Barclays Execution Services Ltd

Gloucester Data Centre
Environmental Permit Application

December 2023

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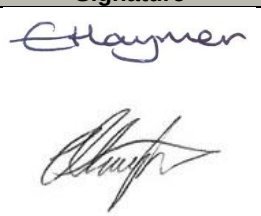
Prepared By	E Haymer J Clayton	Principal Consultant Technical Director	
Approved By	A Wiatr	Air Quality Business Unit Manager	

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Non-Technical Summary

This non-technical summary has been produced in order to support Barclays Execution Services Ltd (Barclays) with an application for an Environmental Permit (EP) to operate a data centre facility in Gloucester. The data centre is owned and operated by Barclays.

The site address is:

Gloucester Data Centre
Barnett Way
Gloucester
Gloucestershire
GL4 3RU

The map in Figure i1 shows the site location.

Electricity provided from the local electricity transmission network will be used to operate the data centre, however, given the nature of data centres and their requirement to have an available energy supply at all times, the site has a back-up power supply, in the form of diesel generators. The generators will provide power to the data centre in the event of an emergency situation such as a loss of power from the local electricity transmission network. The space heating requirements for the site are provided by gas boilers. Currently at the site there are 10 operational diesel-fired back-up generators, 4 gas boilers and one diesel sprinkler pump.

Since the total aggregated rated thermal input of combustion plant is in excess of 50 MW_{th}, they are prescribed under the Environmental Permitting Regulations (as transposed into UK legislation to comply with the requirements of the Industrial Emissions Directive 2010/75/EU (IED))[1].

The site has previously had an EP (ref: EPR/CP3635KA), which was surrendered in September 2014 due to decommissioning of some plant, reducing the total thermal capacity below 50 MW_{th}. However, the site is now operating plant above the 50 MW_{th} threshold defined in IED, and therefore Barclays seeks to secure a new EP to cover these activities.

There is currently no plan to expand on the number of generators at the data centre and, in fact, works are being undertaken to see if some generators can be taken offline.

The total rated thermal input of all plant on site is 71.76 MW_{th}. Therefore, the site is considered to be an 'installation' with the regulated activity defined under Section 1.1, Part A(1), Paragraph (a) of Schedule 12 of the EP regulations[1] as:

"Burning any fuel in an appliance with a rated thermal input of 50 or more megawatts."

In addition to the operation of the generators and associated plant, the storage of fuel oil (diesel) in storage tanks is carried out. This is classed as a 'directly associated activity'.

The data centre has several emission release points to air, but there are no emissions to water.

Barclays recognises the importance of managing any potential environmental impacts of their operations at the Gloucester site and, as such, implements appropriate management and maintenance arrangements in order that environmental compliance is maintained. These arrangements will conform to the Best Available Techniques (BAT) requirements, where applicable. However, given there is not a BAT conclusion document or BAT Reference document (BREF) that covers combustion activities at data centres specifically, a combination of guidance documents has been used for the purpose of this review.

Emissions monitoring for emission points to air will be undertaken as required by the permit. It is anticipated that this will be undertaken for emissions of oxides of nitrogen (NO_x), carbon monoxide (CO), sulphur dioxide (SO_2) and Particulate Matter (PM). The emissions monitoring programme will be agreed with the Environment Agency (EA) and all sampling will be carried out using the EA's

[1] https://www.legislation.gov.uk/uksi/2016/1154/schedule/1/made

Monitoring Certification Scheme (MCERTS), using approved test equipment by a trained technician, or an MCERTS accredited test team.

In order to assess the potential impact of emissions as a result of the proposed permit application, the following elements have been completed:

- Environmental Risk Assessment
- Air Emissions Risk Assessment
- Noise Assessment
- A review of Best Available Techniques and Operating Techniques
- Site Condition Report
- A summary of the sites Environmental Management System (EMS)

Environmental Risk Assessment

An Environmental Risk Assessment (ERA) (Gloucester Data Centre Environmental Risk Assessment) has been undertaken in accordance with Environment Agency (EA) guidance *Risk assessments for your environmental permit*[2]. The ERA evaluates potential environmental risks from the site inclusive of emissions to air, water, noise, fugitive emissions, accidents and global warming potential. The aim of the assessment is to identify any significant risks to human health and the environment within the vicinity of site and demonstrate that the risk of pollution or harm will be managed using appropriate measures.

The ERA will be completed and sent with the application in due course.

Air Emissions Risk Assessment

An assessment of emissions to air has been undertaken in line with the EA's *Air emissions risk assessment for your environmental permit* guidance[3], using detailed dispersion modelling. Air quality impacts from the operation of plant were compared against the relevant standards and limits for both human and ecological receptors.

The generators will each operate for less than 500 hours per annum and will therefore not be subject to Emission Limit Values (ELV) for the substances listed in Annex V of Directive 2010/75/EU within IED.

The following scenarios were considered within the air quality assessment:

- Scenario 1: Maintenance Testing of A&B Block.
- Scenario 2: On load Testing of A&B Block.
- Scenario 3: Maintenance Testing of C Block.
- Scenario 4: On load Testing of C Block.
- Scenario 5: Emergency Operation.

[2] https://www.gov.uk/guidance/risk-assessments-for-your-environmental-permit
[3] https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit

The air quality dispersion modelling assessment concluded:

- Considering annual mean results for all scenarios (except emergency operation), all results at both human and ecological receptors were below the relevant assessment metric, owing to the minimal annual operating hours of the plant. For nitrogen deposition at ecological receptors, the Process Contribution (i.e., the contribution from the back-up generators) makes up less than 1% of the overall result at the designated ecological receptors considered, so the contribution from the plant can be considered not significant. In the same manner, all results for acid deposition can be described as not significant.

- Considering short-term results in Scenarios 1, 2 and 3, all results at human and ecological receptors were below the relevant assessment metric. The results for these scenarios can therefore be considered not significant.

- Some exceedances of the 1-hour mean NO_2 concentration were predicted for Scenarios 4 and 5. However, given the short-term nature of operation, the results could be considered not significant, when allowing for the fact that this assessment metric allows up to 18 permitted exceedances per annum.

- Due to worst-case conditions being employed through the assessment, the modelled predictions are expected to represent the upper limit of concentrations.

Noise Assessment

The permit requirement is for a noise assessment in accordance with the methodology set out in BS4142:2014 'Methods for rating and assessing industrial and commercial sound'.

To establish the current levels of ambient and background sound level at the nearest residential receptors, a measurement survey was undertaken in November 2022.

Existing ambient noise levels at the nearest residential receptors are dominated by distant road traffic and vegetation rustling at daytime and at night. No plant noise from the data centre was audible.

A computational noise model of the site was assembled and populated with noise emission data of the new sound sources. Standard noise propagation calculations were used to predict the plant operation noise levels at the nearest noise sensitive receptors.

The assessment concludes that the noise impact of the plant operation would be Low under the existing conditions. No additional noise mitigation measures would be required.

Site Condition Report

Despite the Environmental Permit being surrendered in 2014, operations have continued at the site. Therefore, site records have been kept during this time, as the Site has continued to operate under in-house environmental management procedures.

Since the previous Environmental Permit was held, the Operator has confirmed that there have been no spillages on site during the operation of the facility. The site has not deteriorated during this interim period, due to the Site being covered with concrete hard standing with suitable drainage control mechanisms. Containment has been maintained to a high standard and comprehensive records are in place.

Environmental Management System

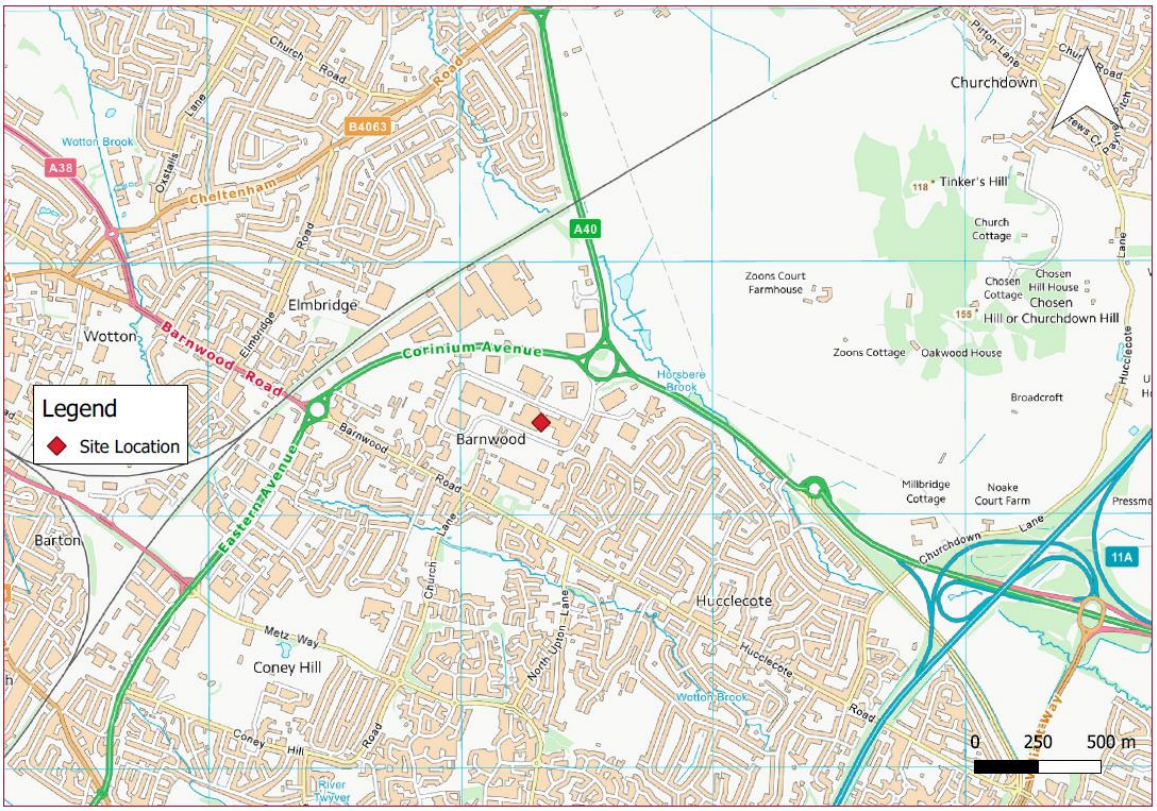
Barclays Environmental Management System (EMS) (as detailed in *Barclays_Gloucester_EMS.pdf)*, establishes and implements processes to undertake the activities

required to address our risks and opportunities, significant environmental aspects, our compliance obligations and any other requirements to ensure our intended outcomes are met.

Our planning activities determine our environmental objectives, how we measure and communicate them and monitor progress against the objectives.

The EMS further supports identification of resources required; operational planning and controls, and our emergency response processes.

Figure i1 – Site Location



1 Introduction

This report has been compiled in order to support Barclays Execution Services Ltd (Barclays) with an Environmental Permit (EP) application under the Environmental Permitting (England and Wales) Regulation (EPR) 2018[4]. The site does not currently operate under an environmental permit. The site has previously had an EP (ref: EPR/CP3635KA), which was surrendered in September 2014 due to decommissioning of some plant, reducing the total thermal capacity below 50 MW_{th}. However, the site is now operating plant above the 50 MW_{th} threshold defined in the Industrial Emissions Directive (IED), and therefore Barclays seeks to secure a new EP to cover these activities.

The Application notice number is EPR/LP3242QD/A001. The EP will cover the operation of several back-up diesel generators, as well as the storage of diesel on site.

This document should be read in conjunction with the Environment Agency (EA) application forms:

- Part A - About you;
- Part B2 - General – new bespoke permit;
- Part B3 - New bespoke installation permit; and
- Part F1 - Charges and declaration.

These are provided in Appendix G of this supporting document.

[4] https://www.legislation.gov.uk/ukdsi/2018/9780111163023/contents

2 About the Application

2.1 The Site and the Operator

Barclays operates a data centre facility in Gloucester, which, for security reasons, requires consistent electrical power supply to the site. The site address is:

Barclays Execution Services Ltd
Gloucester Data Centre
Barnett Way
Barnwood
Gloucester
Gloucestershire
GL4 3RU

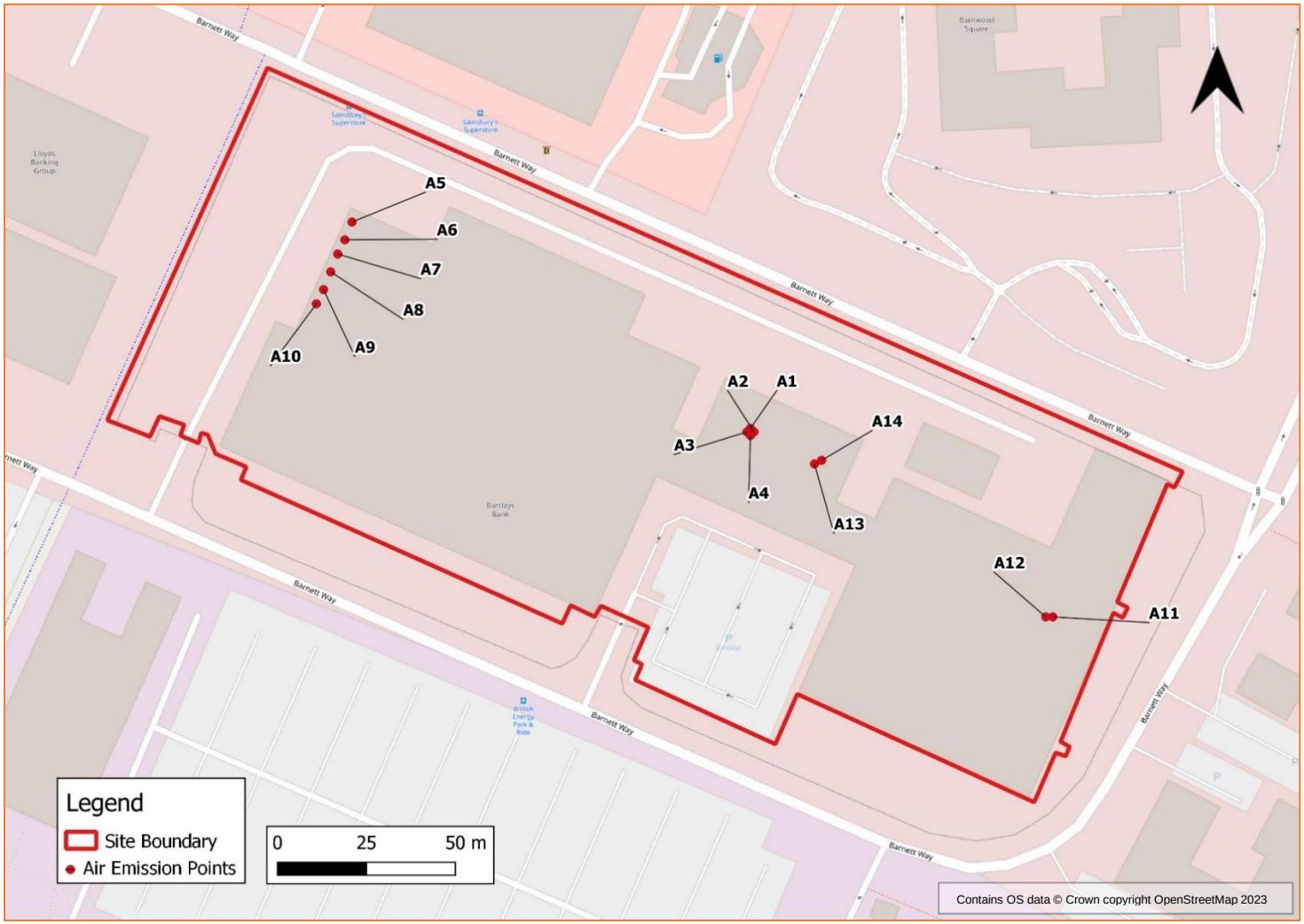
National Grid reference
SO 86320 18361

The Site is situated approximately 2.9 km to the east of Gloucester city centre in an industrial/business area, close to the A417 and M5 major roads. The Site itself is fully covered with hardstanding, with some small areas of landscaping around the Site boundary. The data centre consists of three data halls, known as 'Block A', 'Block B' and 'Block C', used for processing private and corporate banking transactions.

Figure 2.1 provides a location map of the site, whilst Figure 2.2 shows the proposed permitted boundary at the site.

Figure 2.1 – General Site Location

Figure 2.2 – Site Layout showing Site Boundary and Emission Points (See Table 5.1)



3 Operations

3.1 Principal Site Activity

The overall commercial activity for the data centre is data storage. The data centre comprises three data halls, Blocks A, B and C, which take up the majority of the Site area.

The environmental permit application will focus on the Sites combustion activities (comprising 10 diesel-fired back-up generators, 4 gas boilers and one diesel sprinkler pump). The activities related to the operation of the data centre itself (electronic equipment, cooling, etc.) are not included.

The total rated thermal input of all plant on site is 71.16 MW_{th}. Therefore, the site is considered to be an 'installation' with the regulated activity defined under Section 1.1, Part A(1), Paragraph (a) of Schedule 12 of the EP regulations[5] as:

> *"Burning any fuel in an appliance with a rated thermal input of 50 or more megawatts."*

3.1.1 Combustion Plant

The cumulative thermal input across the Site has been calculated for all combustion plant, as summarised in Table 3.1.

Table 3.1 – Gloucester Data Centre Combustion Plant

Type	Plant	Number of Plant	Data Hall Reference	MW_{th} per individual plant item	Total MW_{th}
Generators	Mirlees Back-up Generator	4	A & B	7.855	31.42
	MTU Back-up Generator	6	C	6.368	38.21
Boilers	NGN13 gas boiler	3	A & B	0.380	1.14
	RS34 gas boiler	1	B	0.390	0.39
Total		**14**	**-**	**-**	**71.16**
Other Plant (not included within the AQA)	Sprinkler Pump	1	-	0.096	0.10

All the on-site generators provide back-up power only, i.e., for electrical generation in the event of a failure to the national grid supply. The gas boilers at the Site provide space heating requirements.

The Gloucester data centre works to a 2N at 11 kV standby arrangement, where N is the number of generators necessary to meet the power and load requirements of the data centre.

In 2009 Barclays installed two 11 kV to 132 kV transformers on the national grid, increasing the security of the supplies further. In the MEITS (February 2012) report on the Network reliability and the chance of a failure, they state:

The Probabilistic Risk Assessment (PRA) demonstrates that a total mains failure to the site (loss of both utility supplies) has a Mean Time To First Failure (MTTFF) of 19,560 years. Should this actually occur then the generators would run on load. The Mean Time To Repair (MTTR) is less than 4 hours, therefore the generators would only be on load for approximately 4 hours.

In the last 25 years, only one loss of power event has occurred at the site, this only lasted 6 hours and occurred prior to the upgrade of power supply infrastructure in 2009. No emergency operation events have occurred after the upgrade. Therefore, generator starts have only been for maintenance and testing purposes, required to ensure the generators could meet the power demands of the Site at any

[5] https://www.legislation.gov.uk/uksi/2016/1154/schedule/1/made

point if called upon. However, in the event of a worst-case, loss of grid power event, potentially all the back-up generators will be operated to deliver the required power to the data centre.

3.1.2 Testing Regime

The generators are tested on a regular basis in order to ensure they are capable of fulfilling back-up power supply requirements. During planned maintenance and testing, individual generators will be operated for less than 50 hours per year.

Further details on the data centre testing regime are provided in Table 3.2, whilst the assessment of these impacts on air quality is provided in Appendix B.

Table 3.2 – Gloucester Data Centre Testing Regime

Test	Block	Description	Total Hours per Year
Off load test	A & B Block	All 4 generators tested twice per year, run for 1 hour during each maintenance period	8 hours
On load test	A & B Block	3 of the 4 generators tested twice per year, run for 4 hours during each maintenance period	8 hours
Off load test	C Block	All 6 generators tested twice per year, run for 1 hour during each maintenance period	12 hours
On load test	C Block	All 6 generators tested twice per year, run for 4 hours during each maintenance period	8 hours
		TOTAL	**36 hours**

3.2 Directly Associated Activities

Schedule 1, Part 1 of the EPR defines Directly Associated Activities (DAA) is an operation which, in relation to an activity:

- Has a technical connection with the activity.
- Is carried out on the same site as the activity.
- Could have an effect on pollution.

In addition to the operation of the generators and associated plant, the storage of fuel oil (diesel) in storage tanks is carried out. This is classed as a ‘directly associated activity’.

3.2.1 Fuel Storage

Six tanks, with a storage capacity of 55,000 litres each, are located in purpose built structure adjacent to A & B Block located to the eastern end of the site (X: 386403, Y: 218374). However, one of these tanks is kept empty at all times. Currently, approximately 218,000 litres of fuel are stored here.

All tanks are single skinned, located within a purpose built secondary containment bund sufficient to hold greater than 110% of the maximum capacity of the stored diesel. Leak detection sensors are located within the bund to detect any uncontrolled release of diesel.

A detailed diesel fuel filling procedure is in place for diesel transfers. The procedure details the actions to be taken ahead of, during and after a fuel transfer. The procedure details measures to contain any uncontrolled spills, the measures to be taken to remediate, remove and clean up any spills and what to do and who to contact to report the spills both internally and externally.

3.3 Medium Combustion Plant and Specified Generators

Whilst an Industrial Emissions Directive (IED) Chapter II Environmental Permit is required for this Site, Chapter II of the IED states that:

"Chapter II (of the IED) MCPs are in scope either where they are the primary activity i.e., where there is more than 50 MW_{th} total on the installation, or they are a Directly Associated Activity (DAA) to another Chapter II activity e.g., chemical manufacture. As a minimum, these MCPs must meet the requirements of the directive and there may be occasions where site specific BAT requires more stringent conditions".

As a result of the additional information in IED, this EP application also needs to take into consideration the MCPD and Specified Generator requirements as detailed in the Environmental Permitting Regulations (EPR) 2018.

The Environmental Permitting (England and Wales) (Amendment) Regulations 2018 SI 110 were published in January 2018 to transpose the requirements of the Medium Combustion Plant Directive (MCPD)[6] and to control emissions from the operation of Specified Generators. MCP refers to plant with a rated thermal input of between 1 – 50 MW_{th}, whilst Specified Generators comprise any combustion plant generating electricity.

It is also important to note however, that due to minimal operation of the back-up generators exclusions to the regulations described above apply. EPR states that:

"An existing medium combustion plant which operates for no more than 500 operating hours per year, as a rolling average over a period of five years, is not required to comply with the emission limit values"

In addition, permitting guidance specifically pertaining to Specified Generators on gov.uk[7] states:

"Data centres that use an on-site emergency backup generator when the transmission frequency is unstable are excluded. This is provided the generator is not part of a formal agreement or contract."

As the back-up generators at Gloucester Data Centre are operated in this manner, they will be excluded according to Specified Generator regulations and, in addition, they will not be required to meet the MCPD emission limit values (ELVs).

3.4 Management

Barclays recognises the importance of managing any potential environmental impacts of their operations and have processes and procedures in place, aiming to achieve continuous improvement with regard to environmental performance.

These procedures will be reviewed for compliance by Barclays against the EA's requirements (Best Available Techniques (BAT)) and any required changes following the permit Application will be incorporated into the current environmental management system (EMS). The EMS is a live document that defines the processes, procedures and controls Barclays deploy to manage the environmental impacts of its business operations. It covers all aspects pertaining to management and monitoring environmental performance at the site and it will be updated to ensure that it will be compliant with the updated permit, in line with guidance from the EA[8]. A brief summary of what is contained within the EMS is provided within this document (see Section 8).

Members of the team at the Barclays site have defined roles and responsibilities to ensure that all aspects of environmental performance of applicable plant, processes and discharge points and managed, controlled and reported in a timely manner to comply with any regulatory controls as defined within the permit. This includes the undertaking of regular audits of site operations by senior members on site and (indirectly) external licensor members. The results of these audits are recorded and reported to senior management in a timely manner. If necessary, appropriate corrective actions will be implemented to ensure that permit conditions remain met.

Staff at all levels have the appropriate training for their responsibilities and records of this training are maintained. This includes acknowledgement of any environmental impacts of the process they are responsible for. The training may be updated once the permit Application is issued.

[6] EU/2015/2193, of 25 November 2015

[7] https://www.gov.uk/guidance/specified-generator-when-you-need-a-permit

[8] https://www.gov.uk/guidance/develop-a-management-system-environmental-permits

Barclays understands the importance of documented procedures covering the operation and maintenance of the Gloucester facility and these procedures are included as part of the environmental management system, taking account of manufacturer's manuals. These will be regularly reviewed and updated as required. The management system will also ensure that monitoring and reporting of results to the EA will comply with the requirements of the permit.

3.5 Planned Preventative Maintenance

The Operations Manager has the ultimate responsibility for the effective maintenance of plant and equipment throughout the facility. There are two types of maintenance associated with the plant covered by the Application, planned maintenance and unplanned maintenance.

Planned maintenance is regular maintenance that will be completed at the timescales specified by the plant manufacturer(s). This high level of preventative maintenance is designed to avoid unscheduled downtime, maximising plant availability, its ability to operate efficiently and to maintain an efficient level of operation between maintenance activities.

The Barclays maintenance team or another approved contractor (e.g., facilities management team, manufacturer) will undertake all routine testing and maintenance on the plant. Any waste generated by the maintenance activities will be removed from site for recycling and/or safe disposal. During maintenance and testing the team will, where relevant:

- Visually check for smoke from exhausts. If any black, or white smoke, is noted this will be reported for further investigation.

- Ensure that the generators are operated for the minimal amount of time to complete the required maintenance requirement/test (maintenance and testing of the generators will be completed in accordance with manufacturer requirements to ensure optimal performance and efficient combustion).

In order to limit the generation of emissions to air, the routine testing and maintenance regime ensures that a limited number of generators are subject to planned maintenance and testing at any one time. The testing regime at the data centre will be managed via a Planned Preventative Maintenance (PPM) system, which is already well established at the site. The facility will be manned 24 hours a day by data centre personnel.

Unplanned maintenance covers breakdown of plant and other emergencies. This is generally initiated when there is a divergence from normal operating parameters, as specified by manufacturers. Such issues that require operator intervention outside of the routine maintenance program will be identified by the operator and an appropriate response initiated.

4 Comparison with Indicative BAT

The EP application is made within the context of the Industrial Emissions Directive (IED) and Section 1.1 A(1) (a) of the EPR as a combustion activity aggregated to >50 MW_{th} input (as defined by the IED Chapter II). However, there is not a Best Available Technique (BAT) conclusion document of BAT Reference document (BREF) that covers combustion activities at data centres specifically, where some exclusions from the regulations apply, as mentioned in Section 3.3.

With this in mind, a combination of the following guidance documents has been used to undertake an appraisal of the Site's operating techniques:

- The EA's 'Data Centre FAQ Headline Approach' guidance - developed by the Environment Agency as a draft non-statutory guidance following the principles set out in IED Article 14(6); and

- BAT Reference document for Large Combustion Plant (LCP) – reviewed for potential general measures applicable to data centres (it is noted that the Site does not contain any Large Combustion Plants (LCP) under the meaning of Chapter III of the Industrial Emissions Directive (2010/75/EU).

A comparison against the requirements of the EA's draft non-statutory guidance is presented in Table 4.1, whilst a comparison against the environmental management techniques to be implemented with indicative BAT for LCP is provided in Table 4.2.

Table 4.1 –Conformity with Requirements in Data Centre FAQ Headline Approach, 2018

<table>
<tr><th>EA Requirement</th><th>Description of Proposed Activities/ Facilities</th></tr>
<tr><td>We accept that oil fired diesel generators are presently the default technology for standby generators in data centres. However, the permit application still requires a BAT discussion
detailing the choice of engine, the particular configuration and plant sizing meeting the standby arrangement (e.g. 2n).</td><td>
The Gloucester data centre works to a 2N at 11 kV standby arrangement, where N is the number of generators necessary to meet the power and load requirements of the data centre.

In short, the engines operated at the data centre have been selected to ensure optimum start-up time, power, reliability (including independence of off-system services) and serviceability for emergency generation.

