.114	3585
Nitric acid	EAL	hourly mean	1000	0.150	4739
Nitrogen dioxide	Limit Value	annual mean	40	0.087	2758
Nitrogen dioxide	Limit Value	hourly mean	200	0.030	948
Nitrogen monoxide	EAL	annual mean	310	0.678	21372
Nitrogen monoxide	EAL	hourly mean	4400	0.661	20851
N-nitrosodimethylamine (NDMA)	EAL	annual mean	0.0002	0.0000004	0.01
Orthophosphoric acid	EAL	hourly mean	200	0.030	948
Para-dichlorobenzene	EAL	annual mean	1530	3.345	105480
Para-dichlorobenzene	EAL	hourly mean	30600	4.598	145007
Particulates (PM10)	Limit Value	annual mean	40	0.087	2758
Particulates (PM10)	Limit Value	daily mean	50	0.015	482
Particulates (PM2.5)	Limit Value	annual mean	20	0.044	1379
Phenol	EAL	annual mean	200	0.437	13788
Phenol	EAL	hourly mean	3900	0.586	18481
Phosgene	EAL	annual mean	0.8	0.0017	55

Pollutant	Target Type	Time Period	Target Value ($\mu g/m^3$)	Controlled Emission Rate needed to achieve assessment criteria for compliance with 10% of EAL	
				g/s	kg/yr
Phosgene	EAL	hourly mean	25	0.004	118
Phosphine	EAL	hourly mean	42	0.006	199
Polyaromatic hydrocarbons (benzo(a)pyrene)	Objective	annual mean	0.00025	0.0000005	0.017
Polyaromatic hydrocarbons (benzo(a)pyrene)	Target Value	annual mean	0.001	0.0000022	0.07
Polychlorinated biphenyls (PCBs)	EAL	annual mean	0.2	0.0004	14
Polychlorinated biphenyls (PCBs)	EAL	hourly mean	6	0.0009	28
Propylene oxide	EAL	annual mean	24	0.052	1655
Propylene oxide	EAL	hourly mean	720	0.108	3412
Selenium and compounds, except hydrogen selenide (as selenium)	EAL	daily mean	2	0.0006	19
Sodium hydroxide	EAL	hourly mean	200	0.030	948
Styrene	EAL	hourly mean	800	0.120	3791
Sulphur dioxide	Limit Value	hourly mean	350	0.053	1659
Sulphur dioxide	Limit Value	daily mean	125	0.038	1206
Sulphur hexafluoride	EAL	annual mean	60700	132.696	4184715
Sulphur hexafluoride	EAL	hourly mean	759000	114.052	3596738
Sulphuric acid	EAL	annual mean	10	0.022	689
Sulphuric acid	EAL	hourly mean	300	0.045	1422
Tetrachloroethylene	EAL	daily mean	40	0.012	386
Tetrahydrofuran	EAL	annual mean	3000	6.558	206823
Tetrahydrofuran	EAL	hourly mean	59900	9.001	283853
Toluene	EAL	hourly mean	8000	1.202	37910
Trichloroethylene	EAL	annual mean	2	0.004	138
Trimethylbenzenes, all isomers or mixture	EAL	annual mean	1250	2.733	86176
Trimethylbenzenes, all isomers or mixture	EAL	hourly mean	37500	5.635	177704
Vanadium	EAL	daily mean	1	0.0003	10
Vinyl acetate	EAL	annual mean	360	0.787	24819

