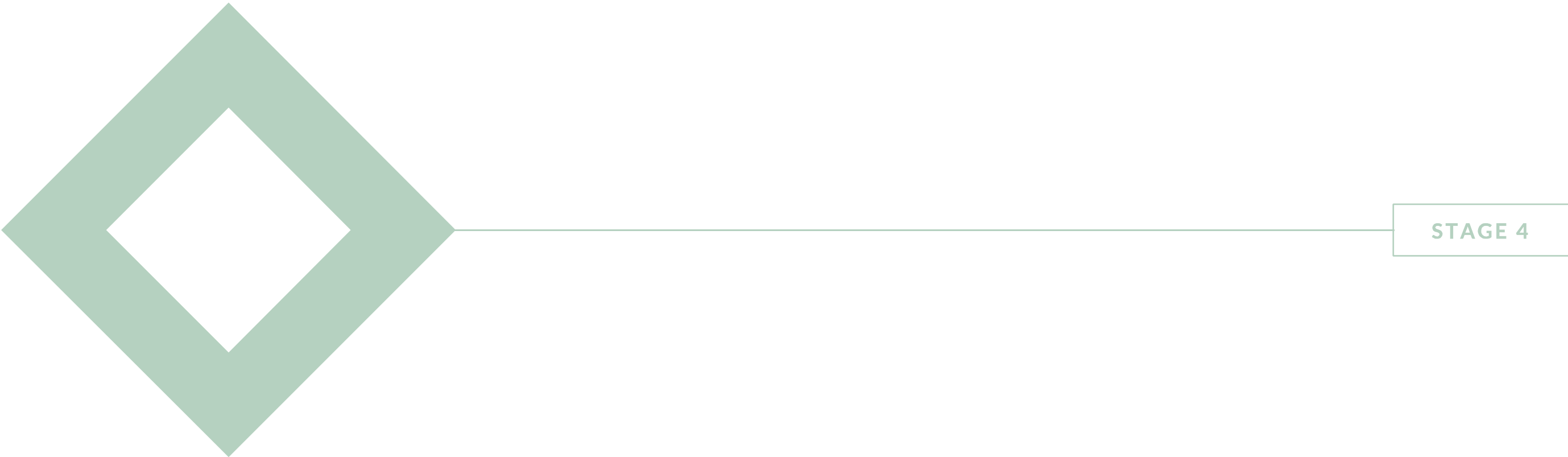


Project RED.
Manchester Royal Infirmary.
Integrated Health Projects.

AIR QUALITY
STAGE 4 REPORT – AIR QUALITY

REVISION 01 – 22 FEBRUARY 2022



Audit Sheet.

Rev.	Date	Description of change / purpose of issue	Prepared	Reviewed	Authorised
00	09/02/2022	First Draft for Client Comment	ER	AD/KW	CR
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Executive Summary.

Hoare Lea have been commissioned by Integrated Health Projects to model pollutant concentrations associated with two proposed diesel generators (the 'Proposed Plant') at Manchester Royal Infirmary, Oxford Road, Manchester (the 'Site') in order to provide advice regarding stack height.

The Proposed Plant comprises two new diesel generators, each with a maximum thermal output of 1.7 MW_e, which are to be installed in an existing car park to the north of the hospital to support the redevelopment and extension of the existing Emergency Department. The emissions from the Proposed Plant will exit via two separate flues which will share a common free-standing windshield located to the north east of the generator sets.

The sole purpose of the generators is to maintain power supply during an on-site emergency, operating only for testing/maintenance purposes for a maximum of 50 hours per year. As such, the Proposed Plant is exempt from meeting the emission limits set out in the Medium Combustion Plant Directive (MCPD) and Schedule 25B (Specified Generators) of the Environmental Permitting Regulations, as detailed in the Environment Agency (EA) guidance.

The baseline assessment shows that the Site is located within an Air Quality Management Area declared for exceedances of the annual mean nitrogen dioxide (NO₂) air quality objective. Pollutant concentrations at nearby monitoring locations have complied with the 1-hour mean NO₂, 24-hour particulate matter (PM₁₀) and annual mean PM₁₀ and PM_{2.5} objectives in the last five years, however the annual mean NO₂ objective has been consistently exceeded.

The emissions from the Proposed Plant have been modelled using the dispersion model ADMS 5 and the impact on local NO₂, PM₁₀ and PM_{2.5} concentrations have been assessed in line with both the Defra and EA online guidance and the Environmental Protection UK (EPUK) and Institute of Air Quality Management (IAQM) planning guidance.

At a 14 m stack height, the NO_x, PM₁₀ and PM_{2.5} emissions released from the Proposed Plant do not have a significant impact on existing sensitive receptors in the vicinity of the Site and are predicted to achieve compliance with the annual mean NO₂, PM₁₀ and PM_{2.5} objectives. Furthermore, a stack height of 14 m gives a less than 1% chance that the 1-hour mean NO₂ objective will be exceeded at any of the existing sensitive receptors when using a hypergeometric distribution.

Based on these results and provided the Proposed Plant meets the modelled parameters set out within this report, a stack height of 14 m is recommended for the proposed flues. At this height, the impact of the Proposed Plant is not considered to be significant without the inclusion of mitigation.

Notwithstanding this, further research into potential mitigation measures could be undertaken to determine whether either a scenario without a flue or with a reduced stack height could be viable. These mitigation measures include the use of Hydrotreated Vegetable Oil (HVO) as the primary fuel, or the addition of Selective Catalytic Reduction (SCR) abatement to reduce NO_x and particulate matter emissions. If viable, these mitigation measures have the potential to reduce costs, advance the hospital's net zero ambitions and/or provide a greater flexibility for the future use of the Proposed Plant. After considering the mitigation measures above, the corresponding MCPD permit, or permit exemption, will need to be obtained from the EA prior to commissioning the Proposed Plant.

It should be noted that the results contained within this report are based on the model parameters provided at the time of assessment for two 2,000 kVA diesel generators. Based on these parameters, a stack height of 14 m has been deemed suitable without the inclusion of mitigation. In the scenario that updates are required to either the generator or flue specifications, the stack height and conclusions of this assessment will need to be reconsidered in order to align with the latest design.

1. Introduction.

Hoare Lea have been commissioned by Integrated Health Projects to model pollutant concentrations associated with two proposed diesel generators (the 'Proposed Plant') at Manchester Royal Infirmary, Oxford Road, Manchester (the 'Site') in order to provide advice regarding stack height.