For completeness, a brief appraisal of the viability of different power generation options for the data centre has been carried out, inclusive of the following:
- Diesel generators (as installed at the Gloucester data centre)
- Natural gas generators
- Combined Cycle Gas Turbines (CCGT)
- Open Cycle Gas Turbines (OCGT)
- Renewable Energy
The table below provides more information against each of the technologies listed above.
<table>
<tr><th>Parameter</th><th>Diesel generators</th><th>Natural gas generators</th><th>CCGT</th><th>OCGT</th><th>Renewable energy</th></tr>
<tr><td>Start-up time</td><td>Low</td><td>Low</td><td>High</td><td>Medium</td><td>High</td></tr>
<tr><td>Reliability for provision of continuous power</td><td>Good</td><td>Good</td><td>Good</td><td>Good</td><td>Poor</td></tr>
<tr><td>Operational constraints</td><td>Diesel generators already installed at the Site, along with suitable fuel storage infrastructure.</td><td>New generators would be required, in addition to sufficient access to gas supply/stores. Insufficient space on Site for stores and storage would pose health and safety risks.</td><td>New generators would be required. Lengthy start up time.</td><td>New generators would be required, high capital costs, as well as significant operating and maintenance costs.</td><td>Insufficient space on Site for required capacity, not always a reliable supply.</td></tr>
</table>
Taking into account the above information, diesel generators have been determined as BAT due to the following being fulfilled:
- They provide a fast response at the required load when called upon (fundamental to the Site’s operation)
- They have relatively low maintenance costs and if replacement parts are required, these are readily available
- The Site already has sufficient provision of fuel storage and associated infrastructure to ensure a reliable supply of diesel.
</td></tr>
</table>

Standby engine capacities are added together in MW thermal input at the quoted standby rating, being usually 110% of the continuous rating	The installed generating capacity at the Gloucester data centre is in excess of 50MW_{th}.
If precise MW_{th} figures are unavailable and spec sheets or face-plates are unclear, the calculation for MW_{th} derived from MVA output is based on: power factor 0.8 and an assumed poor conversion efficiency of 0.35 for MW_{th} to MW_{elec}	This methodology has been followed when calculating values for the back-up diesel generators.
The sum of generator plant capacities is based only on MW thermal inputs of all plant regardless of the standby configuration. MW_{elec} output constraints such as realistic customer load or other practical output limiting factors do not constitute a limit to the MW_{th} input as defined in the EA's guide RGN02.	The installed generating capacity at the Gloucester data centre is in excess of 50MW_{th}.
Proximity of data centres with a company campus, adjacent, neighbouring or close-by buildings in urban locations (e.g., within a common trading estate but only separated by a road width or notional distance) may constitute a single site for determining the boundary of the installation as 'same site – same operator' as per RGN02	Not applicable to the Gloucester data centre.
Permits will include a maximum 500 hour 'emergency/standby operational limit' for any or all the plant producing on-site power under the limits of the combustion activity; and thereby emission limit values ELVs to air (and thus engine emissions monitoring) are not required within the permit.	Emergency operation is highly unusual and is not expected to exceed 500 hours. In the last 25 years, only one loss of power event has occurred at the site, this only lasted 6 hours and occurred prior to the update of power supply infrastructure in 2009. There have been no emergency operation events after the upgrade.
Emergency hours' operation includes those unplanned hours required to come off grid to make emergency repair of electrical infrastructure associated but occurring only within the data centre itself	There is a good level of redundancy in the power supply, so this is very unlikely to only occur regularly, if at all.

Each individual generator with its own discharge stack, can be maintained, tested and used in a planned way for up to 500 hours per calendar year each without ELVs (and hence no monitoring) under IED/MCPD. Though clearly the EA expects planned testing and generator operations to be organised to minimise occasions and durations (subject to client requirements). Ideally a target should seek to keep individual generator testing to below 50 hours/annum each as required for MCPD specified generator exclusion.	It should be noted that the generators installed at the Gloucester data centre are excluded from the Specified Generator regulations. However, individual generator run times are expected to be well under 50 hours per year, as demonstrated in Section 3.1.2.
In summary 7, & 8 means the whole or part site can only operate as emergency plant up to 500 hours as an absolute limit for grid backup issues; but that individual plant (at any load) with its own stack (or a stack with multiple plant) with justification can be operated for up to 500 hours (ideally <50) each as part of its non-emergency role under maintenance and testing.	Gloucester data centre is expected to operate in accordance with this requirement.
For the purposes of determining operating hours, data centre diesel generators are regarded as having a minimal start-up or shut-down times. Operational hours start on the first fuel ignition.	Noted, this follows the same assumption as used within the air quality assessment, available in Appendix B.
Data Centre permits (unless they apply and justify it in a permit application) will expressly have a limit on the activity to exclude voluntary 'elective power operation' such as demand side response (i.e., on-site use) or grid operating reserve (STOR) (i.e., off-site export of electricity) and Frequency Control by Demand Management (FCDM) for grid support. This is primarily to differentiate data centres from 'diesel arrays or MCPD specified generators' that voluntarily operate within the balancing market, and importantly a clear way to demonstrate minimisation of emissions to air as 'Emergency plant'.	The generators at the Gloucester data centre will not be used for demand side response, STOR or FCDM.
The default engine specification as a minimum for new plant to minimise the impacts of emissions to air (NOx) is 2g TA-Luft (or equivalent standard).	The MTU (Rolls-Royce) back-up generators have specified NOx levels below the standard specified in 2g TA-Luft. It has been assumed for the purpose of the assessment that the Mirlees generators conform to 2g TA-Luft; this will be confirmed with periodic emissions to air monitoring. For completeness, emissions from the boilers are significantly below the 2g TA-Luft limits.

CBA for improved exhaust emissions, dispersion and mitigations from the plant is expected for the maintenance/testing and the emergency standby roles. We would be looking for improvements particularly if Local Air Quality (LAQ) modelling (under H1) indicates anything other than an insignificant contribution to short term local air quality for the 'planned' maintenance emissions of the plant.	The air quality assessment demonstrates that air quality impacts are likely to be insignificant under normal operation.
Retrofit abatement techniques for existing installations for engine emissions such as selective non-catalytic or catalytic reduction (SNCR or SCR) would not normally be expected for standby plant to mitigate the emissions for standby/emergency operation. BAT might include improved flue gas dispersion (e.g. stack modifications, increased height) or improved low NOx engine management controls or possibly fuel choice.	The air quality assessment demonstrates that air quality impacts are likely to be insignificant under normal operation.
Operations and management procedures should reflect the outcomes of the air quality modelling by minimising the duration of testing, phasing engines into subgroups, avoiding whole site tests and planning off-grid maintenance days and most importantly times/days to avoid adding to "at risk" high ambient pollutant background levels.	Simultaneous operation of generators during planned maintenance and testing is avoided as per the testing regime provided in Section 3.1.2. In addition, overall run time per annum is reduced as far as possible.
When AQ modelling the emissions from the engines, the certified technical standard provided by the manufacturer should be used (i.e., likely worst case emissions). However any 'fit for purpose' monitoring of the actual emissions from installed plant will be considered as evidence of the likely real impacts as part of the permitting decision process.	Worst-case emissions and assumptions have been used within the air quality assessment where appropriate.

The groundwater monitoring of fuel storage tanks and distribution pipework using GW boreholes is risk based for the site condition report (SCR) and IED 5-yearly monitoring. Should GW monitoring be required for underground tanks and/or the SCR, the boreholes should be positioned for whole site surveillance (for the SCR) rather than as a very local control immediately around the buried fuel oil tanks (i.e., not be just an addition to double skinned tanks already protected by leak detection and hence ignoring distribution pipework etc)	There are no underground fuel oil storage tanks at Gloucester data centre. Therefore, Barclays does not propose to undertake intrusive groundwater or soil quality assessments.
10-yearly soil sampling under IED is normally not needed but still needs some justification.	Given the nature of operations and the preventative measures in place to protect the ground environment, Barclays does not propose to undertake intrusive groundwater or soil quality assessments. The Site was inspected at the time of the previous permit surrender and no issues were found. Since the permit surrender, preventative measures for spillages etc. have been maintained.
The permit application must assess and provide evidence of actual reliability data for the local electricity grid distribution (including data centre internal electrical design) for the EA to judge the realistic likelihood of the plant needing to operate for prolonged periods in an emergency mode (especially if emissions model so as to exceed short term air quality standards).	The Gloucester data centre works to a 2N at 11 kV standby arrangement, where N is the number of generators necessary to meet the power and load requirements of the data centre. In 2009 Barclays installed two 11 kV to 132 kV transformers on the national grid, increasing the security of the supplies further. In the MEITS (February 2012) report on the Network reliability and the chance of a failure, they state: The Probabilistic Risk Assessment (PRA) demonstrates that a total mains failure to the site (loss of both utility supplies) has a Mean Time To First Failure (MTTFF) of 19,560 years. Should this actually occur then the generators would run on load. The Mean Time To Repair (MTTR) is less than 4 hours, therefore the generators would only be on load for approximately 4 hours. In the last 25 years, only one loss of power event has occurred at the site, this only lasted 6 hours and occurred prior to the upgrade of power supply infrastructure in 2009. There have been no emergency operation events after the upgrade.
Optimising grid reliability within the site as part of general BAT to minimise emergency operating hours is required – evaluation is needed within the permit application on the Tier reliability standard under ISO27001 and Uptime.	The Site does not operate under ISO27001 but, as mentioned above, in 2009 Barclays installed two 11 kV to 132 kV transformers on the national grid, increasing the security of the supplies. There have been no emergency operation events after the upgrade.
Reporting of standby engine operational run hours and discussion of any electrical outages (planned or grid failures regardless of duration) required annually.	This requirement is noted.

Assuming AQ modelling, based on operating scenarios, indicates a local air quality risk then notification to the EA of unplanned (and pre-notification of planned) continuous grid outage exceeding 18 hours LAQM (or the otherwise assessed short term interval from modelling) is likely required under a permit schedule 5 notification.	This requirement is noted.
The notification requirement stated in the permit should also indicate the actual number of generators that need to be operating above which the local air quality is at risk e.g. 'notification of continuous emergency operation exceeding 18 hours with 5 or more engines operating together is required' (i.e., model shows 4 or less engines unlikely to breach LAQ)	This requirement is noted.
Assuming AQ modelling, based on emergency outage operating scenarios, indicates a very significant risk to local air quality and identified receptors, the EA will ask the operator to have a written AQ outage action plan to manage the issue for prolonged emergency running of the plant (including sensitive receptors list and mitigations, assessments and impacts evaluation against modelled risk conditions i.e., occurrence at periods of most concern in the year, possibly ambient air monitoring surveillance at very sensitive receptors). An AQ outage action plan is also likely required for sites which might operate in conjunction with other neighbouring large sites during an outage i.e., data centre hubs.	The air quality assessment demonstrates that air quality impacts are likely to be minimal even under emergency operation.

Due to the emphasis of the permit on electrical (and cooling) systems it is noted that the EA considers the F-Gas regulations as falling under the remit of the EPR permit (for notifications and management) where F-gases (or potentially any polluting potential substance) are used directly under the combustion aspects of the permitted activity (e.g., switchgear). It is important to notify the EA of any significant releases. Other uses of F-gases e.g., for server room cooling are not strictly under the EA permit but are regulated by the EA generally so it may still be prudent to make the EA aware of your F-gas releases.	The site has a full F-Gas inventory that is regularly updated as required. This can be made available to the EA if needed.
The permit application should detail the likely quantities of waste engine oil generated annually - EWC 13 02 waste oils following servicing for example. Although unlikely to be huge, the Pollution inventory has a reporting threshold of 1 tonne for non-hazardous waste but technically no lower thresholds for hazardous waste oil.	The site does not generally generate waste engine oil on an annual basis, because the generators have an oil change approximately every 10 years. Therefore, the Pollution Inventory threshold of 1 tonne per year will not be breached for the Gloucester Data Centre.
The permit application is for the combustion plant and associated environmental concerns and not for the Data Centre itself. The applicant should be aware that the permitting process and application is accessible to the public so should have regard to 'Commercial in Confidence' and Critical National Infrastructure. In the first instance discuss particular concerns directly with the EA and/or exclude such priority information from the application but indicate that such is 'available on request'.	This is noted.

Table 4.2 – BAT Review: Conformity with BAT Conclusions

Relevant Indicative BAT	Description of Proposed Activities/ Facilities
General BAT Conclusions – Environmental Management Systems	
BAT 1. In order to improve the overall environmental performance, BAT is to implement and adhere to an environmental management system (EMS) that incorporates the features presented in the BREF.	Barclays has an overarching document, inclusive of Barclays' EMS. Amongst other things, it includes the following: - The scope and processes contained within the management system - Roles and responsibilities of the management team and their accountability - Responsibility of employees - Details on internal and external communication - Compliance obligations - Procedures for emergency preparedness Further detail is provided in Section 8 of this report.
General BAT Conclusions – Monitoring	
BAT 2. BAT is to determine the net electrical efficiency and/or the net total fuel utilisation and/or the net mechanical energy efficiency of the gasification, IGCC and/or combustion units by carrying out a performance test at full load(1), according to EN standards, after the commissioning of the unit and after each modification that could significantly affect the net electrical efficiency and/or the net total fuel utilisation and/or the net mechanical energy efficiency of the unit. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.	As all generators at the Site are considered individually to be medium combustion plants, and for the purpose of emergency generation, they are only required to comply with the Medium Combustion Plant Directive requirements for monitoring instead of the LCP BREF.
BAT 3. BAT is to monitor key process parameters relevant for emissions to air and water including those given in the BREF.	Normal operating conditions for the data centre is for the Site to be powered by grid electricity supply. The only opportunity to monitor the back-up generators is during routine testing for maintenance purposes. Outside of these times, the back-up generators only operate during emergency situations. Monitoring will be required to comply with MCPD requirements only. There is no wastewater to monitor.

BAT 4. BAT is to monitor emissions to air with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.	The generators are considered individually to be medium combustion plants and are used for emergency generation; therefore, they are only required to comply with the MCPD requirements for monitoring instead of LCP BREF.
BAT 5. BAT is to monitor emissions to water from flue-gas treatment with at least the frequency given below and in accordance with EN standards. If EN standards are not available, BAT is to use ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality.	Not applicable - no flue gas treatment on Site.
General BAT Conclusions – General Environment and Combustion Performance	
BAT 6. In order to improve the general environmental performance of combustion plants and to reduce emissions to air of CO and unburnt substances, BAT is to ensure optimised combustion and to use an appropriate combination of the techniques given in the BREF.	Barclays has an all-encompassing preventative maintenance program which is designed to avoid unscheduled downtime, maximising plant availability, its ability to operate efficiently and to maintain an efficient level of operation between maintenance activities.
BAT 7. In order to reduce emissions of ammonia to air from the use of selective catalytic reduction (SCR) and/or selective non-catalytic reduction (SNCR) for the abatement of NOX emissions, BAT is to optimise the design and/or operation of SCR and/or SNCR (e.g. optimised reagent to NOX ratio, homogeneous reagent distribution and optimum size of the reagent drops).	Not applicable – no use of SCR / SNCR.
BAT 8. In order to prevent or reduce emissions to air during normal operating conditions, BAT is to ensure, by appropriate design, operation and maintenance, that the emission abatement systems are used at optimal capacity and availability.	There is no abatement technology installed at the Site. Emissions to air are reduced through minimal operation of the back-up generators, in particular through the scheduling of testing regimes, e.g., generators are not tested using concurrent operation to minimise the magnitude of emissions.

BAT 9. In order to improve the general environmental performance of combustion and/or gasification plants and to reduce emissions to air, BAT is to include the following elements in the quality assurance/quality control programmes for all the fuels used, as part of the environmental management system (see BAT 1).	The fuel used at the Site is ultra-low sulphur diesel. Usage is low due to the generators not being routinely used to power the data centre (i.e., only routinely used through periodic testing and in emergency scenarios), the data centre is powered by electricity from the grid. Therefore, the fuel selected is optimal for the intended use (emergency supply).
BAT 10. In order to reduce emissions to air and/or to water during other than normal operating conditions (OTNOC), BAT is to set up and implement a management plan as part of the environmental management system (see BAT 1), commensurate with the relevance of potential pollutant releases.	Normal operation for the data centre is for it to be powered by grid electricity. There is minimal operation of the generators through testing regimes. IN the event of emergency generation being required (i.e., grid supply is lost) the number of running hours will be recorded and reported to the EA. There are no emissions to water.
BAT 11. BAT is to appropriately monitor emissions to air and/or to water during OTNOC.	Normal operation for the data centre is for it to be powered by grid electricity. Other than normal operating conditions (OTNOC) will only occur in emergency situations where there is no opportunity to schedule monitoring.
General BAT Conclusions – Energy Efficiency	
BAT 12. In order to increase the energy efficiency of combustion, gasification and/or IGCC units operated ≥ 1 500 h/yr, BAT is to use an appropriate combination of the techniques given in the BREF.	Not applicable – the generators provide back-up power only and will operate for less than 1,500 hours per year.
BAT 13. In order to reduce water usage and the volume of contaminated wastewater discharged, BAT is to use one or both of the techniques given in the BREF.	Not applicable – no emissions to water.

BAT 14. In order to prevent the contamination of uncontaminated wastewater and to reduce emissions to water, BAT is to segregate waste water streams and to treat them separately, depending on the pollutant content.	Not applicable – no emissions to water.
BAT 15. In order to reduce emissions to water from flue-gas treatment, BAT is to use an appropriate combination of the techniques given below, and to use secondary techniques as close as possible to the source in order to avoid dilution.	Not applicable – no flue gas treatment or emissions to water.
General BAT Conclusions – Waste Management	
BAT 16. In order to reduce the quantity of waste sent for disposal from the combustion and/or gasification process and abatement techniques, BAT is to organise operations so as to maximise, in order of priority and taking into account life-cycle thinking: *a. waste prevention, e.g., maximise the proportion of residues which arise as by-products;* *b. waste preparation for reuse, e.g., according to the specific requested quality criteria;* *c. waste recycling;* *d. other waste recovery (e.g., energy recovery)*	Waste management on site is under the operational control of ISS who are Barclays appointed facilities management provider. Barclays and ISS have extensive procedures covering all aspects of waste management. This includes multiple waste streams that are generated onsite. Waste is managed using, where possible, established waste hierarchy best practise. Where possible we would aim to prevent waste and if this is not possible would adopt a process of reuse, recycling or recovery. The site is subject to the banks ambition to achieve and maintain TRUE (Total Resource Use and Efficiency) zero waste certified projects across our key campuses by 2035, which means we must divert a minimum of 90% of solid, non-hazardous wastes from the environment, landfill and incineration (waste-to-energy) to recycling facilities or locations where the waste can be reused. The site is currently certified as zero waste to landfill by our external third party verification. The procedures for management of waste on site are included in the UK General and Recycling Waste Procedure document reference BCRESCMS-3-8698, Global Hazardous Waste Minimum Standard document reference BCRESCMS-3-7782 and the Waste Management Global Minimum Standard document reference BCRESCMS-251047637-6932. In relation to the generators specifically, waste production is minimal. The waste produced is limited to maintenance, testing and servicing operations. The waste is all classified as hazardous waste and is disposed of in compliance with the Hazardous Waste (England and Wales) Regulations 2005. A hazardous waste procedure is in place and ensures contaminated waste for onsite activities are disposed of by competent contractors on behalf of Barclays using the hazardous waste transfer note system.
General BAT Conclusions – Noise Emissions	
BAT 17. In order to reduce noise emissions, BAT is to use one or a combination of the techniques given in the BREF.	Extended running will only occur in an emergency situation. All the C-block generators are housed within acoustic enclosures and other combustion plant is housed within buildings.
BAT Conclusions for the Combustion of Solid Fuels	
BAT conclusions for the combustion of coal and/or lignite BAT 18 - 23	Not applicable – liquid/gaseous fuel used.

BAT conclusions for the combustion of solid biomass and/or peat BAT 24 - 27	Not applicable – liquid/gaseous fuel used.
BAT Conclusions for the Combustion of Liquid Fuels	
HFO- and/or gas-oil-fired boilers BAT 28 – 30	Not applicable – natural gas used to fire the boilers.
HFO- and/or gas-oil-fired engines *BAT 31. In order to increase the energy efficiency of HFO and/or gas oil combustion in reciprocating engines, BAT is to use an appropriate combination of the techniques given in BAT 12 and below in the BREF.*	There is no opportunity to use combined cycle operation as the generators are only used for emergency, back-up generators.
HFO- and/or gas-oil-fired engines *BAT 32. In order to prevent or reduce NO_X emissions to air from the combustion of HFO and/or gas oil in reciprocating engines, BAT is to use one or a combination of the techniques given below in the BREF.*	The Gloucester data centre has been designed to operate to an '2N' standby arrangement, where 'n' is the number of generators necessary to meet the requirement of the data centre. Therefore, the combustion plant chosen for the Site is based on the ability to provide power and capacity to the reliability and security standards required for emergency power generation. Engines will meet the 2G TA-Luft emissions standard. SCR is not applicable to combustion plants operating less than 500 hours per year, which is applicable for the Gloucester data centre.
HFO- and/or gas-oil-fired engines *BAT 33. In order to prevent or reduce emissions of CO and volatile organic compounds to air from the combustion of HFO and/or gas oil in reciprocating engines, BAT is to use one or both of the techniques given below in the BREF.*	The back-up generators provide emergency power supply only and combustion/operation is optimised for this purpose. The individual generators fall under emissions requirements for MCPD.
HFO- and/or gas-oil-fired engines *BAT 34. In order to prevent or reduce SO_X, HCl and HF emissions to air from the combustion of HFO and/or gas oil in reciprocating engines, BAT is to use one or a combination of the techniques given below in the BREF.*	Ultra-low sulphur diesel is used at the Site to minimise emissions of sulphur dioxide. The individual generators fall under emissions requirements for MCPD.
HFO- and/or gas-oil-fired engines *BAT 35. In order to prevent or reduce dust and particulate-bound metal emissions from the combustion of HFO and/or gas oil in reciprocating engines, BAT is to use one or a combination of the techniques given below in the BREF.*	The individual generators fall under emissions requirements for MCPD.
Gas-oil-fired gas turbines BAT 36 – 39	Not applicable – no turbines.

BAT Conclusions for the Combustion of Gaseous Fuels	
BAT conclusions for the combustion of natural gas *BAT 40 – 45*	Not applicable. Although the boilers are operated on natural gas, their generating capacity totals less than 1 MW_{th} and therefore this guidance does not apply.
BAT conclusions for the combustion of iron and steel process gases *BAT 46 - 51*	Not applicable.
BAT conclusions for the combustion of gaseous and/or liquid fuels on offshore platforms *BAT 52 - 54*	Not applicable.
BAT conclusions for multi-fuel-fired plants *BAT 55 - 59*	Not applicable.
BAT conclusions for the co-incineration of waste *BAT 60 - 71*	Not applicable.
BAT conclusions for gasification *BAT 72 - 75*	Not applicable.

5 Emissions and Monitoring

5.1 Emissions to Air

All of the emission points are listed in Table 5.1.

Table 5.1 – Existing and Proposed Point Source Emissions to Air

Emission Point Reference	Source	Location
A1	A & B Block Gen 1	See Figure 2.2
A2	A & B Block Gen 2	
A3	A & B Block Gen 3	
A4	A & B Block Gen 4	
A5	C Block Gen 1	
A6	C Block Gen 2	
A7	C Block Gen 3	
A8	C Block Gen 4	
A9	C Block Gen 5	
A10	C Block Gen 6	
A11	A Block Boiler 1	
A12	A Block Boiler 2	
A13	B Block Boiler 1	
A14	B Block Boiler 2	

All emission points listed above have been assessed within the air quality assessment, although normal operation of the site is for it to be powered by grid electricity. Sources A1 – A10 comprise the back-up generators, which are run on diesel. Sources A11 – A14 comprise the boilers, which are powered by natural gas.

It is worth mentioning that an additional source of a Diesel Sprinkler Pump (as detailed in Table 3.1) is not included within the air quality assessment due to both its thermal capacity of 0.01 MW_{th} and the fact that it would be used only in the event of a fire at the site.

The nature of the emissions arising from the above sources above will primarily consist of:

- Oxides of nitrogen (NO_x);
- Carbon monoxide (CO);
- Sulphur dioxide (SO_2) – for diesel sources only; and
- Particulate Matter (PM) – for diesel sources only.

Other emissions will include nitrogen and water vapour. It is considered that, due to the fuel on the boilers being natural gas, emissions of particulates and sulphur dioxide will be negligible for sources A11 – A14.

All emissions from the point sources above are released through individual stacks, as shown in Figure 2.2. All plant will need to be able to operate 24 hours a day 7 days per week in line with the requirements of the facility.

5.2 Noise and Vibration

There is the potential for the data centre to create noise impacts as a result of operating the back-up generators, however it is considered that this will represent a low impact as a result of intermittent operation of the generators.

A noise assessment has been completed for the data centre by Bureau Veritas and is available in Appendix C.

The assessment concluded that existing ambient noise levels at the nearest residential receptors are dominated by distant road traffic and vegetation rustling at daytime and at night. No plant noise from the data centre was audible.

A computational noise model of the site was assembled and populated with noise emission data of the plant. Standard noise propagation calculations were used to predict the plant operation noise levels at the nearest noise sensitive receptors.

The assessment concluded that the noise impact of the plant operation would be Low. No specific additional noise mitigation measures would be required.

5.3 Emissions to Water

The proposed Application does not introduce any emission points to water.

The data centre has separate foul and surface water drainage systems. The drainage to foul sewer will consist of sanitary foul water (sinks, toilets, cleaning water, etc.) and operation of the data centre will not result in the generation of trade effluent.

There are no discharges to foul sewer within the area where the generators are located. All run-off from this area will drain to the on-site surface water drainage system prior to off-site discharge via a full retention interceptor to an on-site soakaway.

5.4 Emissions to Land

The proposed Application does not introduce any emission points to land.

5.5 Odour

The Site does not operate activities which will give rise to odour emissions.

5.6 Monitoring

This section describes the proposed monitoring strategy for emissions monitoring of the combustion plant at the Gloucester Data Centre. As per the previous permit, only monitoring of emissions to air from the back-up diesel generators is expected within the permit requirements. It is anticipated that monitoring of emissions to air from the boilers is excluded due to their small generating capacity.

Barclays is committed to monitoring its pollutant releases and will have an appropriate management structure in place to ensure monitoring is effectively carried out and reported to the Environment Agency in a timely manner.

6 Impact Assessment

An impact assessment has been undertaken for the Site in order to assess the potential environment impact from its emissions and to evaluate those impacts in line with sensitive receptors which may be affected by activities undertaken at the Site.

The impacts of releases from activities at the Site are discussed in this section and include:

- Environmental Risk Assessment for Emissions to Air and subsequent detailed dispersion modelling; and
- Environmental Risk Assessment for Noise Impacts and subsequent modelling.

6.1 Summary of Emissions to Air

The following section collates the information presented in the assessment of emissions to air and summarises the impacts in terms of the following:

- Calculation of Process Contribution (PC);
- Estimation of Predicted Environmental Concentration (PEC);
- Conclusions.

Sources of emissions to air from the Site are described in Section 4 of this report, as well as the Air Quality Impact Assessment report, presented in Appendix B. Details of the stack parameters modelled for each of the emission points summarised are provided in Table 6.1.

Table 6.1 – Modelled stack parameters

Parameter	MTU Gen – C Block	Mirrlees Gen – A/B Block	NGN13 Boiler – A/B Block	RS34 Boiler – B Block
Number of Generators [a]	6	4	3	1
Thermal Input (MW_{th})	6.368	7.855	0.380	0.390
Electrical Output (MW_e)	2.228	2.749	-	-
Stack Height (m) [b]	7.50	16.93	18.30	18.30
Stack Diameter (m) [b]	0.442	0.600	0.275	0.300
Efflux Velocity (m s^{-1})	56.82	31.87	4.90	4.23
Efflux Temperature (°C) [c]	590	450	110	110
Emission Concentrations and Rates (per combustion unit)[d]				
NO_x (Nm^3)	1700	2000	-	-
NO_x (g/s)	3.800	5.520	0.006	0.006
SO_2 (mg/Nm^3)	3.0	3.0	-	-
SO_2 (g/s)	0.01	0.01	-	-
CO (mg/Nm^3)	650	650	-[f]	-[f]
CO (g/s)	1.45	1.79	-	-
PM_{10} (mg/Nm^3)[e]	80	80	-	-
PM_{10} (g/s)	0.18	0.22	-	-

[a] Number of generators provided by Barclays.

[b] Information provided by Barclays.

[c] Temperature assumptions are outlined in Appendix A.

[d] Emission Rates for PM, NO_x and CO have been derived from emission information provided by generator manufacturers or appropriate emissions standards. The emission rate for SO_2 has been derived based on the sulphur content of the fuel used on site, which is known to be no greater than 0.001%.

[e] Ratio of emission between PM_{10} and $PM_{2.5}$ not known, therefore the emission rate for PM_{10} has also been used as a proxy for the emission of $PM_{2.5}$, as a conservative assumption.

[f] Boiler emission rates were calculated using the EcoDesign Directive, therefore there are no emission rates applicable for CO.

6.1.1 Environmental Assessment Levels (EALs)

The Environment Agency's Risk Assessment for a specific activity provides methods for quantifying environmental impacts of emissions to all media. The *air emission risk assessment for your environmental permit guidance* (AER guidance) contains long- and short-term Environment Assessment Levels (EALs) and Environmental Quality Standards (EQSs) for releases to air. For the pollutants considered in this assessment, these assessment levels are equivalent to the Air Quality Standards (AQSs) and Air Quality Objectives (AQOs) set out in legislation in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland.

The AER guidance provides a three-tiered approach to assessment the significance of emissions to atmosphere. The first stage calculates the appropriate PC from each source and "screen out" insignificant emissions to air, which incorporate emission sources that emit in small quantities such that they are unlikely to cause a significant impact at sensitive receptors. The screening criteria is provided in Figure 6.1.

Figure 6.1 – Screening Criteria for Insignificant PCs

To screen out a PC for any substance so that you don't need to do any further assessment of it, the PC must meet both of the following criteria:

- the short-term PC is less than 10% of the short-term environmental standard
- the long-term PC is less than 1% of the long-term environmental standard

If you meet both of these criteria you don't need to do any further assessment of the substance.