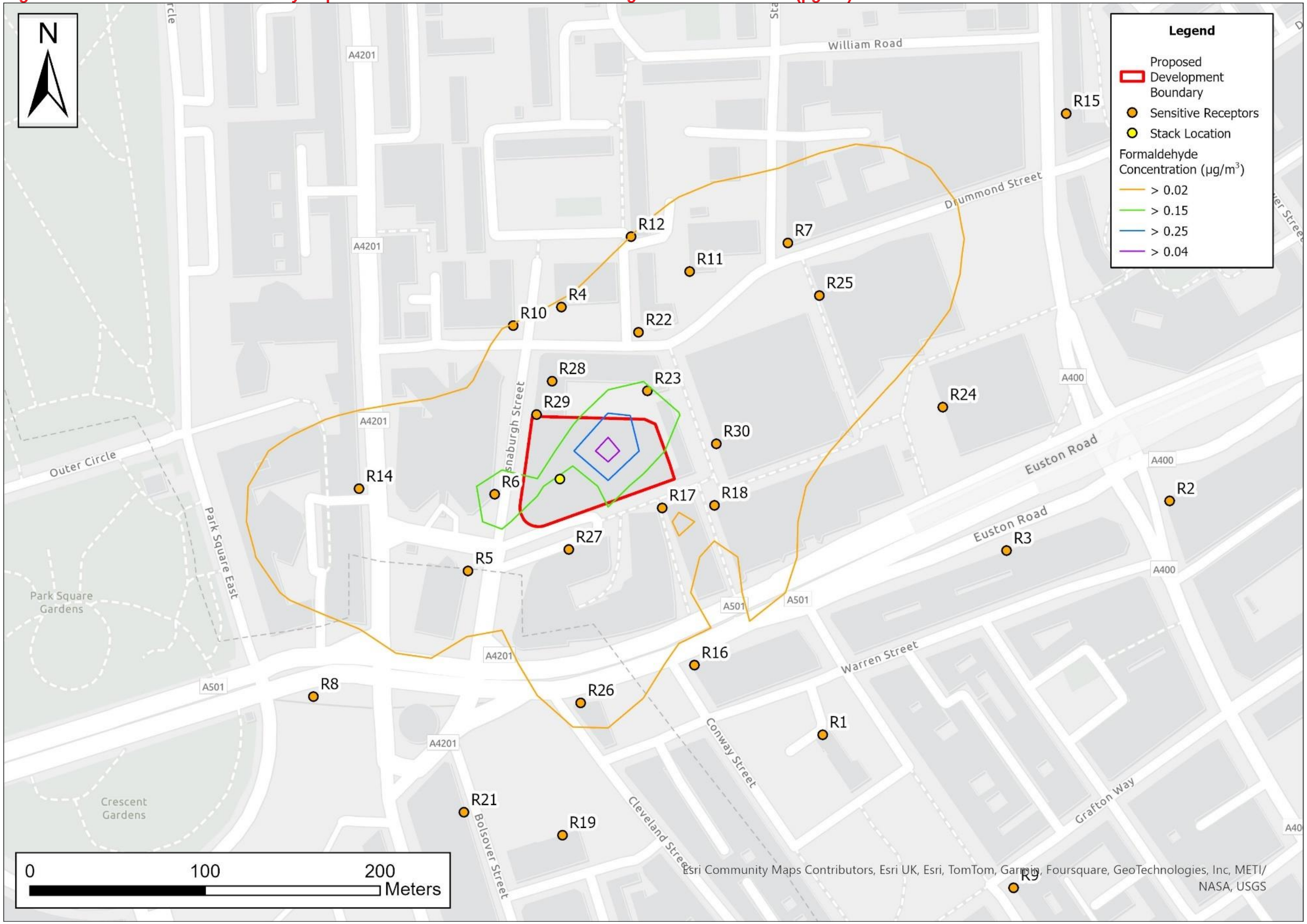
Pollutant	Target Type	Time Period	Target Value ($\mu g/m^3$)	Controlled Emission Rate needed to achieve assessment criteria for compliance with 10% of EAL	
				g/s	kg/yr
Vinyl acetate	EAL	hourly mean	7200	1.082	34119
Vinyl chloride	EAL	annual mean	10	0.022	689
Vinyl chloride	EAL	daily mean	1300	0.398	12541
Xylene (o-, m-, p- or mixed isomers)	EAL	annual mean	4410	9.641	304030
Xylene (o-, m-, p- or mixed isomers)	EAL	hourly mean	66200	9.948	313708
Zinc oxide	EAL	annual mean	50	0.109	3447
Zinc oxide	EAL	hourly mean	1000	0.150	4739