1.1 Proposed Plant.

The Proposed Plant comprises two new diesel generators, each with a maximum thermal output of 1.7 MW_e, which are to be installed in an existing car park to the north of the hospital to support the redevelopment and extension of the existing Emergency Department (planning application reference: 128651/FO/2020). The emissions from the Proposed Plant will exit via two separate flues which will share a common free-standing windshield to the north east of the generator sets.

The sole purpose of the generators is to maintain power supply during an on-site emergency, operating only for testing/maintenance purposes for a maximum of 50 hours per year. As such, the Proposed Plant is exempt from meeting the emission limits set out in the Medium Combustion Plant Directive and Schedule 25B (Specified Generators) of the Environmental Permitting Regulations, as detailed in the Environment Agency (EA) guidance, however an environmental permit exemption will need to be obtained in due course.

1.2 Site Description and Location.

The Site is located within Manchester City Council's (MCC) administrative area at the approximate National Grid Reference (NGR): X 385070 Y 396355. It is situated to the north of the Manchester Royal Infirmary hospital at approximate postcode M13 9NZ, and currently exists as a small car park. The Site is bound by the existing hospital to the south east, the Wellcome Trust Clinical Research Facility to the west and North Road to the north. A visual representation of the Site is shown in Figure 1 below.



Figure 1: Approximate Location of the Site. Contains OS Data © Crown Copyright and Database rights 2022

A glossary of terms is provided in section 8.

2. Air Quality Standards and Guidance.

A summary of the relevant air quality standards and guidance used throughout this assessment has been provided below.

2.1 Air Quality Strategy and Local Air Quality Management.

The Environment Act 1995 (Part IV)¹ requires the Secretary of State to publish an air quality strategy and local authorities to review and assess the quality of air within their boundaries. The latter has become known as Local Air Quality Management (LAQM).

The Air Quality Strategy² provides the policy framework for LAQM and assessment in the UK. It sets out air quality standards and objectives for key air pollutants. These standards and objectives are designed to protect human health and the environment and are summarised in Table 1 below.

Table 1: Air Quality Objectives for NO₂, PM₁₀ and PM_{2.5}

Pollutant	Time Period	Objective
Nitrogen Dioxide (NO ₂)	1-hour Mean	200 µg/m ³ Not to be exceeded more than 18 times a year
	Annual Mean	40 µg/m ³
Fine Particulate Matter (PM ₁₀) †	24-hour Mean	50 µg/m ³ Not to be exceeded more than 35 times a year
	Annual Mean	40 µg/m ³
Fine Particulate Matter (PM _{2.5}) †	Annual Mean	25 µg/m ³
Notes: †Measured gravimetrically.		

The objectives apply at locations where members of the public are likely to be regularly present and exposed over the averaging period of the objective. The 1-hour mean, 24-hour mean and annual mean objectives are all applicable at hospitals such as the Manchester Royal Infirmary.

2.2 Medium Combustion Plant Directive.

The Medium Combustion Plant Directive (MCPD)³, published in 2018, sets out emission limits and monitoring requirements for combustion plants with a total rated thermal input equal to or greater than 1 MW_{th} and less than 50 MW_{th}. The Directive lays down rules to control emissions of sulfur dioxide, nitrogen oxides and dust from medium combustion plants, in order to reduce emissions to air and the potential risks to human health and the environment. The Directive also includes monitoring requirements for the release of carbon monoxide; however, emission limits have not yet been proposed.

2.3 Environmental Permitting (England and Wales) (Amendment) Regulations 2018.

The Environmental Permitting (England and Wales) (Amendment) Regulations were published in January 2018 to transpose the MCPD into UK Law³. Schedule 25B⁴ addresses emissions from the operation of Specified Generators. It states that back-up generators, such as the Proposed Plant, whose sole purpose is to maintain power supply during an on-site emergency, and which are operated for no more than 50 hours a year for testing/maintenance purposes, are exempt from the MCPD emission limits. According to online Defra and EA guidance⁵, an application for permit exemption should be made to the regulating authority, however this should be confirmed through consultation with a permitting expert.

2.4 EPUK-IAQM ‘Air Quality Guidance for Planning’.

Environmental Protection UK (EPUK) and the Institute of Air Quality Management (IAQM) have together published guidance⁶ to clarify when an air quality assessment should be undertaken, what it should contain, and how impacts should be described and assessed including guidelines for assessing the significance of impacts.

2.5 Environment Agency Conversion Ratios for NO_x to NO₂.

Defra and the EA have released online guidance⁷ to facilitate the conversion of annual mean and 99.79 percentile of 1-hour mean nitrogen oxide (NO_x) concentrations to annual mean and 1-hour mean NO₂ concentrations. The approach, which is considered appropriate for combustion sources, assumes:

- Annual mean NO₂ concentrations = annual mean NO_x concentrations x 0.7;
- 99.79 percentiles of 1-hour mean NO₂ concentrations = 99.79 percentiles of 1-hour mean NO_x multiplied by 0.35; and
- Relevant short-term background concentration = 2 x annual mean background concentration.

3. Methodology of Assessment.

3.1 Existing Air Quality in the Study Area.

A baseline air quality review was undertaken to determine the existing air quality in the vicinity of the Site.

This desk-top study was undertaken using the following sources:

- Air quality data for Manchester, including a review of the Greater Manchester Combined Authority (GMCA) air quality reports and local monitoring data;
- The UK Pollutant Release and Transfer Register⁸;
- Background pollution maps from Defra's LAQM website⁹;
- Pollution Inventory from the EA¹⁰; and
- Aerial photography from Google Maps.

3.2 Operational Phase Impacts.

Energy Impacts

Impacts associated with the Proposed Plant have been modelled using the ADMS 5 (v.5.2.2.0) dispersion model. ADMS 5 is an extensively validated Gaussian plume air dispersion model, and is used by regulators, government departments, consultancies and industry. The model is able to simulate the entrainment of the plume in the wake of the building.

The key air pollutants of concern during the operational phase of the Proposed Plant are nitrogen oxides (NO_x), NO₂ derived from NO_x, PM₁₀ and PM_{2.5}. The 24-hour mean PM₁₀ objective is not applicable for this assessment as the proposed usage of the diesel generators will not be sufficient to exceed the 24-hour mean objective for more than 35 days of the year.

Ambient concentrations have been predicted at ground level (1.5 m) and at various stack heights. The concentrations have been predicted across a 1 km by 1 km grid to determine the maximum off-site impact on the annual mean and 99.79 percentile of 1-hour mean NO₂ concentrations. Concentrations were also predicted at existing sensitive receptor locations in the vicinity of the Site, as illustrated in Appendix 1.