If you don't meet them you need to carry out a second stage of screening to determine the impact of the PEC. Record the PCs for your insignificant emissions in your risk assessment.

The second stage is to calculate the PEC from each source (incorporating existing background pollutant levels) and to assess the need for detailed dispersion modelling of emissions to air (see Figure 5.2) If the second stage indicates that a more detailed assessment is required, appropriate dispersion modelling software, such as ADMS or AERMOD should be used. Detailed dispersion modelling constitutes the third stage of the assessment approach.

Figure 6.2 – Criteria for Detailed Modelling

In the second stage of screening if you meet both of the following requirements you don't need to do any further assessment of that substance. You'll need to do detailed modelling of emissions that don't meet both of the following requirements:

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

The AER guidance effectively supersedes the old H1 guidance, using a similar methodology.

6.2 Summary of Noise Emissions

The impact assessment with respect to the plant noise and vibration on the existing environment covers the following issues:

- Potential operational vibration associated with the plant items; and
- Potential operational noise associated with the plant items.

Due to the typically low vibration levels that are likely to be generated, it is expected that operational activities would not result in perceptible vibration impacts on any of the sensitive receptors. Therefore, no further assessment of operational vibration was undertaken.

The assessment of the noise impact of site operation is based on the ambient sound levels (LAeq,T) and the background sound levels (LA90,T) measured/derived in November 2022. The sound levels of the plant operation at the nearest sensitive receptors are calculated by noise modelling, using CadnaA.

Noise propagation was predicted using algorithms described in ISO 9613-2, as incorporated within the noise modelling software.

Based on the site layout provided, the significant operational sound sources are mainly the 10 outdoor generators. The boilers and the diesel sprinkler pump are housed in the boiler room and pump room, of which the noise is largely attenuated by the building envelopes and very unlikely to be perceptible at the noise sensitive receptors (NSRs), given more than 100 m distance between the plants and the NSRs.

As such, to account for the different operating conditions, the following worst-case operation periods have been considered:

- Maintenance period for Block A&B, 4 generators run simultaneously;
- Maintenance period for Block C, 6 generators run simultaneously; and
- Emergency operation (i.e., in the event of a major power outage or grid failure), 10 generators run simultaneously.

6.2.1 Noise Technical Guidance

The Standard provides a method for assessing whether a sound from industrial or commercial premises (e.g., fixed mechanical and electrical (M&E) plant, loading activities etc.) is likely to cause a disturbance to persons living in the vicinity of the site.

BS 4142 assesses potential significance of effect by comparing the 'specific sound level' of an industrial source to the typically representative background sound level (LA90). Certain acoustic features can increase the potential for a sound to attract attention, and therefore increase its relative significance than that expected from a simple comparison between the specific sound level and the background sound level. In particular, BS 4142 identifies noise that contains discrete impulses and/or audible tonal qualities and in these cases recommends that a correction be added to the specific sound level. The specific sound level along with any applicable correction is referred to as the 'rating level'.

The greater the difference between the rating level and the background sound level; the greater the likelihood of complaints. The assessment criteria given by BS 4142 are as follows:

- A difference of +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.
- A difference of +5 dB could be an indication of an adverse impact, depending on the context.
- The lower the rating level is relative to the measured background sound level, the less likely it is that there will be an adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.
- Also to take into account the absolute level, risk that it will cause annoyance/interference with everyday activities, context of the sound, frequency and temporal variations to the sound.

During the daytime and evening, BS 4142 requires that sound levels are assessed over 1-hour periods. During the night-time, because sleep disturbance is the important issue and individual sound events are, therefore, more important, sound levels are assessed over 15-minute periods.

6.3 Impact Assessment

The results of the impact assessments for emissions to air and noise are provided below.

6.3.1 Air Quality Impact Assessment

A detailed dispersion modelling assessment was undertaken, which is presented in Appendix B.

The assessment has used detailed dispersion modelling to undertake a study of emissions to air during generator and boiler operation, comprising the following scenarios:

- Scenario 1: Maintenance Testing of A&B Block.
- Scenario 2: On load Testing of A&B Block.
- Scenario 3: Maintenance Testing of C Block.
- Scenario 4: On load Testing of C Block.
- Scenario 5: Emergency Operation.

The dispersion modelling assessment has included all emission points to air listed in Table 6.1.

The model has assumed that all sources are operating for all hours of the year (8,760 hours)as potentially the plant could be switched on at any point. . A conservative assessment has been demonstrated by using worst-case meteorological data for the reporting of results and inclusion of the impacts of buildings. A summary of those receptors experiencing the highest pollutant concentration as predicted by the model is presented in Table 6.2 for annual mean metrics.

Table 6.2 – Maximum Impacts at Human and Ecological Receptors – All Scenarios Annual Mean

Parameter	Annual Mean				
	AQAL µg/m^3	PC µg/m^3	PEC µg/m^3	% PC OF AQAL	% PEC OF AQAL
Human Receptors					
Annual mean NO_2	40	0.04	14.43	0.1	36.1
Annual mean PM_{10}	40	<0.01	14.48	<0.01	36.2
Annual mean $PM_{2.5}$	50	<0.01	9.48	<0.1	19.0
Ecological Receptors					
Annual mean NO_x	30	0.16	12.51	0.5	41.7
Annual mean SO_2	20	<0.01	2.34	<0.1	11.7
AQAL = Air Quality Assessment Level PC = Process Contribution PEC = Predicted Environmental Concentration (PC + background)					

All maximum results predicted by the model for annual mean metrics are below the relevant assessment metric and, as such, it is considered that air quality impacts from the Gloucester Data Centre will not have a detrimental impact at receptors in the proximity of the Site for long-term metrics.

As previously discussed, short-term metrics were also assessed for all scenarios. All results for Scenarios 1, 2 and 3 were below assessment metrics and therefore, could be considered insignificant.

Therefore, the worst-case scenarios in terms of air quality are Scenarios 4 and, in particular, Scenario 5. Some exceedances of the 1-hour mean NO_2 concentration were predicted for Scenarios 4 and 5.

However, given the short-term nature of operation, the results could be considered not significant, when allowing for the fact that this assessment metric allows up to 18 permitted exceedances per annum.

As the worst-case operating scenario, a summary of those receptors experiencing the highest pollutant concentration as predicted for Scenario 5 is presented in Table 6.3.

Table 6.3 – Maximum Impacts at Human and Ecological Receptors – Scenario 5 (short-term)

Parameter	Short-term Mean				
	AQAL µg/m^3	PC µg/m^3	PEC µg/m^3	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	284.18	307.36	142.1	153.7
90.41 percentile 24-hour mean PM_{10}	50	2.56	29.70	5.1	59.4
1-hour mean CO	30,000	301.05	1035.05	1.0	3.5
8-hour mean CO	10,000	195.67	929.67	2.0	9.3
99.18 percentile 24-hour mean SO_2	125	0.08	5.34	0.1	4.3
99.73 percentile 1 hour mean SO_2	350	1.73	6.41	0.5	1.8
99.9 percentile 15-minute mean SO_2	266	1.87	6.55	0.7	2.5
Ecological Receptors					
24-hour mean NO_x	75	60.71	85.41	81.0	113.9

The results indicate that the results for the majority of short-term assessment metrics are below the relevant AQAL. However, there are exceedances predicted for the 1-hour mean NO_2 metric, as well as 24-hour mean NO_x.

For exceedances of the 1-hour mean NO_2 metric, the hypergeometric distribution has then been used to calculate the probability of those meteorological conditions coinciding with the hours of operation to cause an exceedance. If the emergency scenario ran for a 24-hour period, the model predicted only 9 hours would cause an exceedance of 200 µg/m^3. This is well below the permitted 18 exceedances per year, and therefore it is considered that there is no risk of adverse effects from Scenario 5 operations.

For 24-hour mean NO_x concentrations at ecological receptors, exceedances are only predicted at a Local Nature Reserve site where the PC constitutes less than 100% of the short-term air quality assessment level. Therefore, further assessment is not required.

6.3.2 Noise Impact Assessment

A detailed noise impact assessment was undertaken, which is presented in Appendix C.

The following worst-case operation periods have been considered:

- Maintenance period for Block A&B, 4 generators run simultaneously;
- Maintenance period for Block C, 6 generators run simultaneously; and
- Emergency operation (i.e., in the event of a major power outage or grid failure), 10 generators run simultaneously.

There was no generator maintenance or test arranged during the project periods, therefore the generator noise emission data is based on Bureau Veritas measurement data obtained at similar sites. The existing generators are placed in enclosures, and the typical sound level of generator in an enclosure is 85 dB L_{Aeq} at 1 m.

The maintenance is assumed to occur at daytime only (0700-2300), and emergency operation may occur both daytime and night-time (2300-0700).

The calculated specific sound levels at the nearest receptors during the three operation conditions are shown in Table 6.4 below.

Table 6.4 – Summary of Predicted Sound Levels on the nearest facades at ground floor (day)

Receptor(s)	Sound Pressure Level, dB $L_{Aeq,T}$ (Maintenance - Block A&B)	Sound Pressure Level, dB $L_{Aeq,T}$ (Maintenance - Block C)	Sound Pressure Level, dB $L_{Aeq,T}$ (Emergency)
NSR1 – Residential dwelling off Welveland Ln	35	38	40
NSR2 – Residential dwelling off Greenways	32	34	35

The predicted specific sound levels at the nearest receptors during the night-time operation are shown in Table 6.5 below.

Table 6.5 – Summary of Predicted Sound Levels on the nearest facades at ground floor (night)

Receptor(s)	Sound Pressure Level, dB $L_{Aeq,T}$ (Maintenance - Block A&B)	Sound Pressure Level, dB $L_{Aeq,T}$ (Maintenance - Block C)	Sound Pressure Level, dB $L_{Aeq,T}$ (Emergency)
NSR1 – Residential dwelling off Welveland Ln	-	-	40
NSR2 – Residential dwelling off Greenways	-	-	35

The indicative assessments to BS 4142:2014 are provided in Table 6.6 to Table 6.9, below.

The results indicate that, during the daytime period, the predicted sound levels generated by the operation of the generators would result in no impact at the nearest residential receptors.

The results also indicate that, at night, the predicted sound levels generated by the operation of the proposed development would result in no impact at NSR2. The rating level of generator noise is 4 dB above the background sound level at NSR2, however given the very low chance of emergency operation during night, it is believed the emergency operation of the generators has low impact at NSR1.

A sound reduction of 15 dB is expected through a partially open window for ventilation, therefore internal plant noise levels would be below the limit in BS8233 guidelines for bedrooms (30 dB L_{Aeq},8h).

As such, no additional noise mitigation measures are required.

Table 6.6 – Indicative BS 4142:2014 Assessment during Maintenance - Block A&B - Day

Description	Result	Relevant Clauses of BS 4142:2014	Commentary
Specific Sound Level (free-field)	$L_{Aeq,T}$ = 35 dB (NSR1) $L_{Aeq,T}$ = 32 dB (NSR2)	7.3.6	Predicted level (free-field) at ground floor level at the nearest receptor. Determined by calculation using CadnaA.
Background sound level	46 dB (NSR1) 49 dB (NSR2)	8.1 and 8.2	The background noise levels (free-field) were measured at the

Description	Result	Relevant Clauses of BS 4142:2014	Commentary
			monitoring locations close to the noise-sensitive receptors.
Acoustic features correction	+0 dB	9.2	No perceptible tone or other distinctive acoustic features are predicted to be audible at the receptors due to the high background level.
Rating Level	35 dB (NSR1) 32 dB (NSR2)		
Excess of Rating Level over Background Sound Level	-11 dB (NSR1) -17 dB (NSR2)		
Assessment of impact: indication of no impact due to the generator noise at the receptors		11	
Context		11 8.2	Plant noise levels predicted to be well below existing ambient and background sound levels at both receptor locations.
Uncertainty of the assessment		10	The specific noise level has been predicted by CadnaA, which utilises ISO9613 calculations, which have a claimed uncertainty of +/- 3 dB. The background sound levels at the receptors are decided based on the short-term noise monitoring.

Table 6.7 – Indicative BS 4142:2014 Assessment during Maintenance - Block C - Day

Description	Result	Relevant Clauses of BS 4142:2014	Commentary
Specific Sound Level (free-field)	$L_{Aeq,T}$ = 38 dB (NSR1) $L_{Aeq,T}$ = 34 dB (NSR2)	7.3.6	Predicted level (free-field) at ground floor level at the nearest receptor. Determined by calculation using CadnaA.
Background sound level	46 dB (NSR1) 49 dB (NSR2)	8.1 and 8.2	The background noise levels (free-field) were measured at the monitoring locations close to the noise-sensitive receptors.
Acoustic features correction	+0 dB	9.2	No perceptible tone or other distinctive acoustic features are predicted to be audible at the receptors due to the high background level.
Rating Level	38 dB (NSR1) 34 dB (NSR2)		
Excess of Rating Level over Background Sound Level	-8 dB (NSR1) -15 dB (NSR2)		
Assessment of impact: indication of no impact due to the generator noise at the receptors		11	
Context		11 8.2	Plant noise levels predicted to be well below existing ambient and

Description	Result	Relevant Clauses of BS 4142:2014	Commentary
			background sound levels at both receptor locations.
Uncertainty of the assessment		10	The specific noise level has been predicted by CadnaA, which utilises ISO9613 calculations, which have a claimed uncertainty of +/- 3 dB. The background sound levels at the receptors are decided based on the short-term noise monitoring.

Table 6.8 – Indicative BS 4142:2014 Assessment during Emergency Operation - Day

Description	Result	Relevant Clauses of BS 4142:2014	Commentary
Specific Sound Level (free-field)	$L_{Aeq,T}$ = 40 dB (NSR1) $L_{Aeq,T}$ = 35 dB (NSR2)	7.3.6	Predicted level (free-field) at ground floor level at the nearest receptor. Determined by calculation using CadnaA.
Background sound level	46 dB (NSR1) 49 dB (NSR2)	8.1 and 8.2	The background noise levels (free-field) were measured at the monitoring locations close to the noise-sensitive receptors.
Acoustic features correction	+0 dB	9.2	No perceptible tone or other distinctive acoustic features are predicted to be audible at the receptors due to the high background level.
Rating Level	40 dB (NSR1) 35 dB (NSR2)		
Excess of Rating Level over Background Sound Level	-6 dB (NSR1) -14 dB (NSR2)		
Assessment of impact: indication of no impact due to the generator noise at the receptors		11	
Context		11 8.2	Plant noise levels predicted to be well below existing ambient and background sound levels at both receptor locations.
Uncertainty of the assessment		10	The specific noise level has been predicted by CadnaA, which utilises ISO9613 calculations, which have a claimed uncertainty of +/- 3 dB. The background sound levels at the receptors are decided based on the short-term noise monitoring.

Table 6.9 – Indicative BS 4142:2014 Assessment during Emergency Operation - Night

Description	Result	Relevant Clauses of BS 4142:2014	Commentary
Specific Sound Level (free-field)	$L_{Aeq,T}$ = 40 dB (NSR1) $L_{Aeq,T}$ = 35 dB (NSR2)	7.3.6	Predicted level (free-field) at 1st floor window at the nearest receptors. Determined by calculation using CadnaA.
Background sound level	38 dB (NSR1) 42 dB (NSR2)	8.1 and 8.2	The background noise levels (free-field) were measured at the monitoring locations close to the noise-sensitive receptors.
Acoustic features correction	+2 dB	9.2	Perceptible tone or other distinctive acoustic features are predicted to be audible at the receptors.
Rating Level	42 dB (NSR1) 37 dB (NSR2)		
Excess of Rating Level over Background Sound Level	+4 dB (NSR1) -5 dB (NSR2)		
Assessment of impact: indication of no impact due to the generator noise at NSR2, and low impact due to the generator noise at NSR1		11	
Context		11 8.2	At night the noise-sensitive location is indoors with open windows where residual sound within the dwelling will further mask sound from the plant. A sound reduction of 15 dB is expected through a partially open window for ventilation, therefore internal plant noise levels would be not above BS8233 guidelines for bedrooms (30 dB $L_{Aeq,8h}$).
Uncertainty of the assessment		10	The specific noise level has been predicted by CadnaA, which utilises ISO9613 calculations, which have a claimed uncertainty of +/- 3 dB. The background sound levels at the receptors are decided based on the short-term noise monitoring.

7 Resource Efficiency

7.1 Raw Materials Consumption

The raw materials used at the Gloucester Data Centre comprise:

- Diesel fuel oil – Approximately 4,000 litres per annum (Approximately 218,000 litres stored on site, further detail in Section 3.2.1.
- Lubricating oil – Approximately 200 litres per annum

The back-up generators are designed for the combustion of diesel fuel oil, this being the fuel recommended/specified by the engine manufacturers. The Site uses ultra-low sulphur diesel.

Relevant operating personnel are experienced in acceptance and handling of the raw materials and new personnel will be given appropriate training and personnel training records will be maintained in accordance with management system procedures.

7.2 Water Consumption

There will be no consumption of water associated with combustion activities and diesel use/storage at the Gloucester Data Centre.

7.3 Waste Disposal/Recovery

The Site will characteristically not produce significant amounts of waste. Waste oil will be generated at the site as a result of maintenance and will be removed from Site by the appointed maintenance contractor.

In accordance with the waste hierarchy, the Operator will seek to ensure that the waste oil is subject to re-use, avoiding the need for disposal. The operator will ensure that waste oil will be removed from Site by a suitably permitted waste management contractor.

It is anticipated that waste oils from the generators at the data centre will be less than 1 tonne per annum.

8 Environmental Management System and Emergency Response

8.1 Planning

Barclays' Environmental Management System (EMS) establishes and implements processes to undertake the activities required to address our risks and opportunities, significant environmental aspects, our compliance obligations and any other requirements to ensure our intended outcomes are met.

Our planning activities determine our environmental objectives, how we measure and communicate them and monitor progress against the objectives.

It further supports identification of resources required, operational planning and controls, and our emergency response processes.

8.2 Competence and Training

Barclays EMS establishes and implements processes to ensure persons doing work under our control are competent and have the required training needs associated with our aspects & environmental management systems. The EMS also details how evaluation of the effectiveness of this training will be determined.

The EMS details the process for the provision of resources that will be put in place to acquire the necessary competence.

The EMS will establish and implement the processes to ensure persons doing work under the organisations control are aware of our environmental policy, the significant environmental aspects and related actual or potential environmental impacts associated with their work, how their activity contributes to the effectiveness of the environmental management system, including the benefits of enhanced environmental performance and the implications of not conforming with the environmental management system requirements, including not fulfilling the organisation's compliance obligations.

The EMS will establish, implement and maintain the process(es) needed for internal and external communications relevant to the environmental management system and as required by relevant compliance obligations.

8.3 Operations and Maintenance

Barclays will establish and implement the processes to meet the requirements of the EMS and to implement actions related to its risks and opportunities and environmental objectives by establishing operating criteria for relevant processes and identifying suitable controls.

Operational control is exercised through the planning of operations, the maintenance of plant and equipment and the correct use and storage of substances and is documented within the relevant Barclays minimum standards.

Changes to planned operational activity will be controlled and the impact of unintended changes will be reviewed, and adverse impacts mitigated as required.

So far as is practicable, operational control will extend to outsourced processes where control or influence can be applied.

8.4 Audit

The EMS establishes and implements processes we will undertake to monitor, measure, analyse and evaluate our environmental performance. The EMS details what will be evaluated, how this evaluation will take place, the methodology to be used to perform the evaluation, the system for reviewing

performance with senior leadership and the process for corrective actions to ensure continuous improvement.

In addition, internal audits are regularly undertaken by competent persons to confirm the organisation complies with their compliance obligations and the requirements set out in their EMS. Findings raised are documented, addressed and their effectiveness is reviewed on a regular basis.

8.5 Emergency Response

The EMS establishes and implements processes Barclays will undertake to determine and plan for emergency situations and in the event of an emergency situation provide resources to prevent, limit or mitigate the severity of any emergency.

The EMS will further establish and implement processes Barclays will undertake to recover from and remediate and environmental damage or harm that is caused as a result of the emergency.

The EMS details the arrangements for ensuring relevant staff are trained in emergency response processes and in the event of an incident post incident reviews will be undertaken to identify the root cause of the incident and any changes or actions required to prevent a reoccurrence.

9 Information

9.1 Records

Documents are retained electronically where possible, although some records are hard copies (e.g., copies of plant conditions and performance for existing boilers). All records are:

- Legible;
- Compiled as soon as reasonably practicable;
- Document in such a way that, where amendments are made, the original record and any changes are recorded and retrievable; and
- Retained for a minimum of four years or until permit surrender.

9.2 Reporting

All reports required to comply with the permit will be provided to the Environment Agency to the address that will be provided. The reports will be retained in accordance with the procedures outlined in the appropriate sections of the permit.

9.3 Notification

Barclays will notify the Environment Agency without delay following the detection of:

- Any malfunction, breakdown or failure of equipment or techniques, accident or emission of a substance not controlled by an emissions limit which has caused or may cause significant pollution; and
- Any significant adverse environmental effect.

All notifications will be recorded and reported in line with the appropriate sections of the permit.

Appendix A – Terms and Definitions

Term	Definition
AQAL	Air Quality Assessment Level
AQO	Air Quality Objective
AQS	Air Quality Standard
AURN	Automatic Urban and Rural Network
BAT	Best Available Technique
BREF	BAT Reference Documents
CERC	Cambridge Environmental Research Consultants
CO	Carbon Monoxide
dB	Decibel
Defra	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EAL	Environmental Assessment Level
ELV	Emission Limit Value
EMS	Environmental Management System
EPR	Environmental Permitting Regulations
EU	European Union
g/s	Gram per second
IED	Industrial Emissions Directive
L_{90},T	Background sound level
L_{Aeq},T	Ambient sound level
L_{Amax},T	Maximum sound level
LAQM	Local Air Quality Management
mg/m^3	Milligram per cubic metre
m/s	Metres per second
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
PC	Process Contribution
PEC	Predicted Environmental Concentration
SO_2	Sulphur dioxide
$\mu g/m^3$	Microgram per cubic metre

Appendix B – Air Quality Impact Assessment

Barclays Bank plc

Gloucester Data Centre

Air Dispersion Modelling Report

November 2023

Move Forward with Confidence

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Document Control Sheet

Identification	
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	Name	Job Title	Signature
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Disclaimer

This Report was completed by Bureau Veritas on the basis of a defined programme of work and terms and conditions agreed with the Client. Bureau Veritas confirms that in preparing this Report it has exercised all reasonable skill and care taking into account the project objectives, the agreed scope of works, prevailing site conditions and the degree of manpower and resources allocated to the project.

Bureau Veritas accepts no responsibility to any parties whatsoever, following the issue of the Report, for any matters arising outside the agreed scope of the works.

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Executive Summary

Purpose of Report

Bureau Veritas has been commissioned by Barclays Bank plc (Barclays) to undertake an air quality assessment for 10 back-up diesel generators and 4 gas-fired boilers at their data centre in Gloucester. This document provides supporting technical information for an Environmental Permit application to operate the site through the Environmental Permitting Regulations (EPR) regime. This report should be read in conjunction with (Barclays Gloucester Permit_v1.0).

The assessment has used detailed dispersion modelling to undertake a study of emissions to air during generator and boiler operation, comprising the following scenarios:

- Scenario 1: Maintenance Testing of A&B Block.
- Scenario 2: On load Testing of A&B Block.
- Scenario 3: Maintenance Testing of C Block.
- Scenario 4: On load Testing of C Block.
- Scenario 5: Emergency Operation.

Each of the generators are operated using diesel as the fuel, hence, the following pollutants were included in the assessment: nitrogen oxides (NO_x), sulphur dioxide (SO_2), carbon monoxide (CO) and particulate matter (PM_{10} and $PM_{2.5}$), where applicable.

Release rates for PM, NO_x and CO have been derived using information provided by the generator manufacturers and emission limits legislation. The release rate for SO_2 has been derived based on the sulphur content of the fuel used on site, which is Ultra-Low Sulphur Diesel (ULSD). Due to the short-term nature of emissions released from the generator plant, results have been post-processed, where relevant, to account for the generators running limited hours within a calendar year.

Summary of Conclusions

The assessment has resulted in the following conclusions:

- Considering annual mean results for all scenarios (except emergency operation), all results at both human and ecological receptors were below the relevant assessment metric, owing to the minimal annual operating hours of the plant.
- The results for nitrogen deposition show exceedances at all ecological receptors considered in the assessment. However, this is due to the background deposition rate at all receptors exceeding the minimum critical load. When taking the PC, this makes up less than 1% of the overall result at the designated ecological receptors considered, so the contribution from the plant can be considered not significant. In the same manner, all results for acid deposition can be described as not significant.
- As such, the plant is not expected to have a significant impact on annual mean pollutant concentrations in the surrounding area.
- Considering short-term results in Scenario 1 (maintenance testing of A&B Block), all results at human and ecological receptors were below the relevant assessment metric. The results for Scenario 1 can therefore be considered not significant.

- Considering short-term results in Scenario 2 (on load testing of A&B Block), all results at human and ecological receptors were below the relevant assessment metric. The results for Scenario 2 can therefore be considered not significant.

- Considering short-term results in Scenario 3 (maintenance testing of C Block), all results at human and ecological receptors were below the relevant assessment metric. The results for Scenario 3 can therefore be considered not significant.

- The majority of the short-term results in Scenario 4 (on load testing of C Block) at human and ecological receptors, were below the relevant assessment metric. Although exceedances of the 99.79 percentile 1-hour mean NO_2 concentration were predicted, twice annual testing falls below the 18 hours of permissible exceedance for 1-hour mean NO_2 concentrations, so it is not possible that Scenario 4 operation would cause a true exceedance of this metric. The results for Scenario 4 can therefore be considered not significant.

- Considering short-term results in Scenario 5 (Emergency Operation), the majority of results at human and ecological receptors were below the relevant assessment metric. Exceedances of the 24-hour mean NO_x concentrations for ecological receptors were only predicted at a Local Nature Reserve (LNR) site, where the PC constituted less than 100% of the short-term Air Quality Assessment Level (AQAL). Therefore, further assessment of this ecological site is not required and can be considered as insignificant. At human receptors, an exceedance of the 99.79 percentile 1-hour mean NO_2 concentration was predicted.

- A further probability analysis was then carried out for Scenario 5, taking into account a worst-case maximum run time. A 24-hour run time was utilised in the hypergeometric distribution, to calculate the number of hours of exceedances. Only nine hours were predicted to exceed the AQAL, which is well below the permitted 18 exceedances per year. Therefore, the results for Scenario 5 can be considered not significant.

- Due to worst-case conditions being employed through the assessment, the modelled predictions are expected to represent the upper limit of concentrations.

1 Introduction

Bureau Veritas has been commissioned by Barclays Bank plc (Barclays) to undertake an air quality assessment for 10 back-up diesel generators and four gas-fired boilers at their data centre in Gloucester. This document provides supporting technical information for an Environmental Permit application to operate the site through the Environmental Permitting Regulations (EPR) regime. This report should be read in conjunction with (Barclays Gloucester Permit_v1.0).

Each of the generators utilise diesel fuel, hence, the following pollutants were included in the assessment: nitrogen oxides (NO_x (as NO_2)), sulphur dioxide (SO_2), carbon monoxide (CO) and particulate matter (PM_{10} and $PM_{2.5}$), where applicable.

This report presents the methodology and the subsequent results of the dispersion modelling of emissions to air.

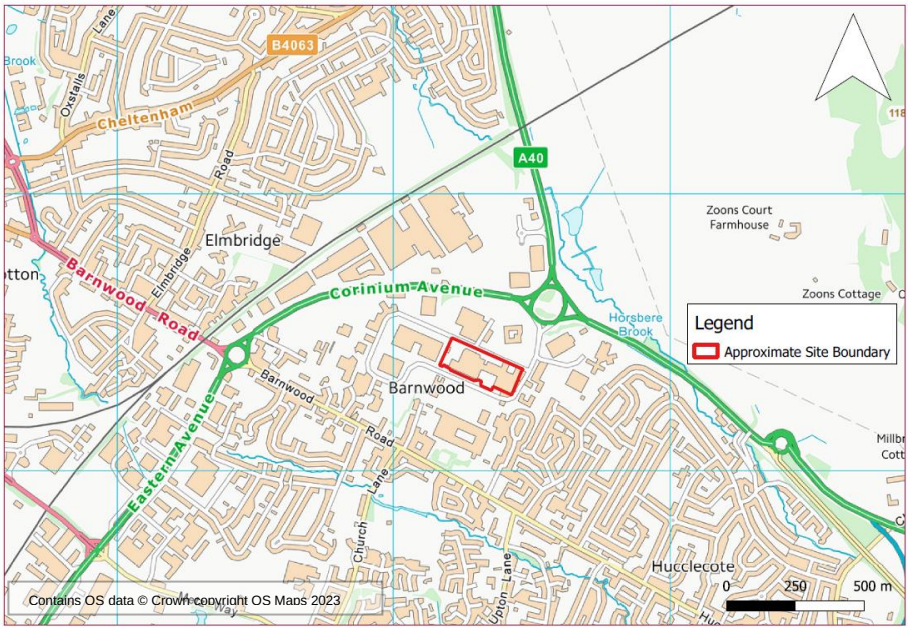
1.1 Site location

The site is located on Barnett Way in the suburb of Barnwood, about 2.6 km east of Gloucester city centre. The area around the site is primarily commercial in nature, with residential areas at a greater distance. The site location is shown in Figure 1.1.