Appendix C

Formaldehyde Maximum Process Contribution Contours

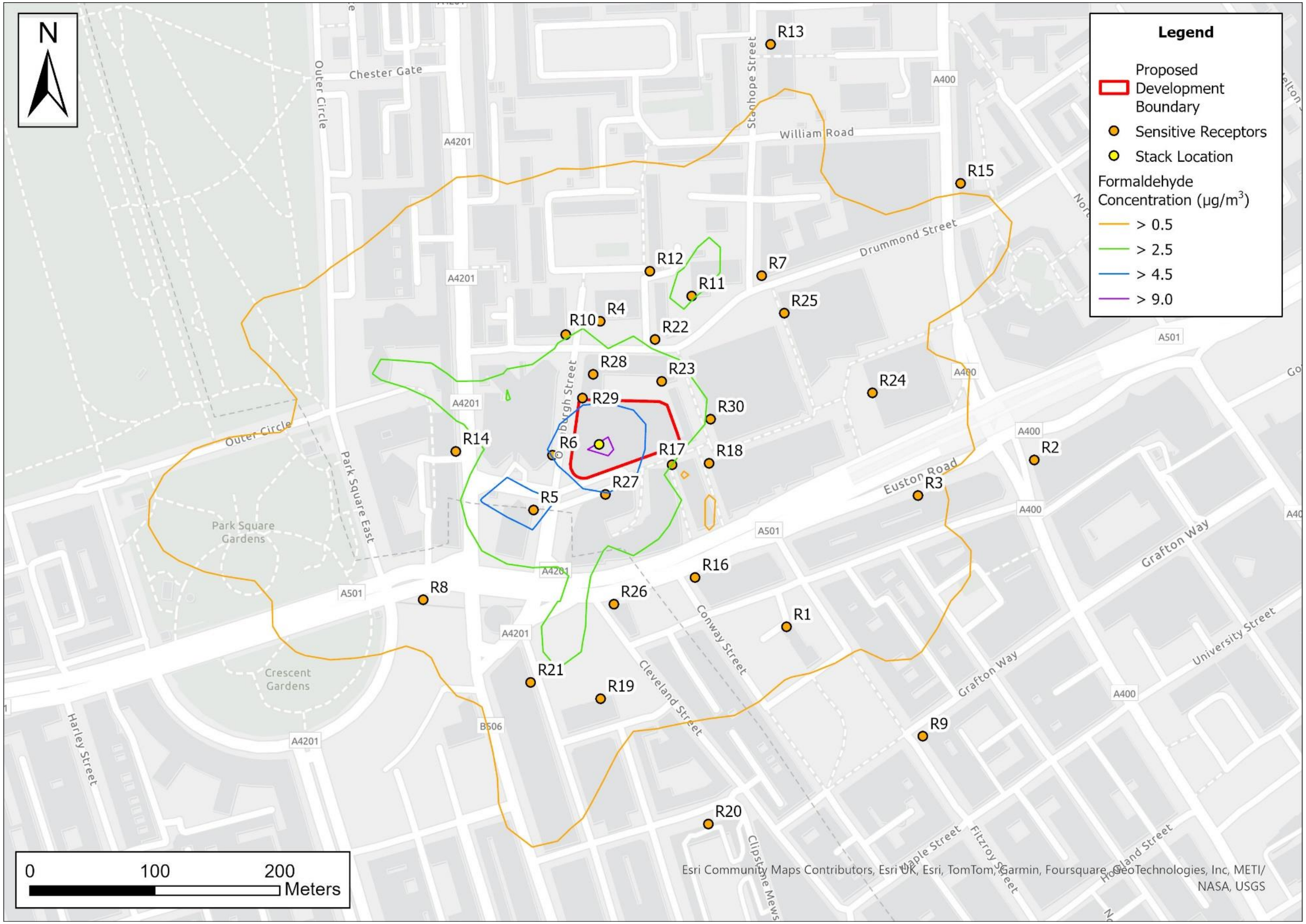
C.1 Annual mean process contribution

Figure C.1: Annual mean formaldehyde process contribution at 43.3m above ground level in 2021 ($\mu g/m^3$)



C.2 30-minute mean process contribution

Figure C.2: 30-minute mean formaldehyde process contribution at 43.3m above ground level in 2020 ($\mu g/m^3$)



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