Full details of the modelling methodology and model input parameters are provided in Appendix 2. Three meteorological years have been modelled using ADMS 5: 2017, 2018 and 2019. The results for 2017 have been presented in this assessment as a 'worst-case' year, predicting the greatest NO₂ contributions from the Proposed Plant.

Operational Hours

The Proposed Plant is expected to operate for 16 hours per year as part of 12 monthly 45-minute tests, which have been assumed to be 60 minutes for modelling purposes, and one annual 4-hour test. The 1-hour mean is not applicable in this assessment if the two generators are operating simultaneously as the proposed usage of the Proposed Plant is not sufficient to exceed the 1-hour mean NO₂ objective for more than 18 hours per year.

Notwithstanding with, a scenario has been modelled under the assumption that the generators will be tested individually rather than simultaneously, giving a worst-case consideration of 32 operational hours per year. This scenario has been modelled using emissions from just one generator and the annual mean model outputs have been scaled by a factor of 32/8760. The 1-hour mean NO₂ objective is applicable in this assessment without scaling by 32/8760 as the proposed usage of the generators could be sufficient to exceed the 1-hour mean NO₂ objective for more than 18 hours a year.

In order to capture all of the various meteorological conditions throughout the year, the model has been run for a full operational year and the following percentiles have been derived:

- 100th percentile to represent the worst-case hour of the year when NO₂ concentrations are predicted to be at their greatest;
- 99.79th percentile to represent the 19th worst-case hour of the year, typically used to assess against the 1-hour mean objective; and

- 62.409th percentile which considers the probability that an exceedance will occur based on the limited operational hours of the Proposed Plant and the use of a hypergeometric distribution.

As the Proposed Plant will only operate for a limited number of hours per year, it is considered unlikely that these operational hours will always coincide with the worst-case meteorological conditions. Assessing against the 99.79th percentile is therefore considered an unreasonably conservative approach and a hypergeometric distribution has been used instead.

A hypergeometric distribution is a discrete probability distribution that can be used to determine the probability that a source which only operates for a limited number of hours per year will lead to an exceedance of an air quality objective. This is achieved through calculating the number of hourly values from a dataset (i.e. 8,760 hours per year) that would need to exceed 200 µg/m³ before the overall chance of exceeding the 1-hour mean NO₂ objective reaches 1%.

For this assessment, concentrations predicted to be below 200 µg/m³ when using the 62.409th percentile will give a less than 1% chance that the 32 operational hours will coincide with 19 meteorological hours predicted to exceed 200 µg/m³, thereby causing an exceedance of the 1-hour mean NO₂ objective. This percentile has been used when assessing the significance of short-term NO₂ impacts from the Proposed Plant and determining a suitable stack height.

3.3 Assessment of Significance.

3.3.1 Operational Impacts

The EPUK and IAQM guidance has been used to assess the potential for significant impacts as a result of emissions from the Proposed Plant on existing sensitive receptor locations in the vicinity of the Site. The air quality impacts at individual receptors have been determined by determining the percentage change in concentrations relative to the air quality objectives and comparing this with the total long-term average concentration (Proposed Plant + existing concentration).

The short-term objectives have also been assessed against the criteria in the EPUK and IAQM document, although these impact descriptors are based solely on the predicted process contribution.

Where significant impacts are predicted, mitigation measures are recommended to reduce the impact. The determination of the significance of impacts includes elements of professional judgement and the professional experience of the consultant preparing the report is set out in Appendix 3.

The overall significance of the air quality impacts is judged as either significant or not significant taking account of:

- The existing and future air quality in the absence of the development;
- The extent of current and future population exposure to the impacts; and
- The influence and validity of any assumptions adopted when undertaking the prediction of impacts.

4. Baseline Environment.

This section sets out the available information on air quality in the vicinity of the Site.

4.1 Site Setting.

The Site is located within MCC’s area of administration at approximate NGR: X 385070 Y 396355. It is situated to the north of the Manchester Royal Infirmary hospital at approximate postcode M13 9NZ, and currently exists as a small car park.

4.2 Local Air Quality Management Review and Assessment.

As required by The Environment Act (1995), MCC and the GMCA have undertaken review and assessment of air quality within their area of administration. This process indicated that there have been exceedances of the annual mean NO₂ objective throughout Manchester. As such, one Air Quality Management Area (AQMA) was declared in 2016 covering the 10 districts of Greater Manchester, including arterial routes, district centres and the airport. The Site is partially located within the GMCA AQMA.

According to the GMCA 2021 Annual Status Report (ASR)¹¹, long term trends have shown improvement in NO₂ concentrations across Greater Manchester, however several areas remain above the annual mean objective. No exceedances of the 1-hour mean NO₂, 24-hour mean PM₁₀ or annual mean PM₁₀ and PM_{2.5} objectives have been recorded at any of GMCA’s monitoring locations in the last five years.

4.3 Local Air Quality Monitoring.

The UK Automatic Urban and Rural Network (AURN) is a countrywide network of air quality monitoring stations operated on behalf of Defra. Monitoring data for AURN sites is available from the UK Air Information Resource website (UK AIR). There is currently one AURN station in operation within MCC’s area of administration, Manchester Piccadilly (ID: MAN3). This monitoring station is located approximately 2.1 km north west of the Site in an urban centre location.

In addition, GMCA operate a further two automatic monitoring stations within MCC’s area of administration. The closest monitoring station, Manchester Oxford Road (ID: MAN1), is a kerbside site located approximately 1.2 km to the north west to the Site.

Recent monitoring data for the nearby automatic stations is detailed in Table 2 and a visual representation of the locations of the automatic monitoring stations is shown in Figure 2. As a result of the Government implemented Covid-19 lockdowns in 2020, monitoring data from 2019 is considered to be the latest representative set of monitoring data and therefore 2020 data has been omitted from this assessment.

Table 2: Automatic Monitoring Stations in the Vicinity of the Site. Data presented in bold represents an exceedance of the relevant air quality objective.