The closest receptors to the site are residential properties on Greenways, located approximately 60 m of the site boundary to the southeast. The closest ecological receptor, designated as a Local Nature Reserve (Barnwood Arboretum), is located approximately 415 m southwest of the site.

In terms of existing air quality conditions in the area, there are three Air Quality Management Areas (AQMAs) declared within the jurisdiction of Gloucester City Council. The closest AQMA to the site is the Painswick Road AQMA, located in Gloucester city centre, and this is declared for exceedances of the annual mean nitrogen dioxide (NO_2) objective.

Figure 1.1 - Site Location



2 Dispersion Modelling Methodology

ADMS 5 version 5.2 modelling software was used for this study. ADMS 5 is an advanced atmospheric dispersion model that has been developed and validated by Cambridge Environmental Research Consultants (CERC). The model was used to predict ground level concentrations of combustion products emitted to atmosphere from the combustion plant at the Gloucester site. The model is used extensively throughout the UK for regulatory compliance purposes. It is accepted as an appropriate air quality modelling tool by the Environment Agency (EA) and local authorities.

ADMS 5 parameterises stability and turbulence in the Atmospheric Boundary Layer (ABL) by the Monin-Obukhov length and the boundary layer depth. This approach allows the vertical structure of the ABL to be more accurately defined than by the stability classification methods of earlier dispersion models such as R91 or ISCST3. In ADMS, the concentration distribution follows a symmetrical Gaussian profile in the vertical and crosswind directions in neutral and stable conditions. However, the vertical profile in convective conditions follows a skewed Gaussian distribution to take account of the inhomogeneous nature of the vertical velocity distribution in the Convective Boundary Layer (CBL).

A number of complex modules, including the effects of plume rise, complex terrain, coastlines, concentration fluctuations, radioactive decay and buildings effects, are also included in the model, as well as the facility to calculate long-term averages of hourly mean concentration, dry and wet deposition fluxes, and percentile concentrations, from either statistical meteorological data or hourly average data.

A range of input parameters is required for the model. This includes, but is not limited to, data describing the local area, meteorological measurements, and emissions data. The data utilised within the modelling assessment is detailed in the following sections of this chapter.

2.1 Process Emissions

Details of the generators at the Gloucester data centre have been provided to Bureau Veritas by Barclays. The assessment has assumed the following numbers of generators (gens) and boilers across the three buildings (units) at the site:

- Block A/B – four gens at 7.855 MW_{th}, three boilers at 0.38 MW_{th} and one boiler at 0.39 MW_{th} (total 32.9 MW_{th}).
- Block C – 6 gens total, made up of six gens at 6.37 MW_{th} (total 38.2 MW_{th}).

The total aggregated capacity of the site is therefore 71.16 MW_{th}. The model input parameters for each type of combustion plant are detailed in Table 2.1.

Release rates for PM, NO_x and CO have been derived from information provided by the generator manufacturer or appropriate emissions standards. The release rate for SO_2 has been derived based on the sulphur content of the fuel used on site, which has been confirmed as being Ultra-Low Sulphur Diesel (ULSD). All generators have been modelled as vertical point sources.

The calculations which have been undertaken to derive pollutant emission rates from information provided by the generator manufacturers are detailed in Table A1 of Appendix A. Assumed grid locations, taken from GIS, for each generator are provided in Table A2 of Appendix A.

Table 2.1 - Model Input Parameters

Parameter	MTU Gen – C Block	Mirrlees Gen – A/B Block	NGN13 Boiler – A/B Block	RS34 Boiler – B Block
Number of Generators [a]	6	4	3	1
Thermal Input (MW_{th})	6.368	7.855	0.380	0.390
Stack Height (m) [b]	7.50	16.93	18.30	18.30
Stack Diameter (m) [b]	0.442	0.600	0.275	0.300
Efflux Velocity ($m\ s^{-1}$)	56.82	31.87	4.90	4.23
Efflux Temperature (°C) [c]	590	450	110	110
Emission Concentrations and Rates (per combustion unit)[d]				
NO_x (mg/Nm^3)	1700	2000	-	-
NO_x (g/s)	3.800	5.520	0.006	0.006
SO_2 (mg/Nm^3)	3.0	3.0	-	-
SO_2 (g/s)	0.01	0.01	-	-
CO (mg/Nm^3)	650	650	-[f]	-[f]
CO (g/s)	1.45	1.79	-	-
PM_{10} (mg/Nm^3)[e]	80	80	-	-
PM_{10} (g/s)	0.18	0.22	-	-

[a] Number of generators provided by Barclays.

[b] Information provided by Barclays.

[c] Temperature assumptions are outlined in Appendix A.

[d] Emission Rates for PM, NO_x and CO have been derived from emission information provided by generator manufacturers or appropriate emissions standards. The emission rate for SO_2 has been derived based on the sulphur content of the fuel used on site, which is known to be no greater than 0.001%.

[e] Ratio of emission between PM_{10} and $PM_{2.5}$ not known, therefore the emission rate for PM_{10} has also been used as a proxy for the emission of $PM_{2.5}$, as a conservative assumption.

[f] Boiler emission rates were calculated using the EcoDesign Directive, therefore there are no emission rates applicable for CO.

The following scenarios have been included in this assessment, based on operating information provided by Barclays.

Table 2.2 – Modelled Scenarios

Scenario No.	Scenario Name	Operations
1	Maintenance Testing of A&B Block	Four generators tested twice a year, each test is one hour per generator, total 8 hours running annually.
2	On load Testing of A&B Block	Onload testing is twice a year, three gens are tested in each test for four hours, totalling 8 hours annually.
3	Maintenance Testing of C Block	Six generators are tested twice a year. Each gen is run for 1 hour, totalling 12 hours annually.
4	On load Testing of C Block	Onload testing is twice a year, all six gens are run for 4 hours in each test, totalling 8 hours annually.
5	Emergency Operation	All generators run and all boilers run, as a worst-case.

Source groups have been used in the dispersion model to account for groups of generators running simultaneously in each of the scenarios considered. The boilers are run continuously throughout the year, therefore the operation of these has been included in each of the scenarios included, with no adjustment for operating hours.

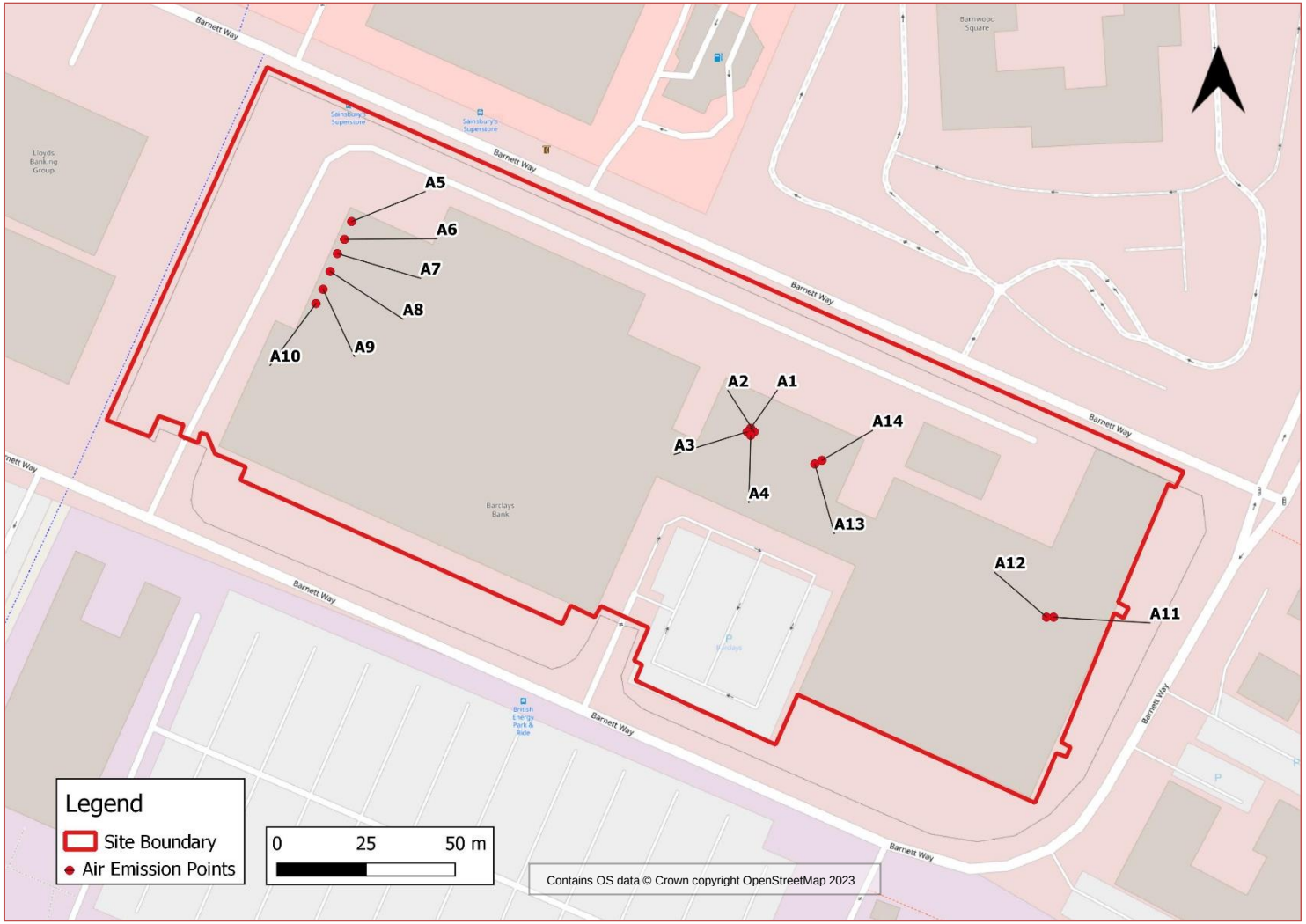
Since it is not known the exact time during the year when the gensets will operate, the model has assumed that they can operate any hour of the year. However, due to the short-term nature of operation of the plant, results have been post-processed to account for short-term averaging periods, according to the follow:

- For annual averaging periods, result have been post-processed using the factor n/8760, where ‘n’ is the total operating hours within an annual period.
- For averaging periods of 24 hours or 8 hours, results have been post-processed using the factor n/24, or n/8, where ‘n’ is the total operating hours within the relevant period.

It is understood that Block A&B and Block C maintenance and testing is not undertaken on the same day, therefore the maximum number of generators that may be running at any one time will be as a result of testing at Block C.

In the event of mains power failure, the site operates a 2N at 11 kV infrastructure. During 2009, two 11 kV to 132 kV transformers were installed on the national grid which has increased the security of electricity supplies at the site further. It is therefore unlikely that the whole site will lose power completely, and it is extremely unlikely that all generators will need to operate simultaneously. However, the Emergency scenario as modelled within this assessment has been modelled worst case, with all generators operating simultaneously.

Figure 2.1 - Emission Points Visualisation



2.2 Meteorology

For meteorological data to be suitable for dispersion modelling purposes, a number of meteorological parameters need to be measured on an hourly basis. These parameters include wind speed, wind direction, cloud cover and temperature. There are only a limited number of monitoring sites where the required meteorological measurements are made. The year of meteorological data that is used for a modelling assessment can also have a significant effect on ground level concentrations.

This assessment has utilised meteorological data recorded at Gloucestershire meteorological station during across a five-year period (2018 to 2022). Gloucestershire meteorological station is located approximately 4 km to the northeast of the data centre and offers data in a suitable format for the model. Figure 2.2– Figure 2.6 illustrate the frequency of wind directions and wind speeds for the years considered.

ADMS cannot, as standard, model calm weather conditions, since this results in a discontinuity produced by a 'divide by zero' calculation. Most Gaussian plume models simply skip lines of meteorological data where calm conditions occur. Met lines will also be skipped where any of the required meteorological input parameters are missing. The generally accepted best practice requirement is to ensure that no more than 10% of meteorological data is omitted from the model run.

Table 2.3 demonstrates that this requirement was not satisfied for the meteorological 'met' data years proposed for the assessment. As such, the model was run with the 'Calms' module applied, which adjusts the default minimum wind speed from 0.75 m/s to 0.3 m/s, allowing the model to include calculations for an increased number of met lines. This is presented in Table 2.3.

Table 2.3 – Meteorological Data Capture – No Calms

Year	Number of met lines used	Number of lines with calm conditions	Number of lines with inadequate data	Number of non-calm met lines with wind speed less than the minimum value of 0.75 m/s	Percentage of lines used
2018	7637	512	209	402	93.0
2019	7571	627	94	468	93.6
2020	7918	417	0	449	95.1
2021	7591	609	92	468	93.6
2022	7466	1009	0	285	96.7

Figure 2.2 - 2018 Gloucestershire Wind Rose

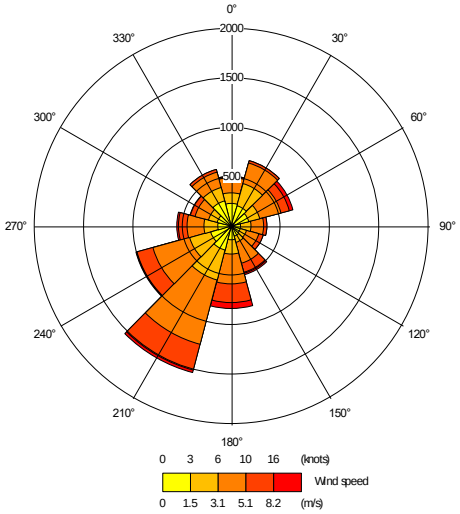


Figure 2.3 - 2019 Gloucestershire Wind Rose

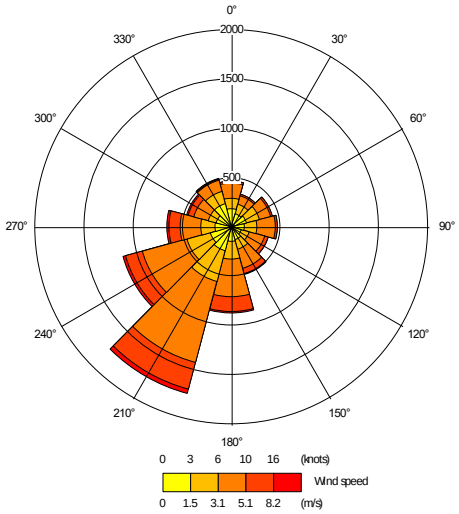


Figure 2.4 - 2020 Gloucestershire Wind Rose

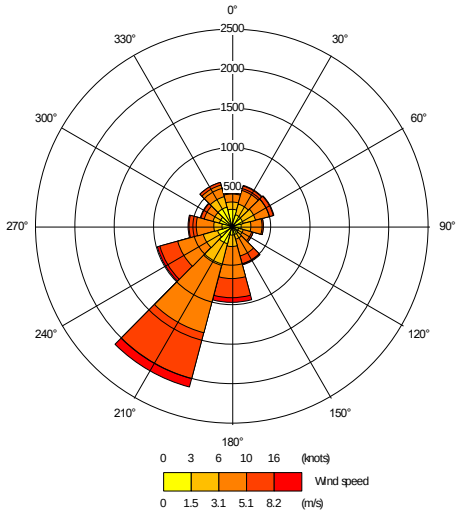


Figure 2.5 - 2021 Gloucestershire Wind Rose

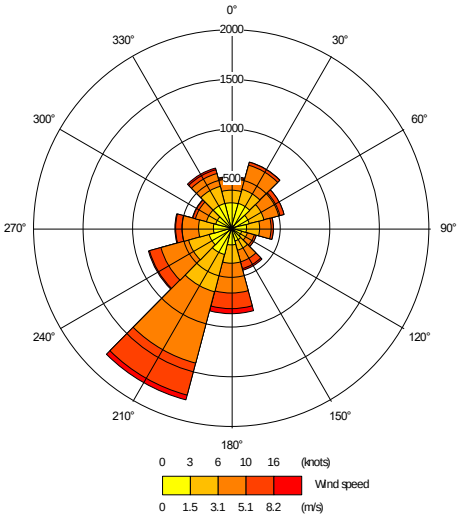
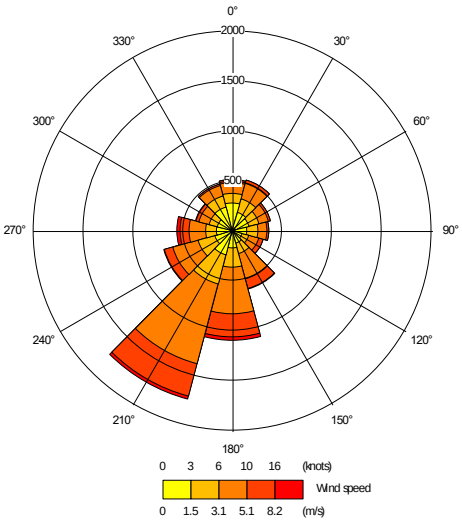


Figure 2.6 - 2022 Gloucestershire Wind Rose



2.3 Surface Characteristics

The predominant surface characteristics and land use in a model domain have an important influence in determining turbulent fluxes and, hence, the stability of the boundary layer and atmospheric dispersion. Factors pertinent to this determination are detailed below.

2.3.1 Surface Roughness

Roughness length, z_0, represents the aerodynamic effects of surface friction and is physically defined as the height at which the extrapolated surface layer wind profile tends to zero. This value is an important parameter used by meteorological pre-processors to interpret the vertical profile of wind speed and estimate friction velocities which are, in turn, used to define heat and momentum fluxes and, consequently, the degree of turbulent mixing.

The surface roughness length is related to the height of surface elements; typically, the surface roughness length is approximately 10% of the height of the main surface features. Thus, it follows that surface roughness is higher in urban and congested areas than in rural and open areas. Oke (1987) and CERC (2003) suggest typical roughness lengths for various land use categories (Table 2.4).

Table 2.4 - Typical Surface Roughness Lengths for Various Land Use Categories

Type of Surface	z_0 (m)
Ice	0.00001
Smooth snow	0.00005
Smooth sea	0.0002
Lawn grass	0.01
Pasture	0.2
Isolated settlement (farms, trees, hedges)	0.4
Parkland, woodlands, villages, open suburbia	0.5-1.0
Forests/cities/industrialised areas	1.0-1.5
Heavily industrialised areas	1.5-2.0

Increasing surface roughness increases turbulent mixing in the lower boundary layer. This can often have conflicting impacts in terms of ground level concentrations:

- The increased mixing can bring portions of an elevated plume down towards ground level, resulting in increased ground level concentrations closer to the emission source; however,
- The increased mixing increases entrainment of ambient air into the plume and dilutes plume concentrations, resulting in reduced ground level concentrations further downwind from an emission source.

The overall impact on ground level concentration is, therefore, strongly correlated to the distance and orientation of a receptor from the emission source.

2.3.2 Surface Energy Budget

One of the key factors governing the generation of convective turbulence is the magnitude of the surface sensible heat flux. This, in turn, is a factor of the incoming solar radiation. However, not all solar radiation arriving at the Earth's surface is available to be emitted back to atmosphere in the form of sensible heat. By adopting a surface energy budget approach, it can be identified that, for fixed values of incoming short and long wave solar radiation, the surface sensible heat flux is inversely proportional to the surface albedo and latent heat flux.

The surface albedo is a measure of the fraction of incoming short-wave solar radiation reflected by the Earth's surface. This parameter is dependent upon surface characteristics and varies throughout the year. Oke (1987) recommends average surface albedo values of 0.6 for snow covered ground and 0.23 for non-snow covered ground, respectively.

The latent heat flux is dependent upon the amount of moisture present at the surface. The Priestly-Taylor parameter can be used to represent the amount of moisture available for evaporation:

$$\alpha = \frac{1}{S(B+1)}$$

Where:

α = Priestly-Taylor parameter (dimensionless)

$$S = \frac{s}{s+\gamma}$$

$$s = \frac{de}{dT}$$

e_s = Saturation specific humidity (kg H_2O / kg dry air)

T = Temperature (K)

$$\gamma = \frac{c_{pw}}{\lambda}$$

c_{pw} = Specific heat capacity of water (kJ kg^{-1} K^{-1})

λ = Specific latent heat of vaporisation of water (kJ kg^{-1})

B = Bowen ratio (dimensionless)

Areas where moisture availability is greater will experience a greater proportion of incoming solar radiation released back to atmosphere in the form of latent heat, leaving less available in the form of sensible heat and, thus, decreasing convective turbulence. Holstag and van Ulden (1983) suggest values of 0.45 and 1.0 for dry grassland and moist grassland respectively.

2.3.3 Selection of Appropriate Surface Characteristic Parameters for the Site

A detailed analysis of the effects of surface characteristics on ground level concentrations by Auld et al. (2002) led them to conclude that, with respect to uncertainty in model predictions:

> *"…the energy budget calculations had relatively little impact on the overall uncertainty"*

In this regard, it is not considered necessary to vary the surface energy budget parameters spatially or temporally, and annual averaged values have been adopted throughout the model domain for this assessment.

As snow covered ground is only likely to be present for a small fraction of the year, the surface albedo of 0.23 for non-snow covered ground advocated by Oke (1987) has been used whilst the model default α value of 1.0 has also been retained.

From examination of 1:10,000 Ordnance Survey maps, it can be seen that within the immediate vicinity of the site, land use is predominately commercial and residential with more open land to the northeast. Consequently, a composite surface roughness length of 1.0 m has been deemed appropriate to take account of the respective land use categories in the model domain. For the meteorological site, a surface roughness of 0.5 m has been utilised given the representative land use categories in this area.

2.4 Buildings

Any large, sharp-edged object has an impact on atmospheric flow and air turbulence within the locality of the object. This can result in maximum ground level concentrations that are significantly different (generally higher) from those encountered in the absence of buildings. The building 'zone of influence' is generally regarded as extending a distance of 5L (where L is the lesser of the building height or width) from the foot of the building in the horizontal plane and three times the height of the building in the vertical plane.

Details of the buildings included in the model are provided in Table 2.5. Block A was used as the main building in the model for all generators.

Table 2.5 - Modelled Buildings

Name	Centre Easting (m)	Centre Northing (m)	Height (m)	Length / Diameter (m)	Width (m)	Angle (º)
Block A	386407	218326	10	71.75	66.12	113.95
Block B	386284	218406	10	50.85	89.37	24.00
Block C	386260	218373	10	115.64	33.31	294.17
Central	386356	218375	10	33.35	62.19	204.00

2.5 Terrain

The concentrations of an emitted pollutant found in elevated, complex terrain differ from those found in simple level terrain. There have been numerous studies on the effects of topography on atmospheric flows. A summary of the main effects of terrain on atmospheric flow and dispersion of pollutants are summarised below:

- Plume interactions with windward facing terrain features;
    - Plume interactions with terrain features whereby receptors on hills at a similar elevation to the stack experience elevated concentrations.
    - Direct impaction of the plume on hill slopes in stable conditions.
    - Flow over hills in neutral conditions can experience deceleration forces on the upwind slope, reducing the rate of dispersion and increasing concentrations.
- Plume interactions with lee sides of terrain features; and
    - Regions of recirculation behind steep terrain features can rapidly force pollutants towards the ground culminating in elevated concentrations.
    - Releases into the lee of a hill in stable conditions can also be recirculated, resulting in increased ground level concentrations.
- Plume interactions within valleys.
    - Releases within steep valleys experience restricted lateral dispersion due to the valley sidewalls. During stable overnight conditions, inversion layers develop within the valley essentially trapping all emitted pollutants. Following sunrise and the erosion of the inversion, elevated ground level concentrations can result during fumigation events.
    - Convective circulations in complex terrain due to differential heating of the valley side walls can lead to the impingement of plumes due to crossflow onto the valley sidewalls and the subsidence of plume centrelines, both having the impact of increasing ground level concentrations.

These effects are most pronounced when the terrain gradients exceed 1 in 10, i.e., a 100 m change in elevation per 1 km step in the horizontal plane. In the model domain the terrain around the site does not exceed this criterion and terrain has therefore been excluded within the model.

2.6 Modelled Domain and Receptors

2.6.1 Modelled Domain

A 2 km x 2 km Cartesian grid centred on the site was modelled, with an approximate receptor resolution of 10 m, to assess the impact of atmospheric emissions from the site on local air quality. This grid resolution has been selected to ensure that all local receptors are within the gridded area and the resolution is such that the maximum impact will be identified.

2.6.2 Human Receptors

The receptors considered were chosen based on locations where people may be located and judged in terms of the likely duration of their exposure to pollutants and proximity to the site, following the guidance given in Section 4 of this report. Details of the locations of human receptors

are given in Table 2.6 and illustrated Figure 2.7 below. Human receptors have been modelled at a height of 1.5 m, representative of the normal 'breathing zone' height.

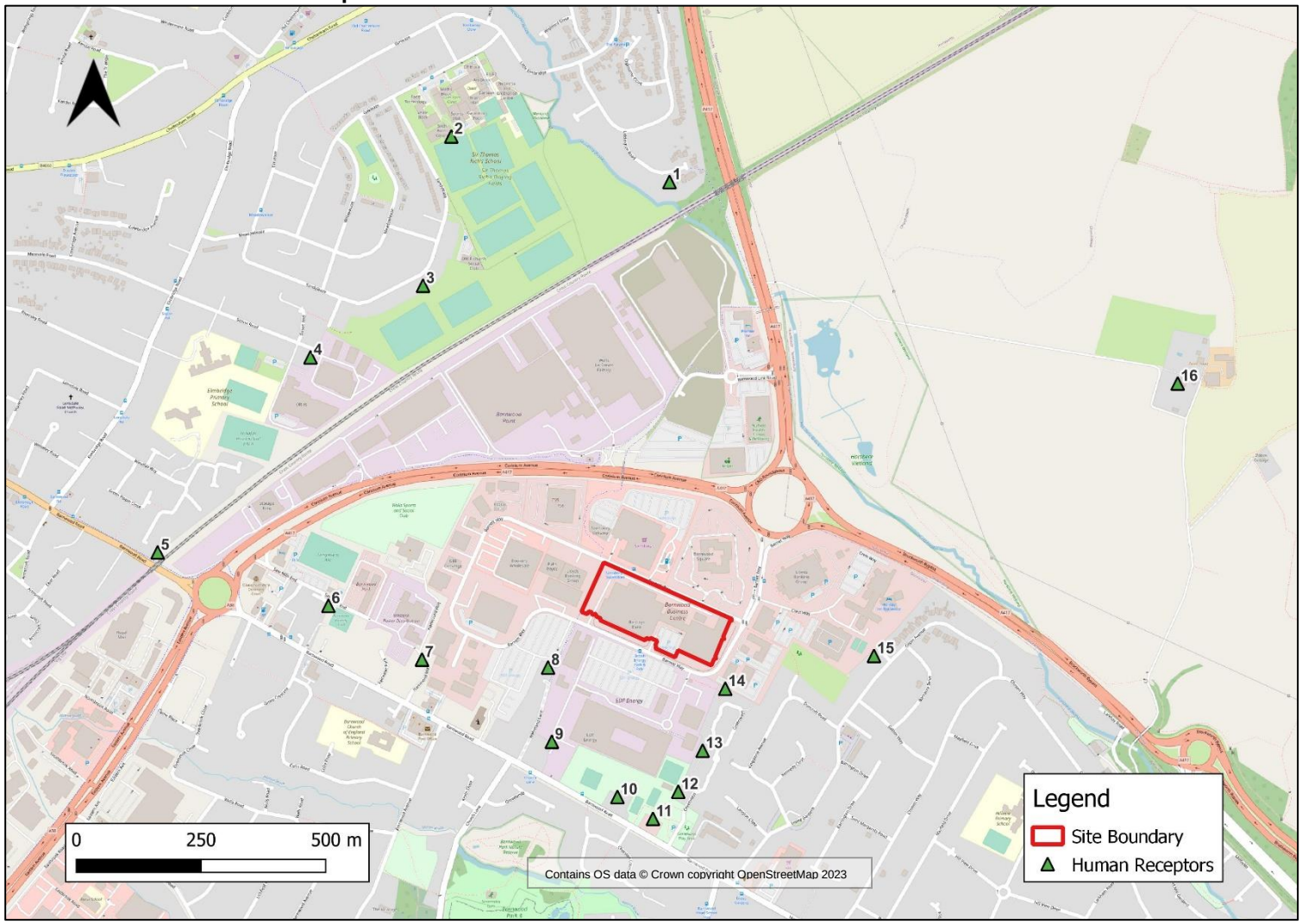
The majority of human receptors are locations where both long-term and short-term pollutant averaging periods will apply (see Table 4.2).

Workplace locations have been excluded in accordance with the guidance from Environmental Protection UK and the Air Quality Standards Regulations 2010. These guidance documents are detailed in Section 4 of this report.