Monitoring station and distance (km) from site boundary (approx.)	Objective	2015	2016	2017	2018	2019
NO ₂						
Manchester Oxford Road (MAN1), 1.2 km	Annual mean (µg/m ³)	66	66	65	62	59
	Number of hours with concentrations >200 µg/m ³	60	90	6	2	1
Manchester Piccadilly (MAN3), 2.1 km	Annual mean (µg/m ³)	39	40	36	35	36
	Number of hours with concentrations >200 µg/m ³	1	0	1	0	0

Monitoring station and distance (km) from site boundary (approx.)	Objective	2015	2016	2017	2018	2019
PM ₁₀						
Manchester Oxford Road (MAN1), 1.2 km	Annual mean (µg/m ³)	28	27	27	30	26
	Number of days with concentrations > 50 µg/m ³	25	16	15	15	18
Manchester Piccadilly (MAN3), 2.1 km	Annual mean (µg/m ³)	20	20	20	21	20
	Number of days with concentrations > 50 µg/m ³	3	3	3	2	7
PM _{2.5}						
Manchester Piccadilly (MAN3), 2.1 km	Annual mean (µg/m ³)	10	10	8	11	12

As shown in Table 2, the Manchester Oxford Road kerbside automatic monitoring station consistently exceeded the annual mean NO₂ objective between 2015 and 2019. However, the annual mean objective was achieved over the same period at the Manchester Piccadilly urban centre automatic monitoring station.

There were no recorded exceedances of the 1-hour mean NO₂, 24-hour mean PM₁₀ or the annual mean PM₁₀ and PM_{2.5} objectives between 2017 and 2019 at either automatic monitoring station.

MCC also utilise passive diffusion tubes to monitor NO₂ concentrations. A review of the most recent monitoring data available indicated that there are five passive diffusion tube monitoring locations within approximately 1.5 km of the Site. Recent monitoring results are shown in Table 3 and the passive diffusion tube locations are illustrated in Figure 3.



Figure 2: Automatic and non-automatic monitoring locations within the vicinity of the Site. Contains OS Data © Crown Copyright and Database rights 2022.

Table 3: Passive Diffusion Tube Monitoring Results in the Vicinity of the Site. Data presented in bold represents exceedances of the annual mean NO₂ objective.

Site ID	Site Type	Site Name	Distance (m) from Site (approx.)	Annual Mean NO ₂ Concentration (µg/m ³)				
				2015	2016	2017	2018	2019
MA96BNO	Roadside	Ardwick Green	800	-	-	-	-	46.0
MA72NO	Urban Background	Lockton Close	1,050	34.8	40.0	34.6	33.4	32.8
MA82NO, MA83NO, MA84NO (triplicate)	Roadside	Manchester Oxford Road	1,220	60.8*	60.2	56.2	54.0	52.0
MA78NO	Urban Background	Rostron Avenue	1,300	31.9	37.0	38.3	33.2	33.0
MA29ANO	Roadside	Oxford Street	1,470	56.4	66.2	57.7	58.8	55.4

*Value averaged using data available for MA82NO, MA83NO and MA84NO in Diffusion Tube Results 2011-16 available at <https://cleanairgm.com/data-hub/monitoring-reports>

As shown in Table 3, exceedances of the annual mean NO₂ objective were often recorded at roadside passive diffusion tube monitoring locations within the vicinity of the Site between 2015 and 2019. The closest passive diffusion tube monitoring location to the Site, Ardwick Green (ID: MA96NO), exceeded the annual mean objective

in the most recent year with representative monitoring data, 2019. However, both nearby urban background passive diffusion tube monitoring locations consistently achieved the annual mean objective between 2015 and 2019.

An annual mean concentration of 60 µg/m³ or above is often used to indicate a possible exceedance of the 1-hour mean NO₂ objective. No passive diffusion tube in the vicinity of the Site has recorded a NO₂ concentration in excess of 60 µg/m³ since 2016.

4.4 Industrial Pollution.

A desk-based review of potential industrial sources using the UK Pollutant Release and Transfer Register⁸ and the EA’s Pollution Inventory¹⁰ identified five industrial or waste management sources in the vicinity of the Site. No relevant pollutant releases have been recorded from these sources in the last five years.

Table 4: Industrial/Waste Sources of Air Pollution in the Vicinity of the Site

Facility	Activity at Facility	Approximate Distance from Site (km)
Heineken UK Brewery	Manufacture of beer	0.9
Operational Depot	Treatment and disposal of non-hazardous waste	1.3
Sims Group UK Limited	Treatment and disposal of non-hazardous waste	1.4
Ashton Old Road Recycling Depot	Treatment and disposal of non-hazardous waste	1.6
Redgate Holdings Limited Materials Recovery Facility	Treatment and disposal of non-hazardous waste	1.7

4.5 Defra Predicted Concentrations.

Background concentrations have been obtained from the national maps published by Defra⁹. These estimated concentrations are produced on a 1 km by 1 km grid basis for the whole of the UK. The Site falls into grid square X 385500 Y 396500 and the predicted concentrations for this grid square for NO₂, PM₁₀ and PM_{2.5} are provided in Table 5 for 2019, the most recent year with representative monitoring data and for 2023, the anticipated operational year for the Proposed Plant.

Table 5: Predicted Background Concentrations at the Site

Year	Predicted Background Concentration (µg/m ³)		
	NO ₂	PM ₁₀	PM _{2.5}
2019	20.9	12.9	8.5
2023	18.0	12.2	8.1

As shown in Table 5, background concentrations are below the air quality objectives for all pollutants in the anticipated operational year of the Proposed Plant, 2023.

4.6 Summary of Background Data.

The baseline assessment has shown that the annual mean NO₂ objective was often exceeded at roadside locations in the vicinity of the Site between 2015 and 2019. The closest passive diffusion tube monitoring location to the Site, Ardwick Green (ID: MA96NO), exceeded the annual mean objective in the most recent year with representative monitoring data, 2019.

The nearby automatic monitoring stations have both complied with the 1-hour mean NO₂, 24-hour mean PM₁₀ and annual mean PM₁₀ and PM_{2.5} objectives in the last three years of representative monitoring data, 2017 to 2019.

Furthermore, the Defra predicted background concentrations at the Site are below the relevant air quality objectives in the anticipated operational year of the Proposed Plant, 2023.

4.7 Background Concentrations used in Dispersion Modelling.

4.7.1 NO₂ Background Concentrations

A background concentration of 33.0 µg/m³ has been applied in this assessment. This concentration has been taken from the monitoring data recorded at the Rostron Avenue (ID: MA78NO) passive diffusion tube, located approximately 1.3 km to the north east of the Site, in 2019. The provides a worst-case scenario as the background concentration is likely to account for contributions from the adjacent railway lines.

In line with the Defra/EA online guidance⁷, the annual mean NO₂ background concentrations have been doubled when assessing against the 1-hour mean NO₂ objective.

4.7.2 PM₁₀ Background Concentrations

The closest PM₁₀ automatic monitoring station to the Site is Manchester Oxford Road, located approximately 1.2 km to the north west. PM₁₀ concentrations recorded at Manchester Oxford Road are not considered representative of background concentrations at the Site, therefore the 2021 Defra predicted background maps have been used to obtain representative PM₁₀ background concentrations at all existing sensitive receptor locations.