Table 2.6 - Modelled Human Receptors

ID	Receptor Description	Easting (m)	Northing (m)	Height (m)
H1	Residential	386342	219243	1.5
H2	School	385904	219334	1.5
H3	Residential	385848	219035	1.5
H4	Residential	385622	218891	1.5
H5	Residential	385316	218501	1.5
H6	Residential	385658	218394	1.5
H7	Residential	385846	218286	1.5
H8	Residential	386099	218270	1.5
H9	Residential	386106	218121	1.5
H10	Residential	386238	218011	1.5
H11	Residential	386309	217967	1.5
H12	Residential	386359	218021	1.5
H13	Residential	386408	218103	1.5
H14	Residential	386454	218227	1.5
H15	Residential	386752	218293	1.5
H16	Residential	387361	218839	1.5

Figure 2.7 - Location of Modelled Human Receptors



2.6.3 Ecological Receptors

The Environment Agency's AER Guidance provides the following detail regarding consideration of ecological receptors:

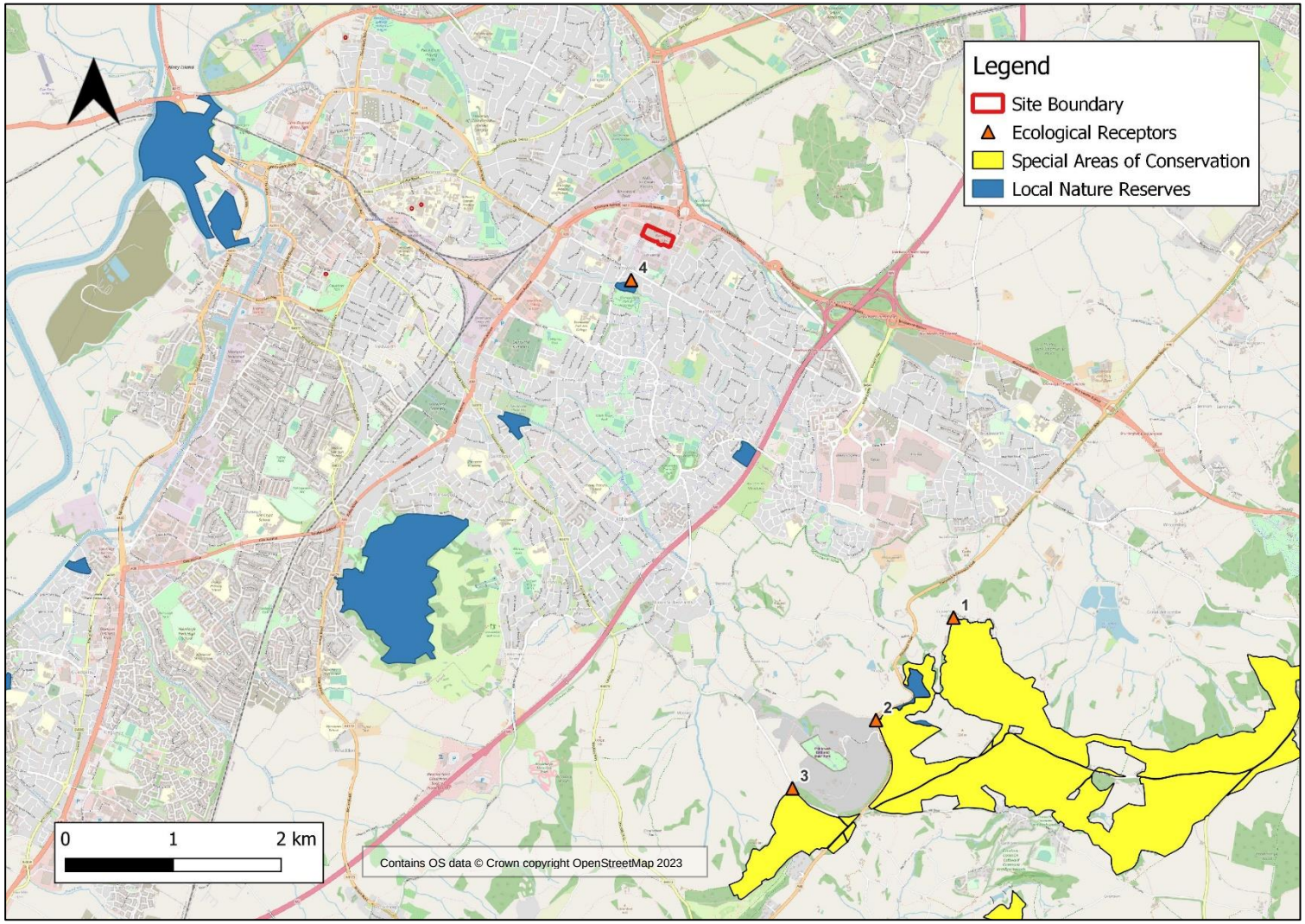
- Check if there are any of the following within 10 km of your site (within 15 km if you operate a large electric power station or refinery):
    - Special Protection Areas (SPAs)
    - Special Areas of Conservation (SACs)
    - Ramsar Sites (protected wetlands)
- Check if there are any of the following within 2 km of your site:
    - Sites of Special Scientific Interest (SSSIs)
    - Local Nature Sites (ancient woods, Local Wildlife Sites (LWS), Sites of Nature Conservation Importance (SNCIs) and national and Local Nature Reserves (LNR)).

Following the above guidance, Table 2.7 and Figure 2.8 provide details of four ecological receptor points which have been considered within this assessment.

Table 2.7 - Modelled Ecological Receptors

ID	Receptor Description	Easting (m)	Northing (m)	Height (m)
E1	Cotswold Beechwoods SAC	389055	214845	0
E2	Cotswold Beechwoods SAC	388336	213896	0
E3	Cotswold Beechwoods SAC	387562	213264	0
E4	Barnwood Arboretum LNR	386068	217970	0

Figure 2.8 - Location of Assessed Ecological Receptors



2.7 Deposition

The predominant route by which emissions to air will affect land in the vicinity of a process is by deposition of atmospheric emissions. Potential ecological receptors can be sensitive to the deposition of pollutants, particularly nitrogen and sulphur compounds, which can affect the character of the habitat through eutrophication and acidification.

Deposition processes in the form of dry and wet deposition remove material from a plume and alter the plume concentration. Dry deposition occurs when particles are brought to the surface by gravitational settling and turbulence. They are then removed from the atmosphere by deposition on the land surface. Wet deposition occurs due to rainout (within cloud) scavenging and washout (below cloud) scavenging of the material in the plume. These processes lead to a variation with downwind distance of the plume strength and may alter the shape of the vertical concentration profile as dry deposition only occurs at the surface.

Near to sources of pollutants (< 2 km), dry deposition is the predominant removal mechanism (Fangmeier et al. 1994). Dry deposition may be quantified from the near-surface plume concentration and the deposition velocity (Chamberlin and Chadwick, 1953);

$$F_d = v_d C(x, y, 0)$$

where:

F_d = dry deposition flux (µg m^{-2} s^{-1})

v_d = deposition velocity (m s^{-1})

$C(x, y, 0)$ = ground level concentration (µg/m^3)

Assuming irreversible uptake, the total wet deposition rate is found by integrating through a vertical column of air;

$$F_w = \int_0^z \Lambda C \, dz$$

where;

F_w = wet deposition flux (µg m^{-2} s^{-1})

Λ = washout co-efficient (s^{-1})

C = local airborne concentration (µg/m^3)

z = height (m)

The washout co-efficient is an intrinsic function of the rate of rainfall.

Environment Agency guidance AQTAG06 (Environment Agency, 2014) recommends deposition velocities for various pollutants, according to land use classification (Table 2.8).

Table 2.8 - Recommended Deposition Velocities

Pollutant	Deposition Velocity (m s^{-1})	
	Short Vegetation	Long Vegetation/Forest
NO_x	0.0015	0.003
SO_2	0.012	0.024

Source: Environment Agency (2014) 'Technical Guidance on Detailed Modelling Approach for an Appropriate Assessment for Emissions to Air', AQTAG06 Updated Version (March 2014)'

In order to assess the impacts of deposition, habitat-specific critical loads and critical levels have been created. These are generally defined as (e.g. Nilsson and Grennfelt, 1988):

> *"a quantitative estimate of exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge"*

It is important to distinguish between a critical load and a critical level. The critical load relates to the quantity of a material deposited from air to the ground, whilst critical levels refer to the concentration of a material in air. The UK Air Pollution Information System (APIS) provides critical load data for ecological sites in the UK.

The critical loads used to assess the impact of compounds deposited to land which result in eutrophication and acidification are expressed in terms of kilograms of nitrogen deposited per hectare per year (kg N ha^{-1} y^{-1}) and kilo equivalents deposited per hectare per year (keq ha^{-1} y^{-1}). To enable a direct comparison against the critical loads, the modelled total wet and dry deposition flux (µg m^{-2} s^{-1}) must be converted into an equivalent value.

For a continuous release, the annual deposition flux of nitrogen can be expressed as:

$$F_{NTot} = \left(\frac{K_2}{K_3}\right) \cdot t \cdot \sum_{i=1}^{T} F_i \left(\frac{M_N}{M_i}\right)$$

where:

F_{NYot} = Annual deposition flux of nitrogen (kg N ha^{-1} y^{-1})

K_2 = Conversion factor for m^2 to ha (= 1x104 m^2 ha^{-1})

K_3 = Conversion factor for µg to kg (= 1x109 µg kg^{-1})

t = Number of seconds in a year (= 3.1536x107 s y^{-1})

i = 1,2,3…….T

T = Total number of nitrogen containing compounds

F = Modelled deposition flux of nitrogen containing compound (µg m^{-2} s^{-1})

M_N = Molecular mass of nitrogen (kg)

M = Molecular mass of nitrogen containing compound (kg)

The unit eq (1 keq ≡ 1,000 eq) refers to molar equivalent of potential acidity resulting from e.g. sulphur, oxidised and reduced nitrogen, as well as base cations. Conversion units are provided in AQTAG(06):

- 1 keq ha^{-1} y^{-1} = 14 kg N ha^{-1} y^{-1}
- 1 keq ha^{-1} y^{-1} = 32 kg S ha^{-1} y^{-1}

For the purposes of this assessment, dry deposition rates of nitrogen and acidic equivalents at the identified ecological receptors have been calculated by applying the 'long vegetation' deposition velocities (as detailed in Table 2.8) to the modelled annual mean concentrations of NO_x and SO_2. Wet deposition has not been assessed since this is not a significant contributor to total deposition over shorter ranges (Fangmeier et al., 1994; Environment Agency, 2006).

2.8 Other Treatments

Specialised model treatments, for short-term (puff) releases, coastal models, fluctuations or photochemistry were not used in this assessment.

2.9 Conversion of NO to NO_2

Emissions of NO_x from combustion processes are predominantly in the form of nitric oxide (NO). Excess oxygen in the combustion gases and further atmospheric reactions cause the oxidation of NO to NO_2. NO_x chemistry in the lower troposphere is strongly interlinked in a complex chain of reactions involving Volatile Organic Compounds (VOCs) and Ozone (O_3). Two of the key reactions interlinking NO and NO_2 are detailed below:

$$NO_2 + hv \xrightarrow{O_2} NO + O_3 \qquad (R_1)$$

$$NO + O_3 \longrightarrow NO_2 + O_2 \qquad (R_2)$$

Where *hv* is used to represent a photon of light energy (i.e., sunlight).

Taken together, reactions R_1 and R_2 produce no net change in O_3 concentrations, and NO and NO_2 adjust to establish a near steady state reaction (photo-equilibrium). However, the presence of VOCs and CO in the atmosphere offer an alternative production route of NO_2 for photolysis, allowing O_3 concentrations to increase during the day with a subsequent decrease in the NO_2:NO_x ratio.

However, at night, the photolysis of NO_2 ceases, allowing reaction R_2 to promote the production of NO_2, at the expense of O_3, with a corresponding increase in the NO_2:NO_x ratio. Similarly, near to an emission source of NO, the result is a net increase in the rate of reaction R_2, suppressing O_3 concentrations immediately downwind of the source, and increasing further downwind as the concentrations of NO begin to stabilise to typical background levels (Gillani and Pliem, 1996).

Given the complex nature of NO_x chemistry, the Environment Agency's Air Quality Modelling and Assessment Unit (AQMAU) have adopted a pragmatic, risk-based approach in determining the conversion rate of NO to NO_2 which dispersion model practitioners can use in their detailed assessments[1]. The AQMAU guidance advises that the source term should be modelled as NO_x (as NO_2) and then suggests a tiered approach when considering ambient NO_2:NO_x ratios:

- **Screening Scenario:** 50 % and 100 % of the modelled NO_x process contributions should be used for short-term and long-term average concentration, respectively. That is, 50 % of the predicted NO_x concentrations should be assumed to be NO_2 for short-term assessments

[1] http://www.environment-agency.gov.uk/static/documents/Conversion_ratios_for__NOx_and_NO2_.pdf

and 100 % of the predicted NO_x concentrations should be assumed to be NO_2 for long-term assessments;

- **Worst Case Scenario:** 35 % and 70 % of the modelled NO_x process contributions should be used for short-term and long-term average concentration, respectively. That is, 35 % of the predicted NO_x concentrations should be assumed to be NO_2 for short-term assessments and 70 % of the predicted NO_x concentrations should be assumed to be NO_2 for long-term assessments; and

- **Case Specific Scenario:** Operators are asked to justify their use of percentages lower than 35 % for short-term and 70 % for long-term assessments in their application reports.

In line with the AQMAU guidance, this assessment has therefore used a NO_x to NO_2 ratio of 70% for long term average concentrations, 35% for short term concentrations.

3 Existing Ambient Data

3.1 Local Air Quality Management

Gloucester City Council ("the Council") under its Local Air Quality Management (LAQM) obligations, continually reviews and assesses concentrations of key air pollutants in the borough to ascertain the requirement, or otherwise, to declare an AQMA.

Due to the historical trend of high pollution levels, the Council have declared three AQMAs within its jurisdiction. Gloucester data centre is located approximately 2.2 km from the closest AQMA boundary, which is declared with respect to exceedances of annual mean NO_2 concentrations.

The most recent publicly available monitoring data has been collated from the Council's Air Quality 2021 Annual Status Report[2], which contains monitoring data for 2020.

3.1.1 Monitoring Data

The Council did not undertake any automatic (continuous) monitoring of pollutants during 2020. However, the Council operated 18 non-automatic (passive) monitoring locations in 2020, of which three are within 1.5 km of the Gloucester data centre. Table 3.1 contains the annual mean NO_2 concentration results for the diffusion tubes sites within 1.5 km of the site, for the years 2018 to 2020.

Table 3.1 - NO_2 Diffusion Tube Monitoring Results

Site Name	X	Y	Site Type	Annual Mean Concentration ($\mu g/m^3$)		
				2018	2019	2020
19: 61 Barnwood Road	385130	218585	Roadside	35.4	34.1	25.8
20: 53 Barnwood Road	385113	218595	Roadside	33.0	34.7	24.8
21: Elmbridge Road	385430	218870	Urban Background	17.5	17.7	17.2
N.B. Data taken from Council's 2021 Annual Status Report.						

Current monitoring results show that recent and current concentrations of NO_2 in the area local to the Gloucester site are comfortably compliant with the annual mean NO_2 Air Quality Strategy objective.

3.2 Defra Mapped Background Concentrations

Defra maintains a nationwide model of existing and future background air quality concentrations at a 1 km grid square resolution. The datasets include annual average concentration estimates for NO_x, NO_2, PM_{10}, $PM_{2.5}$, CO and SO_2 and benzene. The model used is empirical in nature: it uses the National Atmospheric Emissions Inventory (NAEI) emissions to model the concentrations of pollutants at the centroid of each 1 km grid square but then calibrates these concentrations in relation to actual monitoring data.

[2] https://www.gloucester.gov.uk/media/5662/gloucester_asr_2021_i1.pdf

3.2.1 Background Concentrations used in the Assessment

Annual mean background concentrations at the assessed human and ecological receptor locations have been derived from the Defra background maps for the 1 km grid square in which they are located.

The annual average process contribution is added to the annual average background concentration to give a total concentration at each receptor location. This total concentration can then be compared against the relevant Air Quality Standard/Objective (AQS/O) and the likelihood of an exceedance determined.

It is not technically rigorous to add predicted short-term or percentile concentrations to ambient background concentrations not measured over the same averaging period, since peak contributions from different sources would not necessarily coincide in time or location. Without hourly ambient background monitoring data available it is difficult to make an assessment against the achievement or otherwise of the short-term AQS/O. For the current assessment, conservative short-term ambient levels have been derived by applying a factor of two to the annual mean background data as per the recommendation in Environment Agency guidance. Those background annual mean concentrations used in the assessment are detailed in Table 3.2.

Table 3.2 - Background Annual Mean Concentrations used in the Assessment

Grid square (E, N)	2023 Annual Mean Pollutant Concentrations (µg/m^3)					
	NO_x [a]	NO_2 [a]	PM_{10} [a]	$PM_{2.5}$ [a]	CO [b]	SO_2 [b]
385500, 218500	19.13	13.99	13.64	9.33	369	2.63
384500, 218500	17.60	12.99	13.46	9.20	373	2.42
385500, 217500	15.48	11.59	13.57	9.36	367	2.34
386500, 217500	13.50	10.26	13.30	9.17	343	2.63
388500, 214500	8.67	6.80	11.72	7.67	280	1.96
385500, 216500	12.35	9.46	13.38	9.25	265	1.87
387500, 212500	8.40	6.61	11.47	7.57	276	1.94

[a] 2018 annual mean background concentration of NO_2, NO_x, PM_{10} and $PM_{2.5}$ taken from Defra's UK Air Quality Archive (1 km x 1 km grid squares).

[b] Background concentration of SO_2 taken from Defra's UK Air Quality Archive (1 km x 1 km grid squares) 2001 background maps.

3.3 Background Deposition Rates

Estimated background deposition rates of nutrient nitrogen and total acid deposition for the UK are available via the Air Pollution Information Service (APIS) website (http://www.apis.ac.uk). Table 3.3 provides estimated deposition rates for the ecological receptors considered in this study, as obtained from the APIS website. It should be noted that the level of uncertainty associated with these modelled estimates is relatively high and the results are presented from the model across the UK on a 5 km grid square resolution.

Table 3.3 - Estimated Background Deposition Rates

ID	Background Nitrogen Deposition (kg N ha^{-1} y^{-1})	Background Nitric Acid Deposition (keq ha^{-1} y^{-1})	Background Sulphuric Acid Deposition (keq ha^{-1} y^{-1})
E1	34.90	2.41	0.20
E2	34.90	2.41	0.20
E3	34.90	2.41	0.20
E4	18.06	1.29	0.15

Source: Air Pollution Information Service (APIS) website (http://www.apis.ac.uk)

3.4 Sensitivity Analysis and Uncertainty

Wherever possible, this assessment has used worst-case scenarios, which will exaggerate the impact of the emissions on the surrounding area, including emissions, operational profile, ambient concentrations, meteorology and surface roughness. This assessment has considered the years predicting the highest ground-level concentrations at the nearest sensitive receptor for comparison with the AQS objectives.

Sensitivity analysis has been undertaken for a number of model input parameters to investigate the results of the model with respect to changes in buildings and surface roughness.

3.4.1 Buildings

A sensitivity analysis has been undertaken to investigate the impact of modelling with and without buildings on the modelled results. Results have been normalised by the value obtained from the parameter resulting in the highest ground level process contribution at any modelled receptor location and are presented in Table 3.4.

Table 3.4 - Building Inclusion Sensitivity Analysis

Buildings	Normalised Maximum Ground Level Concentration	
	NO_x Annual Mean	NO_x 99.79 Percentile of 1-Hour Mean
With Buildings	1.00	1.00
Without Buildings	1.00	0.82

From the above predicted ground level concentrations, the inclusion of buildings in the model results in higher or similar concentrations for both averaging periods. The model therefore used in this assessment included buildings in order to demonstrate a robust assessment.

3.4.2 Surface Roughness

A sensitivity analysis has been undertaken to investigate the impact of modelling with different surface roughness lengths. Results have been normalised by the value obtained from the parameter resulting in the highest ground level process contribution at any modelled receptor location and are presented below.

Table 3.5 – Surface Roughness Sensitivity Analysis

Parameter	Normalised Maximum Ground Level Concentration	
	NO_x Annual Mean	NO_x 99.79 Percentile of 1-Hour Mean
0.3 m	0.84	1.00
0.5 m	0.90	1.00
1 m	1.00	0.98
1.5 m	1.00	1.00

From the above predicted ground level concentrations, it can be seen that for the annual mean averaging period, a surface roughness of 1.5 m results in the highest results. However, for the 1-hour mean, a surface roughness length of 0.5 m predicts the highest result.

Given the characteristics of the surface roughness at the site, a surface roughness value of 1 m has been used.

3.4.3 Meteorological Year Sensitivity Testing

Results in this assessment are presented for the meteorological year resulting in the highest concentrations at any receptor location, as a worst-case assumption. The worst-case meteorological year was determined separately for long and short-term concentrations at the worst-case receptor location for each pollutant, thus the worst-case data has been reported within Section 5.

For information, a table showing the inter-year variability of met conditions at the worst-case human receptor is provided below. The results have been normalised against the maximum value. At the worst-case human receptor, it demonstrates that 2018 and 2021 provide the worst-case conditions for long-term and short-term means, respectively. However, this can vary by receptor, hence the consideration of the worst-case meteorological year by receptor, as described above.

Table 3.6 - Inter-year Variability in Concentration (Normalised)

Receptor	Annual Mean NOx					1-hour Mean NOx				
	2018	2019	2020	2021	2022	2018	2019	2020	2021	2022
H14	1.00	0.94	0.95	0.95	0.82	0.97	1.00	0.99	1.00	0.98

3.4.4 Model Uncertainty

Dispersion modelling is inherently uncertain but is nonetheless a useful tool in plume footprint visualisation and prediction of ground level concentrations. The use of dispersion models has been widely used in the UK for both regulatory and compliance purposes for a number of years and is an accepted approach for this type of assessment.

In addition to all available input data. this assessment has incorporated a number of worst-case assumptions, as described above, which may result in an overestimation of the predicted ground level concentrations from the process. Therefore, the actual predicted ground level concentrations would be expected to be lower than this and, in some cases, significantly lower.

4 Relevant Legislation and Guidance

4.1 UK Legislation

4.1.1 The Air Quality Standards Regulations 2010

The Air Quality Standards Regulations 2010 (the 'Regulations') came into force on the 11th June 2010 and transpose EU Directive 2008/50/EC into UK legislation. The Directive's limit values are transposed into the Regulations as 'Air Quality Standards' (AQS) with attainment dates in line with the Directive.

These standards are legally binding concentrations of pollutants in the atmosphere which can broadly be taken to achieve a certain level of environmental quality. The standards are based on the assessment of the effects of each pollutant on human health including the effects of sensitive groups or on ecosystems.

Similar to Directive 2008/50/EC, the Regulations define ambient air as;

> *"…outdoor air in the troposphere, excluding workplaces where members of the public do not have regular access."*

With direction provided in Schedule 1, Part 1, Paragraph 2 as to where compliance with the AQS' does not need to be assessed:

> *"Compliance with the limit values directed at the protection of human health does not need to be assessed at the following locations:*
>
> *a) any location situated within areas where members of the public do not have access and there is no fixed habitation;*
>
> *b) on factory premises or at industrial locations to which all relevant provisions concerning health and safety at work apply;*
>
> *c) on the carriageway of roads and on the central reservation of roads except where there is normally pedestrian access to the central reservation."*

4.1.2 The Air Quality Strategy for England, Scotland, Wales and Northern Ireland

The 2007 Air Quality Strategy for England, Scotland Wales and Northern Ireland provides a framework for improving air quality at a national and local level and supersedes the previous strategy published in 2000.

Central to the Air Quality Strategy are health-based criteria for certain air pollutants; these criteria are based on medical and scientific reports on how and at what concentration each pollutant affects human health. The objectives derived from these criteria are policy targets often expressed as a maximum ambient concentration not to be exceeded, without exception or with a permitted number of exceedances, within a specified timescale. Paragraph 22 of the 2007 Air Quality Strategy, states that the objectives are:

> *"…a statement of policy intentions or policy targets. As such, there is no legal requirement to meet these objectives except where they mirror any equivalent legally binding limit values…"*

The AQOs, based on a selection of the objectives in the Air Quality Strategy, were incorporated into UK legislation through the Air Quality Regulations 2000, as amended.

Paragraph 4(2) of The Air Quality (England) Regulations 2000 states:

"The achievement or likely achievement of an air quality objective prescribed by paragraph (1) shall be determined by reference to the quality of air at locations –

a) which are situated outside of buildings or other natural or man-made structures above or below ground; and

b) where members of the public are regularly present

Consequently, compliance with the AQOs should focus on areas where members of the general public are present over the entire duration of the concentration averaging period specific to the relevant objective.

4.1.3 Environment Act 2021

The Environment Act 2021 came into force on 9th November 2021, with Part 4 of the Act (and associated Schedules 11 and 12) reserved for matters pertaining to air quality.

The Environment Act 2021 includes amendments to Environment Act 1995 (further detail in Section 4.2) the Clean Air Act 1993 to give Local Authorities more power. It also requires the Secretary of State to set at least one long-term target in relation to air quality and, in addition, a short-term legally binding target to reduce $PM_{2.5}$.

4.2 Local Air Quality Management

Part IV of the Environment Act 1995 requires that Local Authorities periodically review air quality within their individual areas. As previously discussed, this Act has now been amended and supplemented by the Environment Act 2021 Schedule 11. Defra have said: "Responsibility for tackling local air pollution will now be shared with designated relevant public authorities, all tiers of local government and neighbouring authorities."

This process of Local Air Quality Management (LAQM) is an integral part of delivering the Government's AQOs.

To carry out an air quality Review and Assessment under the LAQM process, the Government recommends a three-stage approach. This phased review process uses initial simple screening methods and progresses through to more detailed assessment methods of modelling and monitoring in areas identified to be at potential risk of exceeding the objectives in the Regulations.

Review and assessments of local air quality aim to identify areas where national policies to reduce vehicle and industrial emissions are unlikely to result in air quality meeting the Government's AQOs by the required dates.

For the purposes of determining the focus of Review and Assessment, Local Authorities should have regard to those locations where members of the public are likely to be regularly present and are likely to be exposed over the averaging period of the objective.

Where the assessment indicates that some or all of the objectives may be potentially exceeded, the Local Authority has a duty to declare an AQMA. The declaration of an AQMA requires the Local Authority to implement an Air Quality Action Plan (AQAP), to reduce air pollution concentrations so that the required AQOs are met.

4.3 Other Guideline Values

In the absence of statutory standards for the other prescribed substances that may be found in the emissions, there are several sources of applicable air quality guidelines.

4.3.1 Air Quality Guidelines for Europe, the World Health Organisation (WHO)

The updated WHO Global Air Quality Guidelines (WHO, 2021) provides a basis for protecting public health from adverse effects of air pollutants and to eliminate or reduce exposure to those pollutants that are known or likely to be hazardous to human health or well-being. These guidelines are intended to provide guidance and information to international, national and local authorities making risk management decisions, particularly in setting air quality standards.

4.3.2 Environmental Assessment Levels (EALs)

The Environment Agency's AER Guidance provides methods for quantifying the environmental impacts of emissions to all media. The AER guidance contains long and short-term Environmental Assessment Levels (EALs) and Environmental Quality Standards (EQS) for releases to air derived from a number of published UK and international sources. For the pollutants considered in this study, these EALs and EQS are equivalent to the AQS and AQOs set in force by the Air Quality Strategy for England, Scotland Wales and Northern Ireland.

4.4 Air Quality Impacts of the Process

The atmospheric emissions of a number of pollutants have been identified as requiring detailed dispersion modelling. The emitted pollutants of primary concern to the local environment are:

- Oxides of nitrogen (NO_x as NO_2);
- Carbon monoxide (CO);
- Particulate matter (PM_{10} and $PM_{2.5}$); and
- Sulphur dioxide (SO_2).

A brief description of each pollutant is given in Table 4.1.

Table 4.1 - Summary of the Pollutants Assessed

Pollutant	Description and effect on human health and the environment	Principal Sources
Oxides of Nitrogen (NO_X) [A, B, C]	Nitrogen dioxide (NO_2) and Nitric oxide (NO) are both collectively referred to as oxides of Nitrogen (NO_X). It is NO_2 that is associated with adverse effects on human health. Most atmospheric emissions are in the form of NO which is converted to NO_2 in the atmosphere through reactions with Ozone. The oxidising properties of NO_2 theoretically could damage lung tissue, and exposure to very high concentrations of NO_2 can lead to inflammation of lung tissue, affect the ability to fight infection. The greatest impact of NO_2 is on individuals with asthma or other respiratory conditions, but consistent impacts on these individuals is at levels of greater than 564 µg/m^3, much higher than typical UK ambient concentrations.	All combustion processes produce NO_X emissions, and the principal source of NO_X is road transport, which accounted for 32% of total UK emissions in 2008. Emissions from power stations contributed a further 20%.
Carbon Monoxide (CO) [B, C]	The toxicity of CO results in it binding avidly to haemoglobin and thus reducing the oxygen-carrying capacity of the blood. In very high doses, the restriction of oxygen to the brain and heart can be fatal. At lower concentrations, CO can affect higher cerebral function, heart function and exercise capacity.	The principal source of CO is emissions from petrol vehicles, accounting for 54% of total UK emissions in 2008.
Particulate Matter (PM_{10} and $PM_{2.5}$) [D,F]	Particulate matter is the term used to describe all suspended solid matter. Particulate matter with an aerodynamic diameter of less than 10 µm (PM_{10}) is the subject of health concerns because of its ability to penetrate and remain deep within the lungs. The health effects of particles are difficult to assess, and evidence is mainly based on epidemiological studies. Evidence suggests that there may be associations between increased PM_{10} concentrations and increased mortality and morbidity rates, changes in symptoms or lung function, episodes of hospitalisation or doctors consultations. Recent reviews by the World Health Organisation (WHO) and Committee on the Medical Effects of Air Pollutants (COMEAP) have suggested exposure to a finer fraction of particles ($PM_{2.5}$) give a stronger association with the observed health effects. $PM_{2.5}$ typically makes up around two-thirds of PM_{10} emissions and concentrations.	Road transport, industrial processes and electricity generation. Other pollutants, including NO_2 and SO_2, have the potential to form secondary particulates which are often smaller than PM_{10}.
Sulphur Dioxide (SO_2) [B]	At high concentrations SO_2 is a potent bronchoconstrictor, and asthmatic individuals are more susceptible. It is likely that SO_2 contributes to respiratory symptoms, reduced lung function and rises in hospital admissions. Exposure to high levels of SO_2 over a long period can result in structural changes in the lungs and may enhance sensitisation to allergens.	The principal source of SO_2 is the combustion of fossil fuels containing sulphur and, in the UK, this is primarily through the combustion of coal in power stations, oil refining and solid fuel manufacturing, accounting for 57% of total UK SO_2 emissions in 2008.

A	Defra, 2021, Part IV of the Environment Act 1995 Local Air Quality Management: Technical Guidance LAQM.TG(22).
B	Harrison, R.M., *Air Pollution: Sources, Concentrations and Measurements*. In: Harrison, R.M., 2000, *Pollution: Causes, Effects and Controls*, 4th Edition Royal Society of Chemistry.
C	Walters, S. and Ayers, J., *The Health Effects of Air Pollution*. In: Harrison, R.M., 2000, *Pollution: Causes, Effects and Controls*, 4th Edition Royal Society of Chemistry.
D	Defra, 2007, The Air Quality Strategy for England, Scotland, Wales and Northern Ireland

4.5 Criteria Appropriate to the Assessment

Table 4.2 sets out those AQS, AQOs and EALs that are relevant to the assessment with regard to human receptors.

Table 4.2 - Air Quality Standards, Objectives and Environmental Assessment Levels

Pollutant	AQS/AQO/ EAL	Averaging Period	Value (µg/m^3)
Nitrogen dioxide (NO_2)	AQS	Annual mean	40
	AQS	1-hour mean, not more than 18 Exceedances a year (equivalent of 99.79 Percentile)	200
Carbon monoxide (CO)	AQS	8-hour mean	10,000
	EAL	1-hour mean	30,000
PM_{10}	AQS	Annual mean	40
	AQS	24-hour mean, not more than 35 Exceedances per year (90.41 percentile)	50
$PM_{2.5}$	AQS	Annual mean	25
Sulphur dioxide (SO_2)	AQS	1-hour mean not to be exceeded more than 24 times a year (equivalent to 99.73 percentile)	350
	AQS	24-hour mean, not to be exceeded more than 3 times a year (equivalent to 99.18 percentile)	125
	AQO	15-min mean, not to be exceeded more than 35 times a year (equivalent to 99.9 percentile)	266

4.6 Critical Levels and Critical Loads Relevant to the Assessment of Ecological Receptors

A summary of the relevant AQS and EAL that apply to the emissions from the plant and their impact on ecological receptors are given in Table 4.3.

Table 4.3 - Relevant Air Quality Standards and Environmental Assessment Levels for Ecological Receptors

Pollutant	AQS/EAL	Averaging Period	Value (µg/m^3)
Oxides of nitrogen (NO_x)	AQS	Annual mean	30
Oxides of nitrogen (NO_x)	Target	Daily mean	75
	WHO Assessment Level	Daily mean	200*
Sulphur dioxide (SO_2)	AQS	Annual mean	20
*Where O_3 and SO_2 are not present above their respective critical levels.			

The Air Pollution Information System (APIS) website[3] provides specific information on the potential effects of nitrogen deposition on various habitats and species. This information, relevant to habitats of some of the ecological receptors considered in this assessment, is presented in Table 4.4.

Table 4.4 - Typical Habitat and Species Information Concerning Nitrogen Deposition from APIS

Habitat and Species Specific Information	Critical Load (kg N ha^{-1} yr^{-1})	Specific Information Concerning Nitrogen Deposition
Saltmarsh	30-40	Many saltmarshes receive large nutrient loadings from river and tidal inputs. It is unknown whether other types of species-rich saltmarsh would be sensitive to nitrogen deposition. Increase in late-successional species, increased productivity but only limited information available for this type of habitat.
Littoral Sediments	20 - 30	Increase late successional species, increase productivity increase in dominance of graminoids.
Coastal Stable Dune Grasslands	10-20	Foredunes receive naturally high nitrogen inputs. Key concerns of the deposition of nitrogen in these habitats relate to changes in species composition.
Alkaline Fens and Reed beds	10-35	Nitrogen deposition provides fertilization. Increase in tall graminoids (grasses or Carex species) resulting in loss of rare species and decrease in diversity of subordinate plant species.
Temperate and boreal forests	10-20	Increased nitrogen deposition in mixed forests increases susceptibility to secondary stresses such as drought and frost, can cause reduced crown growth. Also can reduce the diversity of species due to increased growth rates of more robust plants.
Hay Meadow	20-30	The key concerns are related to changes in species composition following enhanced nitrogen deposition. Indigenous species will have evolved under conditions of low nitrogen availability. Enhanced Nitrogen deposition will favour those species that can increase their growth rates and competitive status e.g. rough grasses such as false brome grass (Brachypodium pinnatum) at the expense of overall species diversity. The overall threat from competition will also depend on the availability of propagules
Acid Grasslands	10-25	Nitrogen deposition provides fertilization to acid grasslands, this increase robust grass growth that may limit other species reducing diversity.
Raised bog and blanket bog	5-10	Nitrogen deposition provides fertilization, this increase robust vegetation growth that may limit other species reducing diversity
Oak Woodland	10-15	Increased nitrogen deposition in Oak forests increases susceptibility to secondary stresses such as drought and frost, can cause reduced crown growth

Information relating specifically to acid deposition is provided using three critical load parameters:

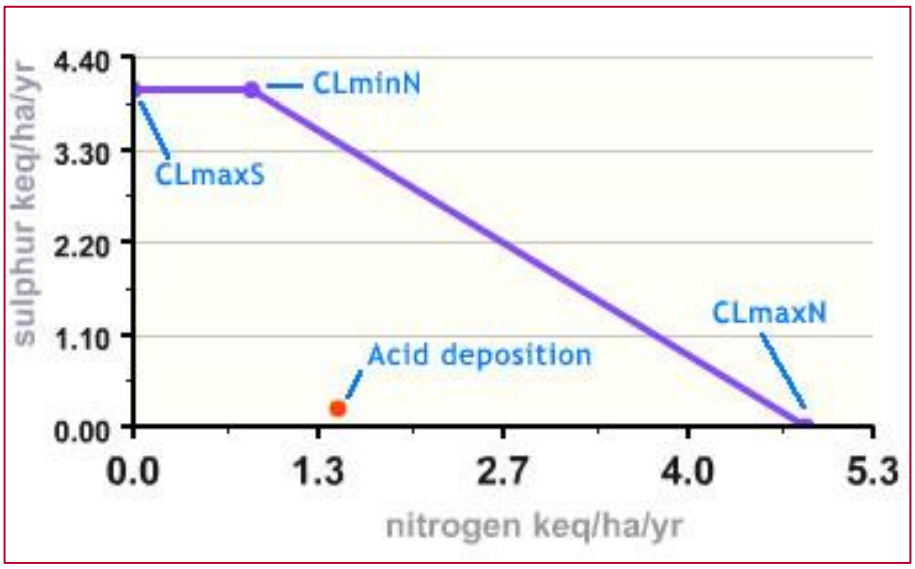
- $CL_{max}S$: the maximum critical load of sulphur, above which sulphur alone would be considered to cause an exceedance;
- $CL_{min}N$: a measure of the ability of the habitat/ecosystem to 'consume' deposited nitrogen; and

[3] http://www.apis.ac.uk/

- $CL_{max}N$: the maximum critical load of nitrogen, above which nitrogen alone would be considered to cause an exceedance.

These three parameters define the critical load function, as illustrated in Figure 4.1. The region under the three-node line represents results where critical loads are not exceeded, whereas combinations of deposition above this line would be considered an exceedance.

Figure 4.1 - Critical Load Function (sourced from APIS)



Source: http://www.apis.ac.uk/clf-guidance

5 Assessment Results

This section sets out the results of the dispersion modelling and compares predicted ground level concentrations to ambient air quality standards. The predicted concentrations resulting from the process are presented with background concentrations and the percentage contribution that the predicted environmental concentrations would make towards the relevant Air Quality Assessment Level (AQAL), i.e., the relevant Air Quality Standard or Objective (AQS/AQO) or Environmental Assessment Level (EAL).

For reference, the scenarios assessed are detailed in Table 5.1.

Table 5.1 – Scenarios Assessed

Scenario No.	Scenario Name	Operations
1	Maintenance Testing of A&B Block	Four generators tested twice a year, each test is one hour per generator, total 8 hours running annually.
2	On load Testing of A&B Block	Onload testing is twice a year, three gens are tested in each test for four hours, totalling 8 hours annually.
3	Maintenance Testing of C Block	Six generators are tested twice a year. Each gen is run for 1 hour, totalling 12 hours annually.
4	On load Testing of C Block	Onload testing is twice a year, all six gens are run for 4 hours in each test, totalling 8 hours annually.
5	Emergency Operation	All generators run and all boilers run, as a worst-case.

Results are presented for the meteorological year resulting in the highest concentrations at any receptor location, as a worst-case assumption. Results that exceed the relevant AQAL are underlined within the results tables.

5.1 Model Results for Annual Mean Metrics

Results assessed against annual mean metrics for NO_x, NO_2, PM_{10}, $PM_{2.5}$ and SO_2 need to take account total annual running hours for each Scenario, as they can all take place over the corresponding proportion of the year.

As such, results for annual mean metrics have been presented separately to short-term metrics, taking account of the cumulative annual operating hours across the five operating scenarios. Summary results are presented in Table 5.2 for the worst-case receptor for each parameter and are inclusive of Scenarios 1, 2, 3 and 4. Full results tables are contained in Appendix C.

The annual operating hours for the generators in each scenario were as follows:

- Scenario 1: total generator hours = 8 hours across four generators. Therefore, annual factor per gen: 2/8760 = 0.00028.
- Scenario 2: total generator hours = 8 hours for three generators. Therefore, annual factor: 8/8760 = 0.00091.
- Scenario 3: total generator hours = 12 hours across six generators. Therefore, annual factor per gen: 2/8760=0.00023.
- Scenario 4: total generator hours = 8 hours for six generators. Therefore, annual factor: 8/8760 = 0.00091.

Annual results have therefore factored generator concentrations separately to the boilers, as per the factors above. These have then been summed to provide total annual mean results for the Site.

5.1.1 Concentrations in Air – All Scenarios

The summary results show that annual mean results for NO_2 and PM_{10} at human receptors and annual mean results for NO_x and SO_2 at ecological receptors are all comfortably below the relevant AQAL.

In terms of human receptors, the maximum long-term results were at receptor H16 (see Appendix C), located within 1.01 km of the site at Zoons Court Farmhouse. The maximum result at any ecological receptor (in terms of PEC) is predicted to occur at Barnwood Arboretum LNR, located 414 m south of the site.

Table 5.2 - Maximum Annual Mean Concentrations in Air at Human and Ecological Receptors – All Scenarios

Parameter	Annual Mean				
	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC OF AQAL	% PEC OF AQAL
Human Receptors					
Annual mean NO_2	40	0.04	14.43	0.1	36.1
Annual mean PM_{10}	40	<0.01	14.48	<0.01	36.2
Annual mean $PM_{2.5}$	50	<0.01	9.48	<0.1	19.0
Ecological Receptors					
Annual mean NO_x	30	0.16	12.51	0.5	41.7
Annual mean SO_2	20	<0.01	2.34	<0.1	11.7
AQAL = Air Quality Assessment Level PC = Process Contribution PEC = Predicted Environmental Concentration (PC + background)					

5.1.2 Deposition – All Scenarios

The impact assessment for ecological receptors also includes an assessment of pollutants deposited to land in the form of nitrogen deposition and acid deposition. These are also based on annual mean metrics, as such, these results are presented in full in Table 5.3 for nitrogen deposition and Table 5.4 for acid deposition.

The results for acid deposition are presented in line with the Critical Load Function Tool as contained on the Air Pollution Information System (APIS) website[4]. As described on APIS: "the Critical Load Function is a three-node line on a graph representing the acidity critical load. Combinations of deposition above this line would exceed the critical load, while all areas below or on the line represent an "envelope of protection" where critical loads are not exceeded". Therefore, where 'no exceedance' is stated with regards to acid deposition, it denotes no exceedance of the critical load function.

The results for nitrogen deposition show exceedances at all ecological receptors considered in the assessment. However, this is due to the background deposition rate at all receptors exceeding the minimum critical load (CL). When taking the PC, this makes up less than 1% of the overall result at all ecological receptors, so the contribution from the plant can be considered not significant. In the same manner, all results for acid deposition can be described as not significant.

[4] http://www.apis.ac.uk/critical-load-function-tool

Table 5.3 - Nitrogen Deposition Rates at Ecological Receptors – All Scenarios

Receptor ID	CL (kg N ha^{-1} yr^{-1})	PC (kg N ha^{-1} yr^{-1})	%PC of CL_{min} (%)	Background Deposition rate (kg N ha^{-1} yr^{-1})	PEDR (kg N ha^{-1} yr^{-1})	%PEDR of CL_{min}
E1	10	<0.01	<0.1	34.90	34.90	349.0
E2	10	<0.01	<0.1	34.90	34.90	349.0
E3	10	<0.01	<0.1	34.90	34.90	349.0
E4	10	0.02	<0.1	18.06	18.08	180.8

CL = Critical load – *the CL selected for each designated site relates to its most N-sensitive habitat (or a similar surrogate) listed on the site citation for which data on Critical Loads are available and is also based on a precautionary approach using professional judgement.*

PC = Process contribution

PEDR = Predicted environmental deposition rate (PC + background)

Table 5.4 - Acid Deposition Rates at Ecological Receptors

Receptor ID	PC	Background	PEC	PC (% of CL function)	Background (% of CL function)	PEC (% of CL function)	Impact
E1	<0.1	2.4	2.4	<0.1	94.3	94.3	Not significant
E2	<0.1	2.4	2.4	<0.1	94.3	94.3	Not significant
E3	<0.1	2.4	2.4	<0.1	94.3	94.3	Not significant
E4	<0.1	1.3	1.3	<0.1	29.2	29.2	Not significant

CL = Critical load
PEC = Predicted environmental concentration (PC + background)
No exceedance as per the output of the critical load function tool available on APIS

5.2 Short-term Model Results for Scenario 1 (A&B Block)

Table 5.5 details the results of the short-term impact assessment results for Scenario 1. The summary table provides the maximum result at any receptor for each pollutant and averaging period under Scenario 1 operating conditions. The full results are contained within Appendix C.

Table 5.5 - Short-term Results at Human and Ecological Receptors for Scenario 1

Parameter	Short-term Mean				
	AQAL µg/m^3	PC µg/m^3	PEC µg/m^3	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	47.51	70.69	23.8	35.3
90.41 percentile 24-hour mean PM_{10}	50	0.06	29.01	0.1	58.0
1-hour mean CO	30,000	47.53	781.53	0.2	2.6
8-hour mean CO	10,000	21.36	755.36	0.2	7.6
99.18 percentile 24-hour mean SO_2	125	0.01	5.27	0.0	4.2
99.73 percentile 1 hour mean SO_2	350	0.09	5.35	0.0	1.5
99.9 percentile 15-minute mean SO_2	266	0.10	5.36	0.0	2.0
Ecological Receptors					
24-hour mean NO_x	75	4.83	29.53	6.4	39.4

Table 5.5 indicates that the results of the short-term assessment metrics are below the relevant AQAL during Scenario 1 operations.

5.3 Short-term Model Results for Scenario 2 (A&B Block)

Table 5.6 detail the results of the short-term impact assessment results for Scenario 2 operations. The summary table provides the maximum result at any receptor for each pollutant and averaging period under Scenario 2 operating conditions. The full results are contained within Appendix C.

Table 5.6 - Short-term Results at Human and Ecological Receptors for Scenario 2

Parameter	Short-term Mean				
	AQAL µg/m^3	PC µg/m^3	PEC µg/m^3	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	140.66	163.85	70.3	81.9
90.41 percentile 24-hour mean PM_{10}	50	0.06	29.01	0.1	58.0
1-hour mean CO	30,000	141.74	875.74	0.5	2.9
8-hour mean CO	10,000	65.77	799.77	0.7	8.0
99.18 percentile 24-hour mean SO_2	125	0.02	5.28	0.0	4.2
99.73 percentile 1 hour mean SO_2	350	0.27	5.53	0.1	1.6

Parameter	Short-term Mean				
	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
99.9 percentile 15-minute mean SO_2	266	0.31	5.57	0.1	2.1
Ecological Receptors					
24-hour mean NO_x	75	15.54	40.23	20.7	53.6

The results indicate that the concentrations for the short-term assessment metrics are below the relevant AQAL.

5.4 Short-term Model Results for Scenario 3 (C Block)

Table 5.7 details the results of the short-term impact assessment results for Scenario 3 operations. The summary table provides the maximum result at any receptor for each pollutant and averaging period under Scenario 3 operating conditions. The full results are contained within Appendix C.

Table 5.7 - Short-term Results at Human and Ecological Receptors for Scenario 3

Parameter	Short-term Mean				
	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	32.35	55.53	16.2	27.8
90.41 percentile 24-hour mean PM_{10}	50	<0.01	14.47	<0.1	36.2
1-hour mean CO	30,000	37.71	771.71	0.1	2.6
8-hour mean CO	10,000	26.09	760.09	0.3	7.6
99.18 percentile 24-hour mean SO_2	125	<0.01	5.26	<0.1	4.2
99.73 percentile 1 hour mean SO_2	350	0.07	5.33	<0.1	1.5
99.9 percentile 15-minute mean SO_2	266	0.12	5.38	<0.1	2.0
Ecological Receptors					
24-hour mean NO_x	75	5.38	30.08	7.2	40.1

The results indicate that the concentrations for all short-term assessment metrics in Scenario 3 are below the relevant AQAL.

5.5 Short-term Model Results for Scenario 4 (C Block)

Table 5.8 details the results of the short-term impact assessment results for Scenario 4 operations. The summary table provides the maximum result at any receptor for each pollutant and averaging period under Scenario 4 operating conditions. The full results are contained within Appendix C.

Table 5.8 - Short-term Results at Human and Ecological Receptors for Scenario 4

Parameter	Short-term Mean				
	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	209.03	232.21	104.5	116.1
90.41 percentile 24-hour mean PM_{10}	50	0.11	29.06	0.2	58.1
1-hour mean CO	30,000	242.90	976.90	0.8	3.3
8-hour mean CO	10,000	103.73	837.73	1.0	8.4
99.18 percentile 24-hour mean SO_2	125	0.03	5.29	0.0	4.2
99.73 percentile 1 hour mean SO_2	350	1.54	6.22	0.4	1.8
99.9 percentile 15-minute mean SO_2	266	1.76	6.44	0.7	2.4
Ecological Receptors					
24-hour mean NO_x	75	23.33	48.02	31.1	64.0

The results indicate that the concentrations for the majority of short-term assessment metrics are below the relevant AQAL.

With regard to human receptors, since the total annual operating hours for Scenario 4 is equal to 4 hours × 6 generators running concurrently × 2 annual test, resulting in 8 hours of operation per year, it is not possible that generator operation in this scenario could cause an exceedance of the 99.79th percentile 1-hour mean, as the operational events are below the 18 permissible hours of exceedance. The maximum number of hours this scenario can run in any given year is 8 hours, therefore it is considered that there is no risk of adverse effects from Scenario 4 operations.

5.6 Short-term Model Results for Scenario 5 (Emergency Operation)

Table 5.9 details the results of the short-term impact assessment results for Scenario 5 operations. Emergency operation is extremely unlikely to occur, as it represents a complete loss of mains power to the Site from two independent supplies. However, in order to provide a robust assessment of worst-case conditions, this scenario has been included. The summary table provides the maximum result at any receptor for each pollutant and averaging period under Scenario 5 operating conditions. The full results are contained within Appendix C.

Table 5.9 - Short-term Results at Human and Ecological Receptors for Scenario 5

Parameter	Short-term Mean				
	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
Human Receptors					
99.79 percentile 1-hour mean NO_2	200	284.18	307.36	142.1	153.7
90.41 percentile 24-hour mean PM_{10}	50	2.56	29.70	5.1	59.4
1-hour mean CO	30,000	301.05	1035.05	1.0	3.5
8-hour mean CO	10,000	195.67	929.67	2.0	9.3

Parameter	Short-term Mean				
	AQAL µg/m³	PC µg/m³	PEC µg/m³	% PC of AQAL	% PEC of AQAL
99.18 percentile 24-hour mean SO_2	125	0.08	5.34	0.1	4.3
99.73 percentile 1 hour mean SO_2	350	1.73	6.41	0.5	1.8
99.9 percentile 15-minute mean SO_2	266	1.87	6.55	0.7	2.5
Ecological Receptors					
24-hour mean NO_x	75	60.71	85.41	81.0	113.9

The tables indicate that the results for the majority of short-term assessment metrics are below the relevant AQAL.

With regard to human receptors, since the total annual operating hours for Scenario 5 could last for a minimum of 4 hours with all generators and boilers operating concurrently, a probability analysis has been undertaken below for the 99.79 percentile of 1-hour mean NO_2.

Exceedances are predicted for 24-hour mean NO_x concentrations (ecological receptors) for emergency operation. These exceedances are only predicted at an LNR site where the PC constitutes less than 100% of the short-term air quality assessment level. Therefore, further assessment is not required.

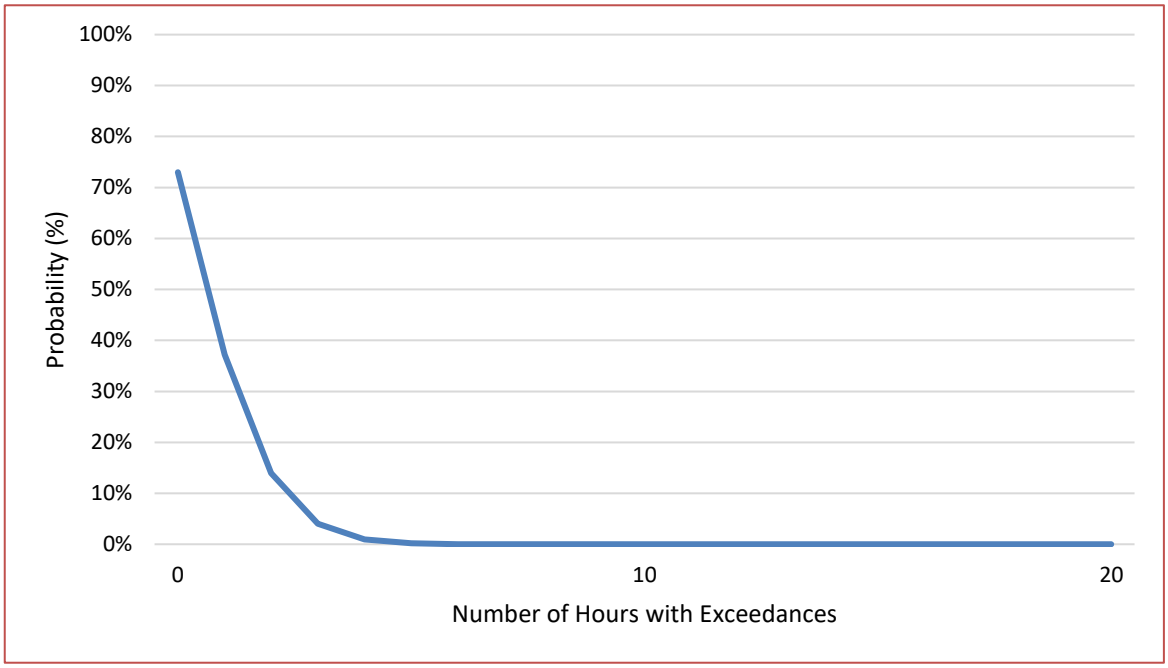
5.6.1 Probability Analysis – Scenario 5

The PEC is predicted to exceed the 99.79 percentile 1-hour mean for NO_2 with predicted values at receptors up to 153.7% of the AQS for Scenario 5. This represents the predicted emissions during the worst 19 hours of meteorological data for the year. Under Scenario 5 operation all 10 generators would fire alongside the boilers and run for a minimum of at least 4 hours.

The worst-case receptor for Scenario 5 was H14, located to the southeast of the Site. This probability analysis has used the exceedance data output from the worst-case gen for the full hour, in order to demonstrate a worst-case assessment.

The model has predicted the greatest number of exceedances at the assessed receptors to be 698 of the 8,760 meteorological lines assessed for the year. The hypergeometric distribution has then been used to calculate the probability of those lines coinciding with the hours of operation to cause an exceedance. If the emergency scenario ran for a 24-hour period, only 9 hours would cause an exceedance of 200 µg/m³. This is well below the permitted 18 exceedances per year, and therefore it is considered that there is no risk of adverse effects from Scenario 5 operations.

Figure 5.1 – Hypergeometric Distribution, Scenario 5 Operations



6 Conclusions

Bureau Veritas have been commissioned by Barclays to undertake an air quality impact assessment for the back-up generators at the Gloucester data centre, in order that the site can apply for a permit to operate.

The assessment has used detailed dispersion modelling to undertake a study of emissions to air during generator operation, comprising the following scenarios:

- Scenario 1: Maintenance Testing of A&B Block.
- Scenario 2: On load Testing of A&B Block.
- Scenario 3: Maintenance Testing of C Block.
- Scenario 4: On load Testing of C Block.
- Scenario 5: Emergency Operation.

Release rates for PM, NO_x and CO were derived using information provided by the generator/boiler manufacturers and emission limits legislation. The release rate for SO_2 was derived based on the sulphur content of the fuel used on site, which is known to be no greater than 0.001%. Due to the short-term nature of emissions released from the back-up generators, results were post-processed, where relevant, to account for the generators running limited hours within a calendar year.

The assessment has resulted in the following conclusions:

- Considering annual mean results for all scenarios, all results at both human and ecological receptors were below the relevant assessment metric, owing to the minimal annual operating hours of the plant.
- The results for nitrogen deposition show exceedances at all ecological receptors considered in the assessment. However, this is due to the background deposition rate at all receptors exceeding the minimum critical load. When taking the PC, this makes up less than 1% of the overall result at the designated ecological receptors considered, so the contribution from the plant can be considered not significant. In the same manner, all results for acid deposition can be described as not significant.
- As such, the plant is not expected to have a significant impact on annual mean pollutant concentrations in the surrounding area.
- Considering short-term results in Scenario 1 (maintenance testing of A&B Block), all results at human and ecological receptors were below the relevant assessment metric. The results for Scenario 1 can therefore be considered not significant.
- Considering short-term results in Scenario 2 (on load testing of A&B Block), all results at human and ecological receptors were below the relevant assessment metric. The results for Scenario 2 can therefore be considered not significant.
- Considering short-term results in Scenario 3 (maintenance testing of C Block), all results at human and ecological receptors were below the relevant assessment metric. The results for Scenario 3 can therefore be considered not significant.
- The majority of the short-term results in Scenario 4 (on load testing of C Block) at human and ecological receptors, were below the relevant assessment metric. Although exceedances of the 99.79 percentile 1-hour mean NO_2 concentration were predicted, twice annual testing falls below the 18 hours of permissible exceedance for 1-hour mean NO_2

concentrations, so it is not possible that Scenario 4 operation would cause a true exceedance of this metric. The results for Scenario 4 can therefore be considered not significant.

- Considering short-term results in Scenario 5 (Emergency Operation), the majority of results at human and ecological receptors were below the relevant assessment metric. Exceedances of the 24-hour mean NO_x concentrations for ecological receptors were only predicted at an LNR site where the PC constituted less than 100% of the short term AQAL. Therefore, further assessment of this ecological site is not required and can be considered as insignificant. At human receptors, an exceedance of the 99.79 percentile 1-hour mean NO_2 concentration was predicted.

- A further probability analysis was then carried out for Scenario 5, taking into account a worst-case maximum run time. A 24hour run time was utilised in the hypergeometric distribution, to calculate the number of hours of exceedances. Only nine hours were predicted to exceed the AQAL, which is well below the permitted 18 exceedances per year. Therefore, the results for Scenario 5 can be considered not significant.

- Due to worst-case conditions being employed through the assessment, the modelled predictions are expected to represent the upper limit of concentrations.