It has been assumed that the 2021 Defra background concentrations are representative of background concentrations in 2023, when the Proposed Plant is anticipated to be operational. As air quality is predicted to improve in the future, holding the background concentration at 2021 levels is considered a worst-case scenario and allows for a robust assessment of impacts.

4.7.3 PM_{2.5} Background Concentrations

The closest PM_{2.5} automatic monitoring station to the Site is Manchester Piccadilly, located approximately 2.1 km to the north west. Therefore, the 2021 Defra predicted background maps have been used to obtain representative PM_{2.5} background concentrations.

4.7.4 Summary

A summary of the background concentrations for NO₂, PM₁₀ and PM_{2.5} applied at the existing sensitive receptors is provided in Table 5. All existing sensitive receptors fall into grid square X 385500 Y 396500 except R18, R19, R20 and R22.

Table 6: Background Concentrations Applied at the Existing Sensitive Receptor Locations

Grid Square	Background Concentration (µg/m ³)		
	NO ₂	PM ₁₀	PM _{2.5}
X 384500 Y 396500	33.0	12.5	8.3
X 385500 Y 396500	33.0	11.9	7.9

5. Modelling Results.

5.1 NO₂ Concentrations.

NO₂ concentrations have been modelled at existing sensitive receptor locations in the vicinity of the Site using three different stack heights: 3.5 m, 14 m and 17 m. A stack height of 3.5 m represents a scenario without a flue where emissions are released via the generator exhausts. A 14 m and 17 m stack height represent scenarios with two separate flues sharing a common free-standing windshield located to the north east of the generator sets.

Three percentiles have been derived in order to assess the short term NO₂ impacts from the Proposed Plant, as outlined in section 3.2. The maximum NO₂ concentrations across all of the existing sensitive receptor locations have been summarised in Table 7 below for each of these percentiles, in addition to maximum modelled annual mean concentrations.

Table 7: Summary of Modelled NO₂ concentrations using 2017 Meteorological Data. Exceedances of the relevant air quality objectives are presented in bold.

Stack Height (m)	Maximum NO ₂ Concentration (µg/m ³)				Worst-Case Receptor
	Annual Mean	100 th Percentile	99.79 th Percentile	62.409 th Percentile	
3.5	34.8	9105.2	7945.6	304.09	R4 – Hospital
14	33.7	1644.5	1473.7	81.6	R25 - Residential
17	33.8	1672.6	1543.0	78.6	R25 –Residential

As shown above, the annual mean NO₂ objective of 40 µg/m³ is predicted to be achieved at all existing sensitive receptors in the vicinity of the Site at each stack height, but multiple exceedances of the short-term percentiles are likely.

The 100th percentile, which represents the worst-case meteorological hour in the year, significantly exceeds the 1-hour mean NO₂ objective of 200 µg/m³. At a stack height of 3.5 m (without a flue), NO₂ concentrations are predicted to be more than 4500% of the 1-hour mean objective. As such, a scenario without a flue is not considered to be viable without the inclusion of mitigation measures against NO_x emissions. The maximum NO₂ concentrations modelled using the 100th percentile are significantly lower with a stack height of 14 m and 17 m, although these concentrations are still in exceedance of the objective.

Elevated NO₂ concentrations are also predicted using the 99.79th percentile, which represents the 19th worst hour of the year and is often used to assess against the 1-hour mean NO₂ objective. As with the 100th percentile, the maximum NO₂ concentrations modelled using the 99.79th percentile significantly reduce with a flue stack height of 14 m and 17 m, although these are still in exceedance of the 1-hour mean objective.

The hypergeometric distribution percentile (62.409th) remains in exceedance of 200 µg/m³ at a stack height of 3.5 m, however the corresponding maximum NO₂ concentrations at a stack height of 14 m and 17 m are below 200 µg/m³. As a result, there is a less than 1% chance that the 1-hour mean NO₂ objective will be exceeded at both at 14 m and 17 m and therefore these stack heights are considered suitable for the Proposed Plant.

Increasing the stack height by 3 m to 17 m gives a 3 µg/m³, or 4 %, improvement in the maximum modelled NO₂ concentrations as a result of the operation of the Proposed Plant. This suggests that the additional 3 m will not provide a significant additional benefit and, as such, it is recommended that a stack height of 14 m is utilised.

Local air quality impacts have been assessed using a stack height of 14 m. At this height, the modelling results predict negligible and slight impacts on annual mean and 1-hour mean NO₂ concentrations at all existing sensitive receptor locations in the vicinity of the Site. This is based on the worst-case consideration of 32 operational hours of the Proposed Plant where the generators will be tested individually rather than simultaneously.

Provided a 14 m stack height is implemented, the overall impact of the Proposed Plant is not considered to be significant in line with the EPUK and IAQM guidance.

5.2 PM₁₀ and PM_{2.5} Concentrations.

PM₁₀ and PM_{2.5} concentrations are not expected to exceed the annual mean objectives at any of the existing sensitive receptor locations in the vicinity of the Site for any of modelled stack heights. As such, mitigation measures against particulate matter concentrations are not considered to be required.

6. Next Steps.

Based on the results of the modelling assessment, it is recommended that a stack height of 14 m is progressed for each flue. At this height, and provided the Proposed Plant meets the modelled parameters set out within this report, the impact of the Proposed Plant is not considered to be significant without the inclusion of mitigation measures.

Notwithstanding this, further research into potential mitigation measures could be undertaken to determine whether either a scenario without a flue or with a reduced stack height could be viable. These mitigation measures include:

- The use of Hydrotreated Vegetable Oil (HVO) fuel in replacement of diesel fuel; and
- The use of Selective Catalytic Reduction (SCR) abatement and diesel particulate filters (DPF).

HVO fuel is FAME (Fatty Acid Methyl Ester)-free fuel and is known to reduce both CO₂ emissions and NO_x emissions by delivering a cleaner combustion. The use of HVO fuel will not only reduce the probability of short-term NO₂ impacts in the vicinity of the Site and at the hospital, but will be beneficial for advancing the Trust's net zero ambitions. To determine whether the use of HVO fuel is a viable option, more information needs to be obtained on the percentage reduction in NO_x emissions that could be achieved for the Proposed Plant and any fuel compatibility issues when using HVO in stand-by generators.