Appendices

Appendix A:
Emission Calculations and Model Input Parameters

Table A1 - Generator Emission Rate Calculations

ID	Source Name	Calculation / Information Source[1]	Generator Model			
			MTU	Mirlees	NGN13 Boiler	RS34 Boiler
a	**Electrical Output of Generators (kW)**	Detailed on generator specification sheet [2]	2.2288	2.74925	0.3344	0.3432
b	**Efficiency (%)**	Provided by Barclays[3]	35	35	88	88
c	**Thermal Input (kW)**	Calculated by **a/b**	6.37	7.86	0.38	0.39
d	**Discharge Diameter (mm)**	Provided by Barclays[3]	442	600	275	300
e	**Discharge Height (m)**	Provided by Barclays[3]	7.5	16.93	18.3	18.3
f	**Discharge Temperature (ºC)**	Detailed on generator specification sheet [2]	590	450	110	110
g	**Actual O_2 (%)**	Data not available, proxy data used based on previous modelling.	8%		5%	
h	**Reference O_2 (%)**	From Emission Limits	5%		3%	
i	**Net Calorific Value of Diesel (MJ/kg)**	Heat Values of various fuels (http://www.world-nuclear.org/information-library/facts-and-figures/heat-values-of-various-fuels.aspx)	44.5		24.0	
j	**Fuel Required to provide energy input (kg/s)**	Calculated by **c/i/1000**	0.14310	0.17652	0.01583	0.01625
k	**Waste gas from combustion (m^3/kg)**	Oil Fuel Properties http://www.globalcombustion.com/oil-fuel-properties/	12.55		10.52	
l	**Total waste gas at 0% O_2 (m^3/s)**	Calculated by **j*k**	1.796	2.215	0.167	0.171
m	**Total waste gas at ambient temperature and 15% O_2 (Reference Conditions (m^3/s))**	Calculated by **l**/((273+15)/273)*(20.9/(20.9-**h**))	2.24	2.76	0.18	0.19
n	**Sulphur Content of Diesel Fuel (ppm)**	Provided by Barclays[3]	10			

[1] Where equations appear in **bold** in the Calculation / Information Source column these represent values in the table with the relevant labelled IDs in the first column.
[2] Barclays provided manufacturer's specification sheets
[3] Barclays document

Table A2 - Location of Modelled Sources

Source Name	Block	Generator Make / Model	X (m)	Y (m)
MTU1	C Block	X2800C	386234	218437
MTU2	C Block	X2800C	386232	218432
MTU3	C Block	X2800C	386230	218428
MTU4	C Block	X2800C	386228	218423
MTU5	C Block	X2800C	386226	218418
MTU6	C Block	X2800C	386224	218414
Mirrlees1 Blackstone	A & B Block	ESL16	386346	218379
Mirrlees2 Blackstone	A & B Block	ESL16	386347	218378
Mirrlees3 Blackstone	A & B Block	ESL16	386345	218378
Mirrlees4 Blackstone	A & B Block	ESL16	386346	218377
NGN13	A block	NGN13	386431	218326
NGN13	A block	NGN13	386429	218326
NGN13	B block	NGN13	386364	218369
RS 34	B block	RS 34	386366	218370

Appendix B:
Pollutant Concentration Isopleths

Figure B1 - 99.79th Percentile of 1 hour mean NO_2 PC isopleth for Scenario 1 (met 2020) (µg/m³)

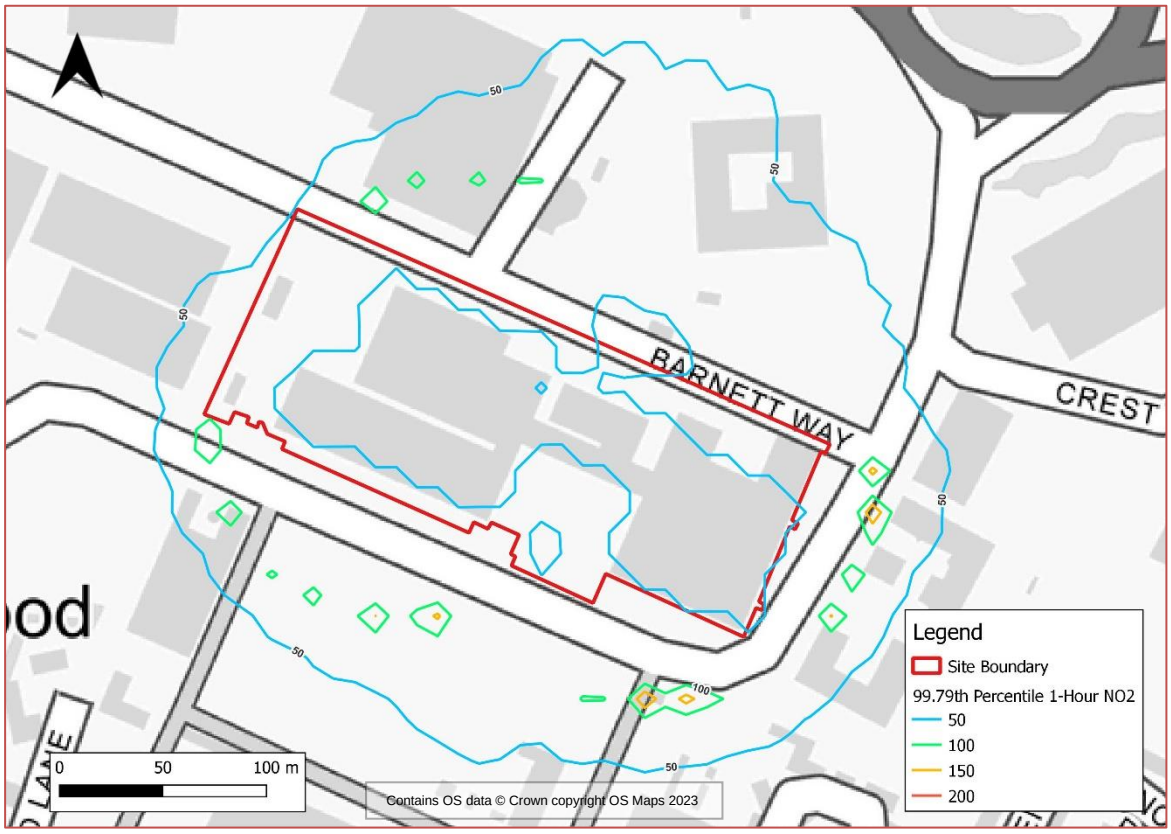


Figure B2 - 99.79th Percentile of 1 hour mean NO_2 PC isopleth for Scenario 2 (met 2020) (µg/m³)

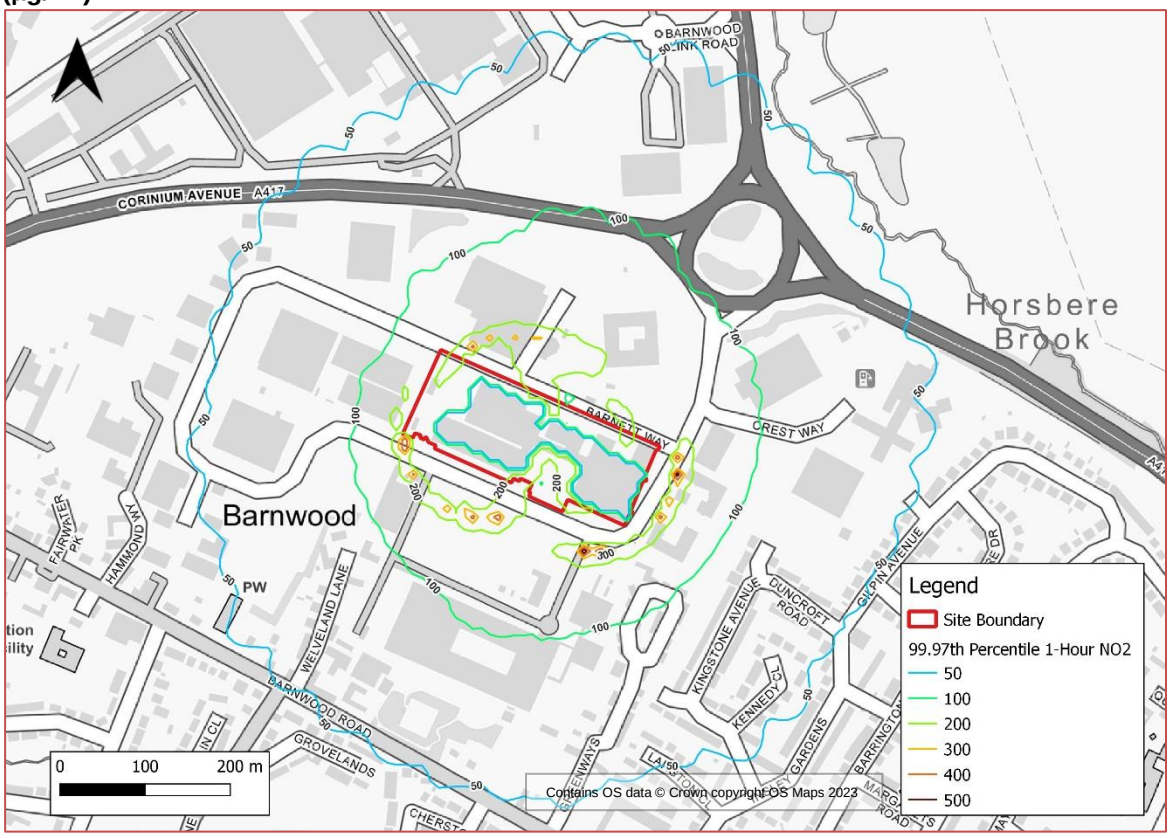


Figure B3 - 99.79th Percentile of 1 hour mean NO_2 PC isopleth for Scenario 3 (met 2020) (µg/m³)

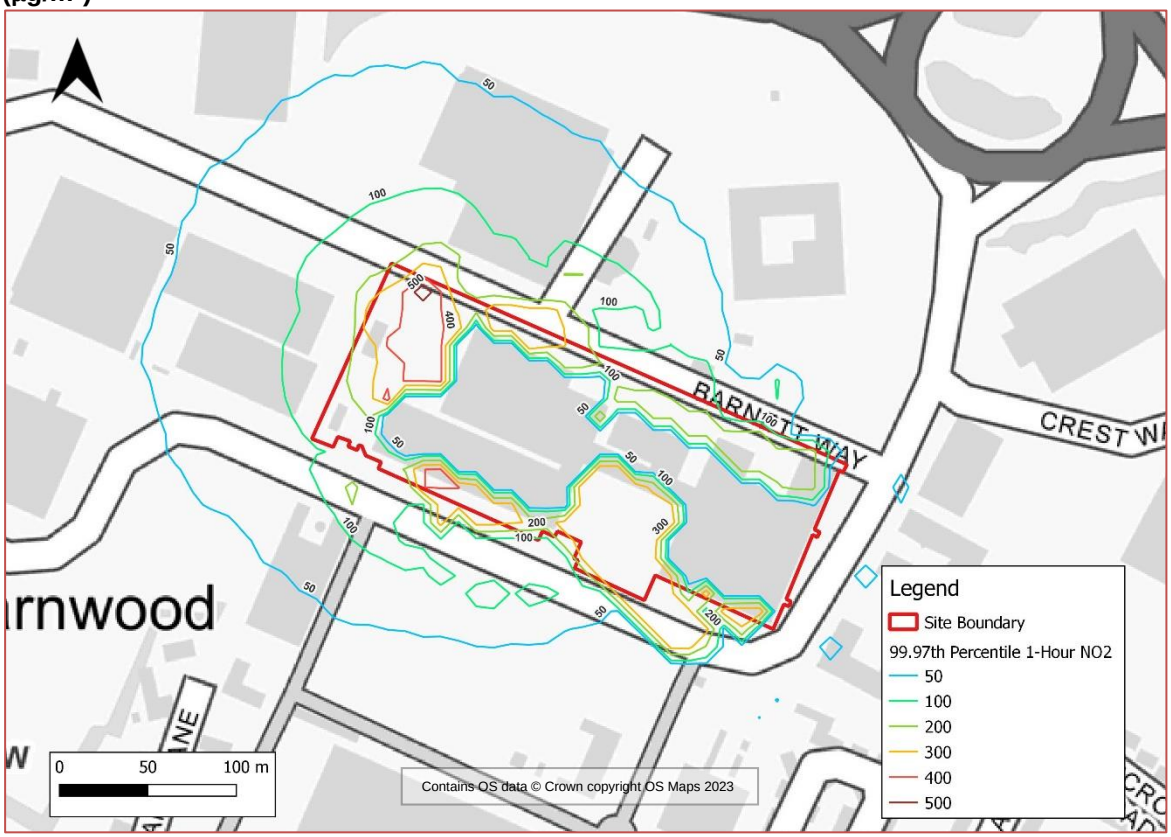
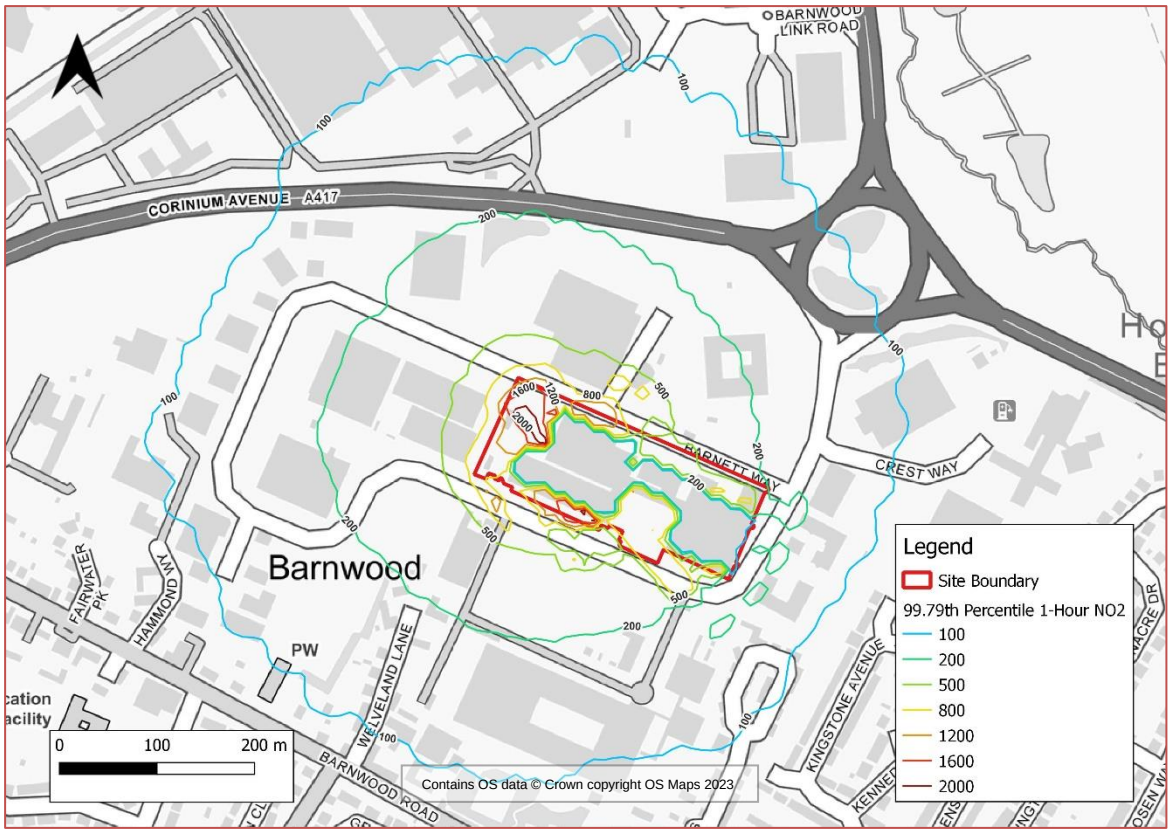


Figure B4 - 99.79th Percentile of 1 hour mean NO_2 PC isopleth for Scenario 4 (met 2020) (µg/m^3)



Appendix C:
Full Results Tables

Appendix D:
Model Files

Appendix C – Noise Impact Assessment

Barclays Execution Services Ltd

Gloucester Data Centre

Noise Impact Assessment

16032779/02 – March 2023

Move Forward with Confidence

BUREAU VERITAS

Document Control Sheet

Identification	
Client	Barclays Execution Services Ltd
Document Title	Noise Impact Assessment – Gloucester Data Centre
Bureau Veritas Ref No.	16032779/02

Contact Details		
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Configuration				
Version	**Date**	**Author**	**Reason for Issue/Summary of Changes**	**Status**
01	14/11/22	Y Hao	Draft for discussion	Superseded
02	15/03/23	Y Hao	Changes to plant details	Live

	Name	Job Title	Signature
Prepared By	Y Hao MIOA	Principal Consultant (Acoustics, Vibration & Occupational Hygiene)	
Approved By	R Cope MIOA	Technical Director (Acoustics, Vibration & Occupational Hygiene)	

Contents

Executive Summary

Bureau Veritas was instructed by Barclays Execution Services Ltd to undertake an environmental noise impact assessment in relation to an Environmental Permit (EP) application operation (maintenance run-up) of the emergency back-up generators and boilers at Barclay's data centre site in Gloucester.

The permit requirement is for a noise assessment in accordance with the methodology set out in BS4142:2014 'Methods for rating and assessing industrial and commercial sound'.

To establish the current levels of ambient and background sound level at the nearest residential receptors, a measurement survey was undertaken in November 2022.

Existing ambient noise levels at the nearest residential receptors are dominated by distant road traffic and vegetation rustling at daytime and at night. No plant noise from the data centre was audible.

A computational noise model of the site was assembled and populated with noise emission data of the new sound sources. Standard noise propagation calculations were used to predict the plant operation noise levels at the nearest noise sensitive receptors.

The assessment concludes that the noise impact of the plant operation would be Low under the existing conditions. No additional noise mitigation measures would be required.

1 Introduction

1.1 Bureau Veritas was instructed by Barclays Execution Services Ltd to undertake an environmental noise impact assessment in relation to an Environmental Permit (EP) application for operation (maintenance run-up) of the emergency back-up generators and boilers at Barclay's data centre site in Gloucester.

1.2 The purpose of this assessment is to provide an indication of its potential impacts on sensitive receptors off site in terms of noise, based on current guidance and best practice.

1.3 The report also details the baseline noise surveys, assessment methods used, and mitigation measures if required.

1.4 A glossary of acoustic terminology is included in **Appendix One**.

2 Site Location

2.1 The installed plant items are within the Barclay's data centre site in Gloucester. The site is accessed from Barnett Way which connects A417 to the north of the site.

2.2 The site is in an industrial and commercial area, with a supermarket and an IT security service (temporarily closed) to the north, a manufacturing plant to the west, office buildings to the east, and car parking to the south. A cycling club is located to the southwest of the site.

2.3 The nearest residential dwellings are identified as those situated approximately 160 m to the southwest of the site, off Welveland Ln, and those approximately 70 m to the southeast of the site, off Greenways.

2.4 The locations of the nearest sensitive receptors (NSRs) are shown in **Appendix Two**.

3 Details of Plants

3.1 The 10 back-up diesel generators and 4 gas boilers at the site have a total aggregated capacity of just over 71 MWth. It is also noted that there is a diesel sprinkler pump which may need to be considered.

3.2 Table 3.1 detailed the information of the plants.

Table 3.1: Gloucester Data Centre Combustion Plant

Type	Number of Plant	Data Hall Reference	MW_{th} per Generator	Total Generator MW_{th}
Mirless Back-up Generator	4	A & B	7.855	31.42
MTU Back-up Generator	6	C	6.368	38.21
NGN13 Gas Boiler	3	A & B	0.38	1.14
RS 34 Gas Boiler	1	B	0.39	0.39
Sprinkler Pump	1	-		95 (kW)
Total	**15**	**-**	**-**	**71.16**

3.3 For Block A&B of the Data Centre, four generators are maintained twice a year and within each maintenance period they are run for one hour, therefore a total of eight hours running off-load. On-load testing is undertaken twice a year, 2- of 4-hour periods and during each test three generators are run, giving a total of 24 hours of on-load running.

3.4 For Block C of the Data Centre, six generators are maintained twice a year and within each maintenance period they are run for one hour, therefore a total of 12 hours running off-load. On-load testing is undertaken twice a year, 2- of 4-hour periods and during each test six generators are run, giving a total of 32 hours of on-load running.

3.5 The Diesel Sprinkler Pump gets maintained twice a year and runs for 30 minutes during each visit, so a total of 1 hours running. Weekly sprinkler tests are carried out and the pump is run for 30 minutes each time, so a total of 26 hours running.

3.6 The site layouts, showing the locations of the plants are shown in **Appendix Three**.

4 Criteria for Assessment

Guidance and Planning Policy

Risk Assessments for Your Environmental Permit (updated August 2022) from Environment Agency and Department for Environment, Food & Rural Affairs

Risks from noise and vibration

4.1 The Environment Agency may ask you to submit a noise and vibration impact assessment and a noise management plan if:

- your activity uses noisy plant or machinery, for example cooling equipment or fans
- you will be doing any noisy operations, such as loading or unloading, shredding, shearing, crushing, grinding, combustion, using trommels and conveyors or moving bulk materials
- your activities are not contained within buildings
- some of your activities take place at night
- the area where you are planning to carry out your activity is sensitive to noise, for example rural areas may have quieter background noise levels than urban areas
- there are sensitive receptors close to the site, for example houses or habitats

4.2 The noise impact assessment for human residential receptors must be done in line with the BS 4142:2014 standard and by a suitably qualified person.

4.3 When applying for a variation, noise from the existing site (before changes) should not be included as part of the background. This is known as the ‘residual level’ in BS 4142:2014. The noise impact assessment must consider all the noise resulting from the proposed variation – the existing site and the variation together. Both components should be clearly shown and then added together to give a new total for site noise at the receptors. The impact assessment is based on this new value, known as the ‘specific level’ in BS 4142:2014.

Noise impact assessments involving calculations or modelling (updated August 2022) from Environment Agency

4.4 This guidance clarified the required information for a noise impact assessment that uses computer modelling or spreadsheet calculations, including general information and noise data. It also details noise data required for the following:

- Fixed and mobile plant;
- Noise emitting buildings;
- Site traffic;
- Site buildings;
- Off-site buildings;
- Site acoustic barriers;
- Terrain data; and
- Receptors

Gloucester, Cheltenham and Tewkesbury Joint Core Strategy 2011-2031

4.5 The Joint Core Strategy, adopted in December 2017, provides a policy framework for development plan in Gloucester, Cheltenham and Tewkesbury. In specific relation to noise pollution, the following policies are relevant to this with assessment:

Policy SD4: Design Requirements

4.6 *"Where appropriate, proposals for development - which may be required to be accompanied by a masterplan and design brief - will need to clearly demonstrate how the following principles have been incorporated:*

…

iii. Amenity and space;

New development should enhance comfort, convenience and enjoyment through assessment of the opportunities for light, privacy and external space, and the avoidance or mitigation of potential disturbances, including visual intrusion, noise, smell and pollution.

…"

Policy SD14: Health and Environmental Quality

"1. High-quality development should protect and seek to improve environmental quality. Development should not create or exacerbate conditions that could impact on human health or cause health inequality.

2. New development must:

…

ii. Result in no unacceptable levels of air, noise, water, light or soil pollution or odour, either alone or cumulatively, with respect to relevant national and EU limit values;

…"

Technical Guidance

4.7 The newly installed plants are the noise sources considered in the noise assessment, therefore British Standard 4142 is the main guidance for the assessment, along with the

other relevant references, to assess the potential noise impact on the nearby sensitive receptors.

4.8 The relevant guidance documents are listed below:

- British Standard 4142: 2014+A1:2019*, "Methods for rating and assessing industrial and commercial sound"* (BS4142);
- British Standard 8233: 2014, *"Guidance on sound insulation and noise reduction for buildings"*; and

British Standard 4142: 2014+A1:2019 'Methods for rating and assessing industrial and commercial sound'

4.9 The Standard provides a method for assessing whether a sound from industrial or commercial premises (e.g. fixed mechanical and electrical (M&E) plant, loading activities etc.) is likely to cause a disturbance to persons living in the vicinity of the site.

4.10 BS 4142 assesses potential significance of effect by comparing the 'specific sound level' of an industrial source to the typically representative background sound level (L_{A90}). Certain acoustic features can increase the potential for a sound to attract attention, and therefore increase its relative significance than that expected from a simple comparison between the specific sound level and the background sound level. In particular, BS 4142 identifies noise that contains discrete impulses and/or audible tonal qualities and in these cases recommends that a correction be added to the specific sound level. The specific sound level along with any applicable correction is referred to as the 'rating level'.

4.11 The greater the difference between the rating level and the background sound level; the greater the likelihood of complaints. The assessment criteria given by BS 4142 are as follows:

- A difference of +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.
- A difference of +5 dB could be an indication of an adverse impact, depending on the context.
- The lower the rating level is relative to the measured background sound level, the less likely it is that there will be an adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.
- Also to take into account the absolute level, risk that it will cause annoyance/interference with everyday activities, context of the sound, frequency and temporal variations to the sound.

4.12 During the daytime and evening, BS 4142 requires that sound levels are assessed over 1-hour periods. During the night-time, because sleep disturbance is the important issue and individual sound events are, therefore, more important, sound levels are assessed over 15-minute periods.

British Standard 8233: 2014 Guidance on Sound Insulation and Noise Reduction for Buildings

4.13 BS 8233:2014 provides guidance for the control of noise in and around buildings. It is applicable to the design of new buildings, or refurbished buildings undergoing a change of use.

4.14 With regards to external sound sources affecting habitable residential spaces, Table 4 of BS 8233:2014 provides guideline values that it is desirable to not exceed during daytime and night time periods. These guideline values are reproduced in Table 4.1.

Table 4.1: Indoor ambient sound levels for dwellings

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living Room	35 dB $L_{Aeq,16hour}$	-
Dining	Dining room/area	40 dB $L_{Aeq,16hour}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,16hour}$	30 dB $L_{Aeq,8hour}$

4.15 For traditional external areas that are used for amenity space, such as gardens and patios, BS8233 states that it is desirable that the external sound level does not exceed 50 dB $L_{Aeq,T}$, with an upper guideline value of 55 dB $L_{Aeq,T}$ which would be acceptable in noisier environments.

5 Baseline Sound Levels

5.1 To establish the ambient and background sound levels at the nearest residential receptors, baseline monitoring was carried out during quiet periods of daytime and night-time on the 9th to 10th November 2022. The measurements lasted for one hour at each monitoring location at daytime and 15 minutes at night-time.

5.2 The measurement locations were adjacent to the noise sensitive receptors off Welveland Ln (NSR1) and Greenways (NSR2). The measurement locations are shown in **Appendix Two**.

5.1 All measurements were undertaken in free-field conditions at a height of approximately 1.5 m above ground. The noise monitoring equipment was calibrated at the beginning and end of the assessment period using an acoustic calibrator, which had itself been calibrated against a reference set traceable to National and International Standards. No shift in calibration level was observed.

5.2 During the daytime measurement survey, the meteorological conditions comprised a slight (3-4 m/s) breeze from SSW. The temperature was 14 °C, dry, with 82% humidity and an atmospheric pressure of 1017 mb.

5.3 Distant road traffic noise and vegetation rustling are predominant and constant at the two NSRs. Plant noise from the EDF building to the southwest was just audible in absence of road traffic at NSR2 off Greenways. No plant noise from the data centre was audible.

5.4 At night, there was a slight (1-2 m/s) breeze from SSW. The temperature was 11 °C, dry, with 88% humidity and an atmospheric pressure of 1013 mb.

5.5 Distant road traffic noise and vegetation rustling are predominant and constant at the two NSRs. No plant noise from the data centre was audible.

5.6 Table 5.1 presents a summary of the sound level survey results.

Table 5.1: Summary of Derived Sound Levels at the short-term monitoring location

Monitoring Location	Date	Period	Start time	Sound Pressure Level, dB re: 20µPa (Fast, Free-field)			
				$L_{Aeq,T}$	$L_{Amax,T}$	$L_{A10,T}$	$L_{A90,T}$
ML1	10/11/2022	Daytime	10:35	50.4	75.8	50.5	45.5
	09/11/2022	Night-time	23:20	40.7	53.1	42.8	38.4
ML2	10/11/2022	Daytime	09:30	51.6	74.2	52.7	49.3
	09/11/2022	Night-time	23:00	44.5	61.7	46.1	42.4

5.7 As shown in Table 5.1, at quiet daytime periods, the measured sound levels are 46 dB $L_{A90,T}$ and 50 dB $L_{Aeq,T}$ at ML1; the measured sound levels are 49 dB $L_{A90,T}$ and 52 dB $L_{Aeq,T}$ at ML2.

5.8 At night, the measured sound levels are 38 dB $L_{A90,T}$ and 41 dB $L_{Aeq,T}$ at ML1; the measured sound levels are 42 dB $L_{A90,T}$ and 45 dB $L_{Aeq,T}$ at ML2.

5.9 Therefore, **46** dB L_{A90} is considered to be the representative background sound level for NSR1 and **49** dB L_{A90} is the representative background sound level for NSR2 during daytime. **38** dB L_{A90} is the representative background sound level for NSR1 and **42** dB L_{A90} is representative background sound level for NSR2 during night-time.

6 Noise and Vibration Assessment

6.1 The impact assessment with respect to the plant noise and vibration on the existing environment covers the following issues:

- Potential operational vibration associated with the plant items; and
- Potential operational noise associated with the plant items

6.2 Due to the typically low vibration levels that are likely to be generated, it is expected that operational activities would not result in perceptible vibration impacts on any of the sensitive receptors. Therefore, no further assessment of operational vibration was undertaken.

6.3 The assessment of the noise impact of site operation is based on the ambient sound levels ($L_{Aeq,T}$) and the background sound levels ($L_{A90,T}$) measured/derived in November 2022. The sound levels of the plant operation at the nearest sensitive receptors are calculated by noise modelling, using CadnaA.

6.4 Noise propagation was predicted using algorithms described in ISO 9613-2, as incorporated within the noise modelling software.

6.5 Based on the site layout provided, the significant operational sound sources are mainly the 10 generators outdoor. The boilers and the diesel sprinkler pumps are housed in the boiler room and pump room, of which the noise is largely attenuated by the building envelopes and very unlikely to be perceptible at the NSRs, given more than 100 m distance between the plants and the NSRs.

6.6 As such, to account for the different operating conditions, the following worst-case operation periods have been considered:

- Maintenance period for Block A&B, 4 generators run simultaneously;
- Maintenance period for Block C, 6 generators run simultaneously; and
- Emergency operation (i.e., in the event of a major power outage or grid failure), 10 generators run simultaneously.

6.7 There was no generator maintenance or test arranged during the project periods, therefore the generator noise emission data is based on BV measurement data obtained at similar sites. The existing generators are placed in enclosures, and the typical sound level of generator in an enclosure is 85 dB L_{Aeq} at 1 m. The measured spectrum of generator noise is shown in **Appendix Four**.

6.8 The maintenance is assumed to occur at daytime only (0700-2300), and emergency operation may occur both daytime and night-time (2300-0700).

6.9 The calculated specific sound levels at the nearest receptors during the three operation conditions are shown in **Table 6.1** below.

Table 6.1: Summary of Predicted Sound Levels on the nearest facades at ground floor (day)

Receptor(s)	Sound Pressure Level, dB $L_{Aeq,T}$ (Maintenance - Block A&B)	Sound Pressure Level, dB $L_{Aeq,T}$ (Maintenance - Block C)	Sound Pressure Level, dB $L_{Aeq,T}$ (Emergency)
NSR1 – Residential dwelling off Welveland Ln	35	38	40
NSR2 – Residential dwelling off Greenways	32	34	35

6.10 The predicted specific sound levels at the nearest receptors during the night-time operation are shown in **Table 6.2** below.

Table 6.2: Summary of Predicted Sound Levels on the nearest facades at first floor (night)

Receptor(s)	Sound Pressure Level, dB $L_{Aeq,T}$ (Maintenance - Block A&B)	Sound Pressure Level, dB $L_{Aeq,T}$ (Maintenance - Block C)	Sound Pressure Level, dB $L_{Aeq,T}$ (Emergency)
NSR1 – Residential dwelling off Welveland Ln	-	-	40
NSR2 – Residential dwelling off Greenways	-	-	35

6.11 **Figures A5.1** to **Figure A5.4** in **Appendix Five** show the predicted sound propagation grids at 1.5 m (ground floor) at daytime and 4 m (first floor) at night.

BS4142 Assessment

6.12 The indicative assessments to BS 4142:2014 are provided in **Table 6.3** to **Table 6.6**, below:

6.13 The results in **Table 6.3** to **Table 6.5** indicate that, during the daytime period, the predicted sound levels generated by the operation of the generators would result in no impact at the nearest residential receptors.

6.14 The results in **Table 6.6** indicate that, at night, the predicted sound levels generated by the operation of the proposed development would result in no impact at NSR2. The rating level of generator noise is 4 dB above the background sound level at NSR2, however given the very low chance of emergency operation during night, it is believed the emergency operation of the generators has low impact at NSR1.

6.15 A sound reduction of 15 dB is expected through a partially open window for ventilation, therefore internal plant noise levels would be below the limit in BS8233 guidelines for bedrooms (30 dB $L_{Aeq,8h}$).

6.16 As such, no additional noise mitigation measures are required.

Table 6.3: Indicative BS 4142:2014 Assessment during Maintenance - Block A&B - Day

Description	Result	Relevant Clauses of BS 4142:2014	Commentary
Specific Sound Level (free-field)	$L_{Aeq,T}$ = 35 dB (NSR1) $L_{Aeq,T}$ = 32 dB (NSR2)	7.3.6	Predicted level (free-field) at ground floor level at the nearest receptor. Determined by calculation using CadnaA.
Background sound level	46 dB (NSR1) 49 dB (NSR2)	8.1 and 8.2	The background noise levels (free-field) were measured at the monitoring locations close to the noise-sensitive receptors.
Acoustic features correction	+0 dB	9.2	No perceptible tone or other distinctive acoustic features are predicted to be audible at the receptors due to the high background level.
Rating Level	35 dB (NSR1) 32 dB (NSR2)		
Excess of Rating Level over Background Sound Level	-11 dB (NSR1) -17 dB (NSR2)		
Assessment of impact: indication of no impact due to the generator noise at the receptors		11	
Context		11 8.2	Plant noise levels predicted to be well below existing ambient and background sound levels at both receptor locations.
Uncertainty of the assessment		10	The specific noise level has been predicted by CadnaA, which utilises ISO9613 calculations, which have a claimed uncertainty of +/- 3 dB. The background sound levels at the receptors are decided based on the short-term noise monitoring.

Table 6.4: Indicative BS 4142:2014 Assessment during Maintenance - Block C - Day

Description	Result	Relevant Clauses of BS 4142:2014	Commentary
Specific Sound Level (free-field)	$L_{Aeq,T}$ = 38 dB (NSR1) $L_{Aeq,T}$ = 34 dB (NSR2)	7.3.6	Predicted level (free-field) at ground floor level at the nearest receptor. Determined by calculation using CadnaA.
Background sound level	46 dB (NSR1) 49 dB (NSR2)	8.1 and 8.2	The background noise levels (free-field) were measured at the monitoring locations close to the noise-sensitive receptors.
Acoustic features correction	+0 dB	9.2	No perceptible tone or other distinctive acoustic features are predicted to be audible at the receptors due to the high background level.
Rating Level	38 dB (NSR1) 34 dB (NSR2)		
Excess of Rating Level over Background Sound Level	-8 dB (NSR1) -15 dB (NSR2)		
Assessment of impact: indication of no impact due to the generator noise at the receptors		11	
Context		11 8.2	Plant noise levels predicted to be well below existing ambient and background sound levels at both receptor locations.
Uncertainty of the assessment		10	The specific noise level has been predicted by CadnaA, which utilises ISO9613 calculations, which have a claimed uncertainty of +/- 3 dB. The background sound levels at the receptors are decided based on the short-term noise monitoring.

Table 6.5: Indicative BS 4142:2014 Assessment during Emergency Operation - Day

Description	Result	Relevant Clauses of BS 4142:2014	Commentary
Specific Sound Level (free-field)	$L_{Aeq,T}$ = 40 dB (NSR1) $L_{Aeq,T}$ = 35 dB (NSR2)	7.3.6	Predicted level (free-field) at ground floor level at the nearest receptor. Determined by calculation using CadnaA.
Background sound level	46 dB (NSR1) 49 dB (NSR2)	8.1 and 8.2	The background noise levels (free-field) were measured at the monitoring locations close to the noise-sensitive receptors.
Acoustic features correction	+0 dB	9.2	No perceptible tone or other distinctive acoustic features are predicted to be audible at the receptors due to the high background level.
Rating Level	40 dB (NSR1) 35 dB (NSR2)		
Excess of Rating Level over Background Sound Level	-6 dB (NSR1) -14 dB (NSR2)		
Assessment of impact: indication of no impact due to the generator noise at the receptors		11	
Context		11 8.2	Plant noise levels predicted to be well below existing ambient and background sound levels at both receptor locations.
Uncertainty of the assessment		10	The specific noise level has been predicted by CadnaA, which utilises ISO9613 calculations, which have a claimed uncertainty of +/- 3 dB. The background sound levels at the receptors are decided based on the short-term noise monitoring.

Table 6.6: Indicative BS 4142:2014 Assessment during Emergency Operation - Night

Description	Result	Relevant Clauses of BS 4142:2014	Commentary
Specific Sound Level (free-field)	$L_{Aeq,T}$ = 40 dB (NSR1) $L_{Aeq,T}$ = 35 dB (NSR2)	7.3.6	Predicted level (free-field) at 1st floor window at the nearest receptors. Determined by calculation using CadnaA.
Background sound level	38 dB (NSR1) 42 dB (NSR2)	8.1 and 8.2	The background noise levels (free-field) were measured at the monitoring locations close to the noise-sensitive receptors.
Acoustic features correction	+2 dB	9.2	Perceptible tone or other distinctive acoustic features are predicted to be audible at the receptors.
Rating Level	42 dB (NSR1) 37 dB (NSR2)		
Excess of Rating Level over Background Sound Level	+4 dB (NSR1) -5 dB (NSR2)		
Assessment of impact: indication of no impact due to the generator noise at NSR2, and low impact due to the generator noise at NSR1		11	
Context		11 8.2	At night the noise-sensitive location is indoors with open windows where residual sound within the dwelling will further mask sound from the plant. A sound reduction of 15 dB is expected through a partially open window for ventilation, therefore internal plant noise levels would be not above BS8233 guidelines for bedrooms (30 dB $L_{Aeq,8h}$).
Uncertainty of the assessment		10	The specific noise level has been predicted by CadnaA, which utilises ISO9613 calculations, which have a claimed uncertainty of +/- 3 dB. The background sound levels at the receptors are decided based on the short-term noise monitoring.

7 Conclusions

7.1 Bureau Veritas was instructed by Barclays Execution Services Ltd to undertake an environmental noise impact assessment in relation to an Environmental Permit (EP) application for operation (maintenance) of emergency diesel generators and boiler plant at Barclay's data centre site in Gloucester.

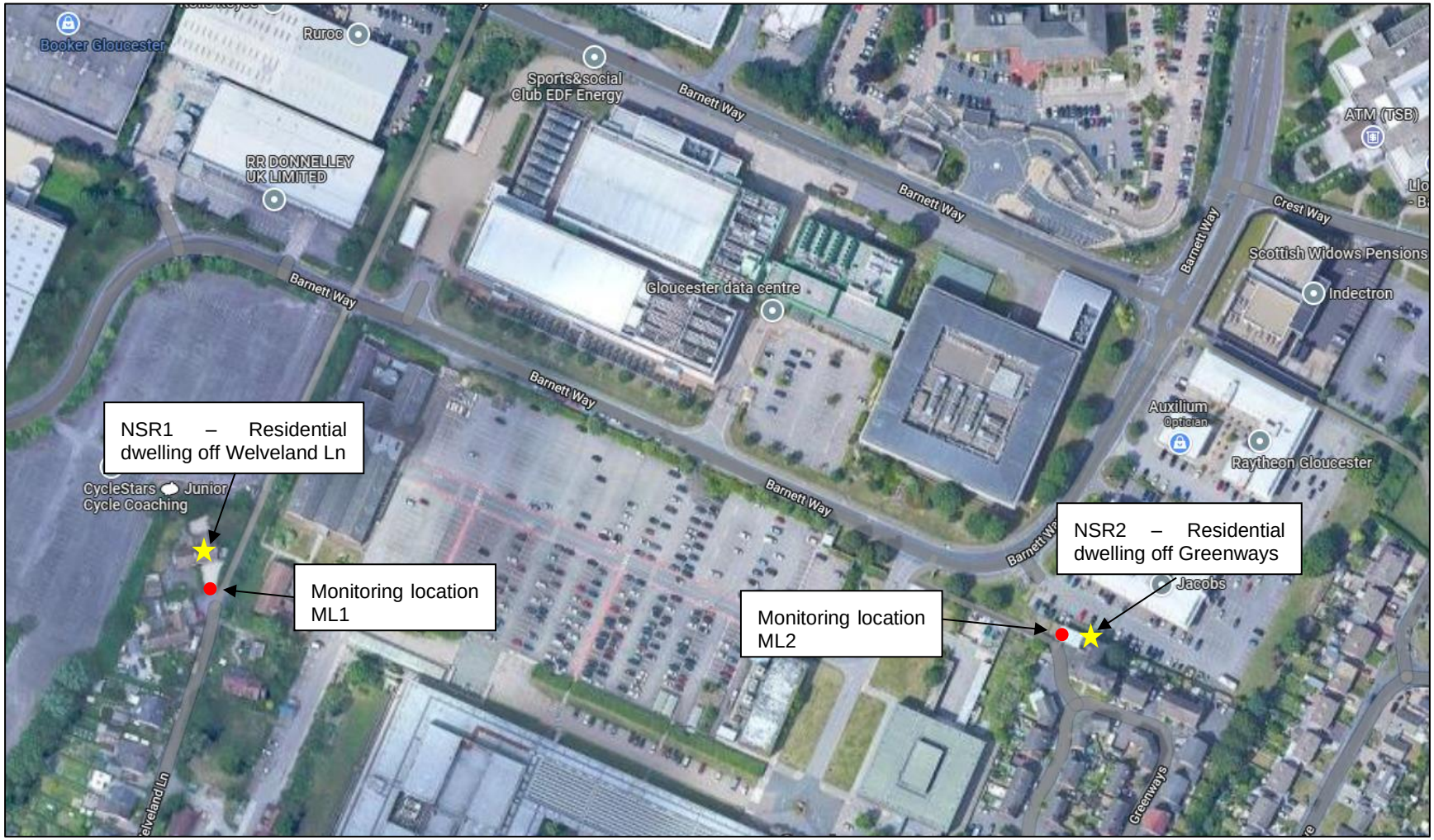
7.2 According to BS4142 assessment, the predicted daytime sound levels generated by the plant items would not result in a significant noise impact at the nearest noise sensitive receptors. At night, taking account of the context, the assessment also determined that the noise impacts at night will not be significant.

7.3 The noise impact of the plants is therefore assessed as being Low at the nearest sensitive receptors.

Appendix One – Glossary of Acoustic Terminology

Sound power level	A logarithmic measure of the power of a sound relative to a reference value.
"A" Weighting (dB(A))	The human ear does not respond uniformly to different frequencies. "A" weighting is commonly used to simulate the frequency response of the ear. It is used in the assessment of the risk of damage to hearing due to noise.
Decibel (dB)	The range of audible sound pressures is approximately 2 x 10^{-5} Pa to 200 Pa. Using decibel notation presents this range in a more manageable form, 0 dB to 140 dB.
Ambient sound level, $L_{Aeq,T}$	equivalent continuous A-weighted sound pressure level of the totally encompassing sound in a given situation at a given time, usually from many sources near and far, at the assessment location over a given time interval, T. NOTE The ambient sound level is a measure of the residual sound and the specific sound when present.
Background sound level, $L_{90,T}$	A-weighted sound pressure level that is exceeded by the residual sound at the assessment location for 90% of a given time interval, T, measured using time weighting F and quoted to the nearest whole number of decibels.
Maximum sound level, $L_{Amax,T}$	The maximum RMS A-weighted sound pressure level occurring within a specified time period.
Noise	Unwanted sound.
Ambient sound	Totally encompassing sound in a given situation at any given time composed of noise from many sources, near and far.
Residual sound	Ambient sound remaining at the assessment location when the specific sound source is suppressed to such a degree that it does not contribute to the ambient sound.
Rating level	Specific sound level plus any adjustment for the characteristic features of the sound.

Appendix Two – NSRs and Baseline Monitoring Locations



Appendix Three – Site Layouts

Appendix Four – Sound Spectrum of Generator Noise

25 Hz	31.5 Hz	40 Hz	50 Hz	63 Hz	80 Hz	100 Hz	125 Hz	160 Hz	200 Hz	250 Hz	315 Hz	400 Hz	500 Hz	630 Hz	800 Hz	1 kHz	1.25 kHz	1.6 kHz	2 kHz	2.5 kHz	3.15 kHz	4 kHz	5 kHz	6.3 kHz	8 kHz	10 kHz
88.4	84.2	86.2	80.3	82.7	84.8	76.2	75.5	76.5	85.9	88	85.3	84.2	82.5	77.3	74.6	74.6	69.8	70.7	70.5	65.3	63.9	64.2	62.8	58.3	55.7	51.4

Appendix Five – Noise Contours

Figure A5.1: Indicative Specific Sound Level (Day) during the maintenance period for Block A&B – 1.5 m above ground

Figure A5.2: Indicative Specific Sound Level (Day) during the maintenance period for Block C – 1.5 m above ground

Figure A5.3: Indicative Specific Sound Level (Day) during the emergency operation period – 1.5 m above ground

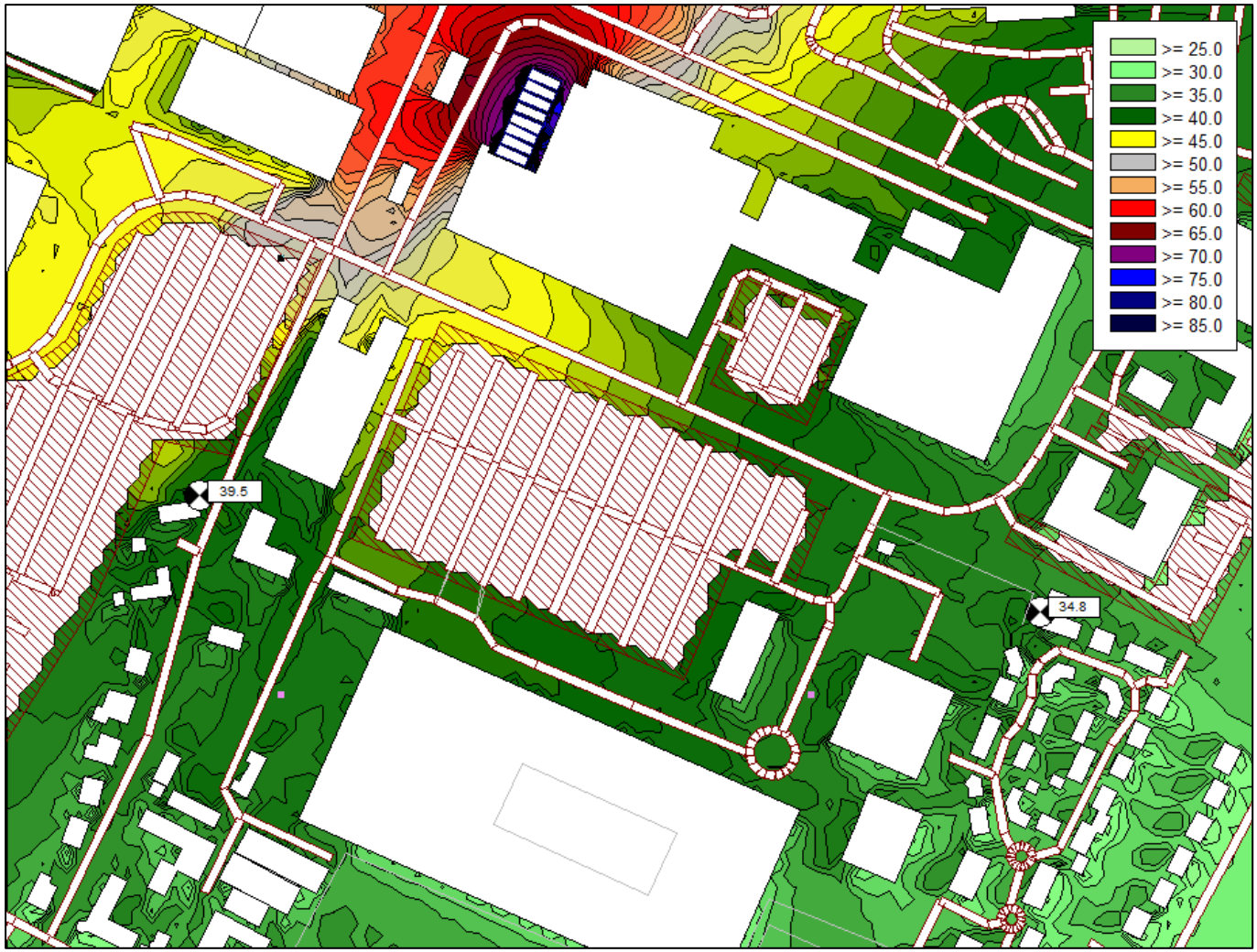
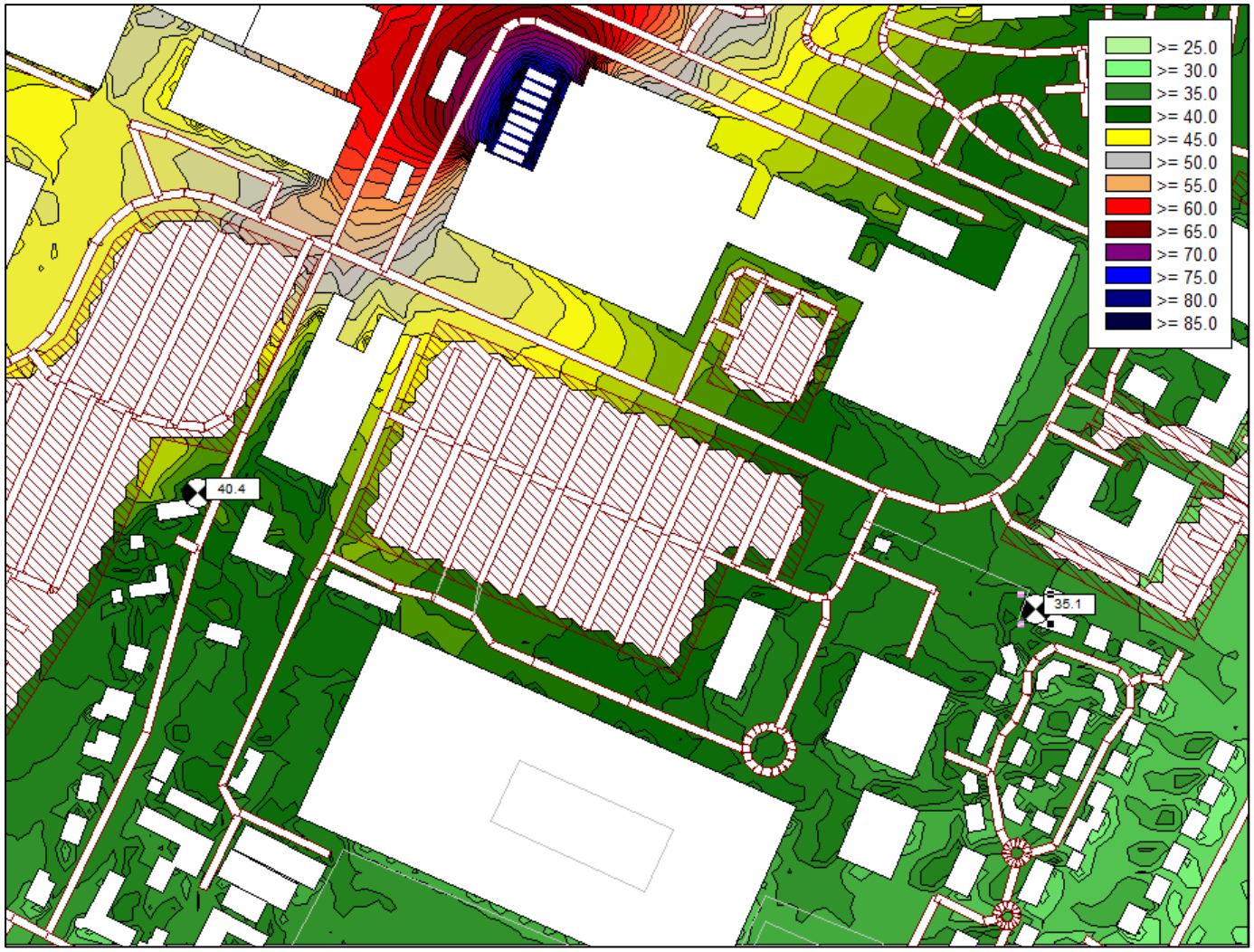


Figure A5.4: Indicative Specific Sound Level (Night) during the emergency operation period – 4 m above ground



Appendix D – Site Condition Report

SITE CONDITION REPORT TEMPLATE

For full details, see H5 *SCR guide for applicants* v2.0 4 August 2008

COMPLETE SECTIONS 1-3 AND SUBMIT WITH APPLICATION

DURING THE LIFE OF THE PERMIT: MAINTAIN SECTIONS 4-7

AT SURRENDER: ADD NEW DOC REFERENCE IN 1.0; COMPLETE SECTIONS 8-10; & SUBMIT WITH YOUR SURRENDER APPLICATION.

V2.0 4 August 2008

1.0 SITE DETAILS	
Name of the applicant	Barclays Execution Services Ltd
Activity address	Gloucester Data Centre Barnett Way Gloucester Gloucestershire GL4 3RU
National grid reference	SO 86320 18361

Document reference and dates for Site Condition Report at permit application and surrender	Permit Application report – Barclays Gloucester Permit_v1.0.pdf

Document references for site plans (including location and boundaries)	Permit Application report – Barclays Gloucester Permit_v1.0.pdf

Note:
In Part A of the application form you must give us details of the site's location and provide us with a site plan. We need a detailed site plan (or plans) showing:

- Site location, the area covered by the site condition report, and the location and nature of the activities and/or waste facilities on the site.
- Locations of receptors, sources of emissions/releases, and monitoring points.
- Site drainage.
- Site surfacing.

If this information is not shown on the site plan required by Part A of the application form then you should submit the additional plan or plans with this site condition report.

2.0 Condition of the land at permit issue	
Environmental setting including: • geology • hydrogeology • surface waters	**Geology** British Geological Survey (BGS) data indicate that that the Site's bedrock geology is Charmouth Mudstone Formation; a sedimentary bedrock formed between 199.3 and 182.7 million years ago during the Jurassic period. The BGS also provides information on area's superficial deposits overlying the bedrock, comprising Cheltenham Sand and Gravel. This is a sedimentary superficial deposit formed between 2.588 million years ago and the present during the Quaternary period. **Hydrogeology** The Multi-Agency Geographic Information for the Countryside (MAGIC) Map was used to investigate hydrogeology at the Site. The bedrock beneath the Site is classified as Secondary (undifferentiated), whilst superficial deposits are classed as Secondary A aquifer.

	The Site is located outside groundwater Source Protection Zones (SPZs). **Hydrology** MAGIC map showed that there are two surface water features within 500 m of the site's EP boundary; Horsbere Brook 362 m to the northeast, and Wotton Brook to the 476 m south. The Flood Map for Planning identifies the site as lying within a Flood Zone 1, defined as having a less than 1 in 1,000 annual probability of river or sea flooding.
Pollution history including: • pollution incidents that may have affected land • historical land-uses and associated contaminants • any visual/olfactory evidence of existing contamination • evidence of damage to pollution prevention measures	Despite the Environmental Permit being surrendered in 2014, operations have continued at the site (but have below the 50 MW threshold required for an Environmental Permit). Therefore, site records have been kept during this time, as the Site has continued to operate under an in-house environmental management procedures. Since the previous Environmental Permit was held, the Operator has confirmed that there have been no spillages on site during the operation of the facility. The site has not deteriorated during in this interim period, due to the Site being covered with concrete hard standing with suitable drainage control mechanisms. Containment has been maintained to a high standard and comprehensive records are in place.
Evidence of historic contamination, for example, historical site investigation, assessment, remediation and verification reports (where available)	Since the previous Environmental Permit was held, the Operator has confirmed that there have been no spillages on site during the operation of the facility.
Baseline soil and groundwater reference data	Not applicable, no reference data collected.
Supporting information	• British Geological Survey Geology Viewer: https://geologyviewer.bgs.ac.uk/?_ga=2.61397804.1679054795.1673429022-995892759.1673429022 • MAGIC Map Application: https://magic.defra.gov.uk/MagicMap.aspx • Flood Map for Planning: https://flood-map-for-planning.service.gov.uk/ • Source information identifying environmental setting and pollution incidents

3.0 Permitted activities

Permitted activities	Environmental Permitting (England and Wales) Regulations 2016 (as amended): Combustion Activities, Schedule 1 Section 1.1 Part A(1)(a).
Non-permitted activities undertaken	All areas other than the diesel fired generators and the associated diesel storage.

Document references for: • plan showing activity layout; and • environmental risk assessment.	EMS Report – Barclays_Gloucester_EMS.pdf

Note:

In Part B of the application form you must tell us about the activities that you will undertake at the site. You must also give us an environmental risk assessment. This risk assessment must be based on our guidance (*Environmental Risk Assessment - EPR H1*) or use an equivalent approach.

It is essential that you identify in your environmental risk assessment all the substances used and produced that could pollute the soil or groundwater if there were an accident, or if measures to protect land fail.

These include substances that would be classified as 'dangerous' under the Control of Major Accident Hazards (COMAH) regulations and also raw materials, fuels, intermediates, products, wastes and effluents.

If your submitted environmental risk assessment does not adequately address the risks to soil and groundwater we may need to request further information from you or even refuse your permit application.

Appendix E – Environmental Risk Assessment

Appendix F – Environmental Management System

Appendix G – Application Forms