Alternatively, SCR abatement could be utilised to bring NO_x and particulate matter emissions into compliance with the MCPD and Schedule 25B emission limits without the use of a flue. This would provide greater future flexibility as it would enable the Trust to use the generators on the capacity market if required as the NO_x and PM emissions will have already been reduced to acceptable concentrations. It is worth noting that if the Proposed Plant is used on the capacity market, an environmental permit would be required from the EA which will come with an associated cost. Furthermore, Diesel Particulate Filters (DPF) will need to be installed to control particulate matter emissions from the Proposed Plant.

After considering the potential mitigation measures above, the appropriate MCPD and Schedule 25B permit, or exemption, will need to be obtained from the EA prior to commissioning the Proposed Plant. If the proposed usage of the generators remains below 50 hours per year after adopting any mitigation measures such as SCR, the Proposed Plant will remain exempt from complying with the MCPD and Schedule 25B emission limits. An application for an exemption must be made to the EA, and an exemption granted prior to commissioning the Proposed Plant in 2023. The responsibility for obtaining a MCPD and Schedule 25B permit ultimately lies with the plant operator.

It should be noted that the results contained within this report are based on the model parameters provided at the time of assessment for two 2,000 kVA diesel generators. Based on these parameters, a stack height of 14 m has been deemed suitable without the inclusion of mitigation. In the scenario that updates are required to either the generator or flue specifications, both the stack height and the conclusions of this assessment will need to be reconsidered in order to align with the latest design.

7. Summary and Conclusions.

This report details the potential air quality impacts associated with the operation of two proposed diesel generators at Manchester Royal Infirmary, Oxford Road, Manchester.

The emissions from the Proposed Plant have been modelled using ADMS 5 to assess their impact on local air quality at various stack heights. The results indicated that a stack height of 14 m was sufficient to achieve compliance with the annual mean NO₂, PM₁₀ and PM_{2.5} objectives and gives rise to a less than 1% chance that the operation of the Proposed Plant will lead to an exceedance the 1-hour mean NO₂ objective.

Local air quality impacts have been assessed using a stack height of 14 m. At this height, the modelling results predict negligible and slight impacts on annual mean and 1-hour mean NO₂ concentrations at all existing sensitive receptor locations in the vicinity of the Site.

Based on these results and provided the Proposed Plant meets the modelled parameters set out within this report, a stack height of 14 m is recommended for the proposed flues. At this height, the impact of the Proposed Plant is not considered to be significant without the inclusion of mitigation.

Notwithstanding this, further research into potential mitigation measures could be undertaken to determine whether either a scenario without a flue or with a reduced stack height could be viable. These mitigation measures include the use of HVO as the primary fuel, or the addition of SCR abatement to reduce NO_x and particulate matter emissions. If viable, these mitigation measures have the potential to reduce costs, advance the hospital's net zero ambitions and/or provide a greater flexibility for the future use of the Proposed Plant. After considering the mitigation measures above, the corresponding MCPD permit, or permit exemption, will need to be obtained from the EA prior to commissioning the Proposed Plant.

It should be noted that the results contained within this report are based on the model parameters provided at the time of assessment for two 2,000 kVA diesel generators. Based on these parameters, a stack height of 14 m has been deemed suitable without the inclusion of mitigation. In the scenario that updates are required to either the generator or flue specifications, the stack height and conclusions of this assessment will need to be reconsidered in order to align with the latest design.

8. Glossary of Terms.

Defra	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EPUK	Environmental Protection UK
FAME	Fatty Acid Methyl Ester
GMCA	Greater Manchester Combined Authority
HVO	Hydrotreated Vegetable Oil
IAQM	Institute of Air Quality Management
LAQM	Local Air Quality Management
MCC	Manchester City Council
MCPD	Medium Combustion Plant Directive
µg/m³	Micrograms per cubic metre
NO₂	Nitrogen dioxide
NOₓ	Nitrogen oxides (taken to be NO₂ + NO)
Objectives	A nationally defined set of health-based concentrations for nine pollutants, seven of which are incorporated in Regulations, setting out the extent to which the standards should be achieved by a defined date. There are also vegetation-based objectives for sulphur dioxide and nitrogen oxides
PM₁₀	Particulate matter with an aerodynamic diameter less than 10 micrometres
PM₂.₅	Particulate matter with an aerodynamic diameter less than 2.5 micrometres
SCR	Selective Catalytic Reduction
Standards	A nationally defined set of concentrations for nine pollutants below which health effects do not occur or are minimal

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Appendix 1 – Combustion System Model Receptor Locations.

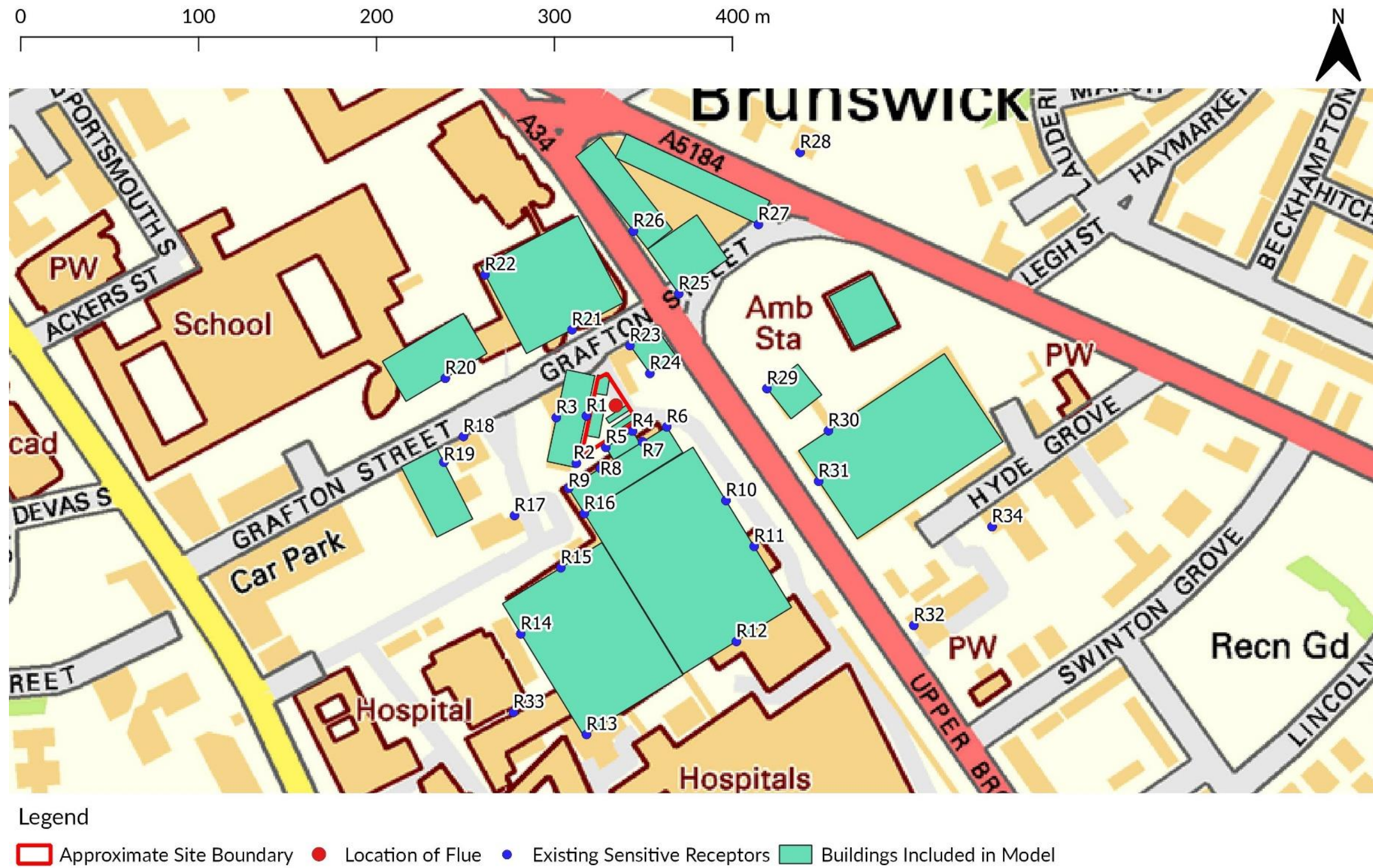


Figure 3: Existing Sensitive Receptor Locations Considered in the Assessment. Contains OS Data © Crown Copyright and Database rights 2022

Appendix 2 – Energy Combustion System Model Input Data.

Energy Centre.

The ADMS-5 model has been run to predict the contribution of the Proposed Plant to annual mean nitrogen oxides and the 99.79th percentile of 1-hour mean nitrogen oxides (NO_x) concentrations. The approach recommended by Defra/EA online guidance has been used to estimate annual mean NO₂ concentrations and 99.79 percentiles of 1-hour mean NO₂ concentrations from the modelled NO_x output assuming:

- Annual mean NO₂ concentrations = annual mean NO_x concentrations multiplied by 0.7; and
- 99.79 percentiles of 1-hour mean NO₂ concentrations = 99.79 percentiles of 1-hour mean NO_x multiplied by 0.35⁷

The model has also been run to predict the contributions to annual mean PM₁₀ and PM_{2.5} concentrations. The 24-hour mean PM₁₀ objective is not applicable for this assessment as the proposed usage of the generators will not be sufficient to exceed the 24-hour mean objective for more than 35 days a year.

Model Input Parameters.

The Proposed Plant will include two 1.7 MW_e diesel generators with two separate flues sharing a common free-standing windshield located to the north east of the generator sets. A scenario has also been modelled without a common flue and has been based on the locations of the two generator exhausts at a height of 3.5 m. The data input to the model are shown in Table 8.

Entrainment of the plume into the wake of the building (the building downwash effect) has been simulated within the model. The Wellcome Trust building to the south west of the Proposed Plant has been included as the main building, with a height of 13 m. Other buildings within in the local area have also been included in the model.

The Proposed Plant will be used for maintaining power supply during an on-site emergency and is expected to operate for approximately 16 hours a year for testing/maintenance purposes when operating simultaneously, or 32 hours a year when operating individually.

The diameter of the proposed flue is expected to a maximum of 500 mm, based on information provided by Ingrams for a 17 m stack height.

It has been assumed that the PM₁₀ and PM_{2.5} emissions rates are both equal to the PM emission rate detailed in Table 8, to provide a worst-case scenario for each pollutant.

Table 8: Model Input Parameters used in ADMS 5

Parameter	Generator	
	Without Flue	With Flue
Number of Units	2	2
Make and Model	Mitsubishi S16R-PTAA2 Engine	Mitsubishi S16R-PTAA2 Engine
Fuel	Diesel	Diesel
Electrical output (MW)	1.68	1.68
Exhaust gas temperature (°C)	530	530
Exhaust gas volume flow rate (Nm³/s)	6.717	6.717

Parameter		Generator	
		Without Flue	With Flue
Flue height above ground (m)		3.5	14
Flue diameter (mm)		350	500
NO _x emission rate per unit	g/s	8.475	8.475
PM emission rate per unit	g/s	0.224	0.224

Meteorological Data.

The meteorological data has been taken from the monitoring station located at Manchester Airport, which is considered suitable for the area. Table 9 shows the values for surface roughness and the Monin-Obukhov length inputs used in the model.

ADMS-5 has been run for three meteorological years: 2017, 2018 and 2019. The maximum predicted NO₂ contributions for each meteorological year are presented in Table 10. The assessment considers the results for 2017, the ‘worst-case’ year.

Table 9: Grid and Meteorological Data Settings used in ADMS 5

Meteorology		Value		
Monin-Obukhov Length (m)	Dispersion Site	30		
	Meteorological Measurement Site	10		
Surface Roughness (m)	Dispersion Site	0.8		
	Meteorological Measurement Site	0.3		
Grid		Start	Finish	Number of Points
x		384567	385567	51
y		395855	396855	51
z		1.5	16	2

Table 10: Meteorological Analysis to Determine Worst Case Conditions at a 14 m Stack Height

Meteorological Data Year	Maximum Predicted Annual Mean NO ₂ Contribution: Lowest Receptor Level (1.5 m) (µg/m ³)	Maximum Predicted Annual Mean NO ₂ Contribution: at height (µg/m ³)	Maximum Predicted 1-hour mean NO ₂ Contribution: Lowest Receptor level (1.5 m) (µg/m ³)	Maximum Predicted 1-hour mean NO ₂ Contribution: at height (µg/m ³)
2017	0.20	0.74	0.01	8.09
2018	0.16	0.59	0.79	8.09
2019	0.16	0.68	1.56	5.64

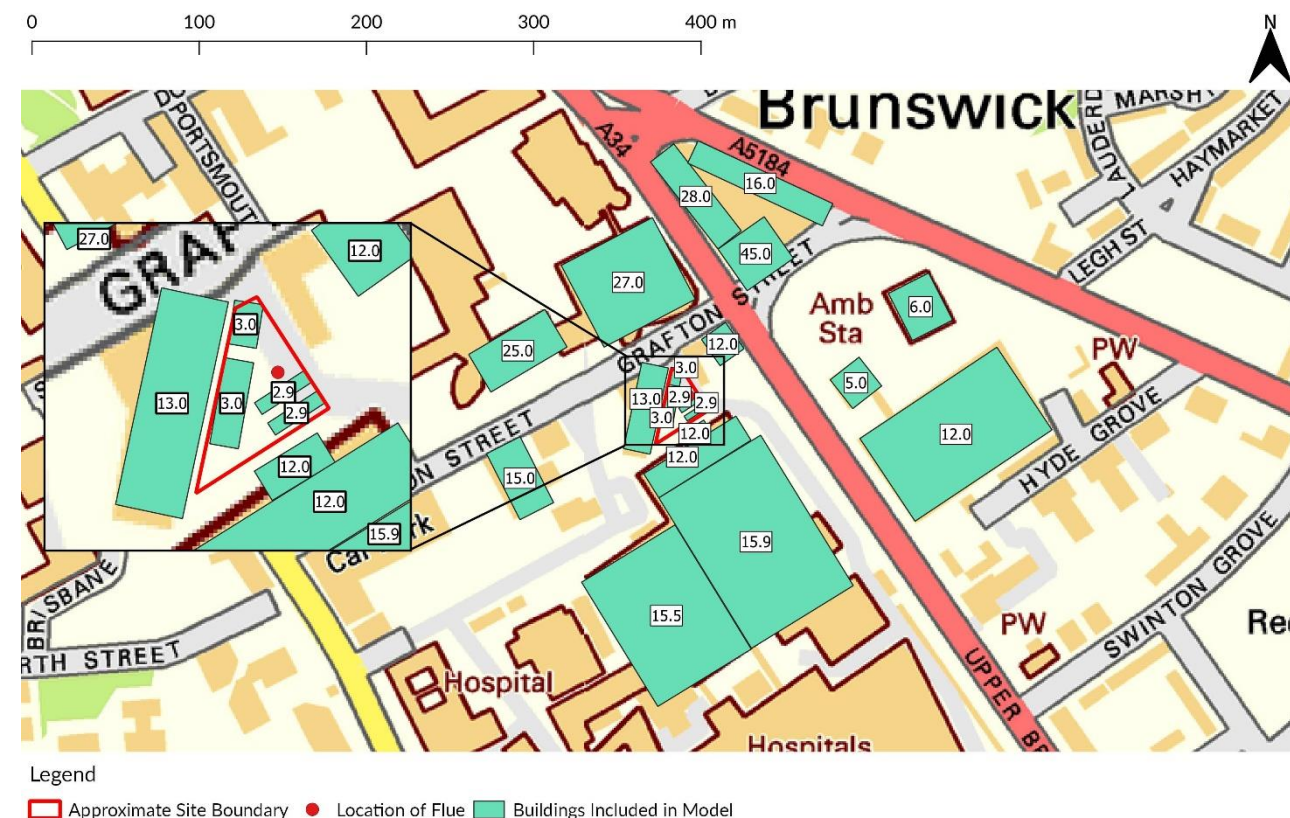


Figure 4: Flue Locations and Buildings Included in the Dispersion Model Labelled with Height (m). Contains OS Data © Crown Copyright and Database rights 2022

Appendix 3 – Professional Experience.

Chris Rush (Hoare Lea), BSc (Hons), MSc, PG Dip Acoustics, CEnv, MIOA, MIEMA, MIEEnvSc, MIAQM

Chris is an Associate Director Air Quality Consultant with Hoare Lea. He is a Chartered Environmentalist, a Member of the Institute of Acoustics, a Full Member of the Institute of Environmental Management and Assessment, a Member of the Institution of Environmental Sciences and a Full Member of the Institute of Air Quality Management (IAQM).

He has a diverse portfolio of experience and has worked on a range of projects from initial site feasibility, through planning and development to construction and operation. Chris's expertise covers planning, noise and air quality, specifically in relation to residential developments, industrial fixed installations such as waste management centres and transportation environmental impact on developments including air traffic. Chris is involved in the testing and assessment of the impact of indoor air quality and how building design contributes to this. He also is a member of Chartered Institute of Building Services Engineers (CIBSE) Air Quality Working Group and a committee member of the IAQM.

Kathryn Woolley (Hoare Lea), BSc (Hons), AMIEnvSc, MIAQM

Kathryn is an Associate of the Air Quality team with Hoare Lea. She's is an Associate Member of the Institution of Environmental Sciences and a Full Member of the Institute of Air Quality Management.

She has a diverse portfolio of experience and has worked on a range of projects from initial site feasibility, through planning and development to construction and operation. Kathryn's expertise covers planning, and air quality, specifically in relation to residential developments, industrial fixed installations such as district heating networks. Kathryn has completed over 50 EIA in the past 8 years throughout the UK and abroad including; St Johns Masterplan in Manchester (residential led), Leicester City Football club training facility north of Leister (sports use), 1-5 Grosvenor Place, Westminster (mixed use residential, retail and hotel site), and Chestnut Avenue in Eastleigh (residential and community use).

Andy Day (Hoare Lea), BSc (Hons), MSc, AMIEnvSc, AMIAQM

Andy is a Senior Air Quality Consultant with Hoare Lea. He is an Associate Member of the Institute of Environmental Sciences and an Associate Member of the Institute of Air Quality Management. He is a chemistry graduate with a Master's specialising in the catalysed removal of harmful volatile organic compounds (VOCs) often generated from the combustion of fuel in car engines.

Andy has worked on a range of projects of varying size across a number of different sectors. His experience focusses on work up to and through planning for air quality assessments and environmental impact assessments. Andy also has experience in detailed dispersion modelling of road traffic and energy combustion plant, emission mitigation statements, damage cost calculations, indoor and outdoor air quality monitoring and assessing the air quality impact at ecologically sensitive sites.

Andy has a particular interest in reducing emissions for the benefit of human health and the environment through the life cycle of a building.

Emma Rigler (Hoare Lea), MChem (Hons), AMIEnvSc, AMIAQM

Emma is an Air Quality Consultant with Hoare Lea. She graduated from the University of York with a Chemistry degree focusing on Resources and the Environment. Emma's MChem project involved monitoring and mitigating pollutants released during the manufacture of antiperspirant sticks, to prevent adverse effects on human health and the environment.

Emma has worked on projects across a range of sectors including residential, commercial, hospitals, schools and film and television studios. She has experience preparing air quality, odour and environmental impact assessments, indoor air quality plans and Medium Combustion Plant Directive permitting reports. Emma's interests lie in the chemical and photochemical interactions of pollutants throughout the atmosphere.



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