FICHTNER
Consulting Engineers Limited

Rugby

Britvic plc

Dispersion Modelling Assessment for EP Variation

ENGINEERING CONSULTING

Document approval

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Management Summary

Fichtner Consulting Engineers Ltd ("Fichtner") has been engaged to undertake a Dispersion Modelling Assessment to support the Environmental Permit (EP) variation application for the Britvic Soft Drinks Installation at Rugby (the Facility). Heat and power are produced for the on-site processes by an energy centre which comprises two combined heat and power (CHP) engines and three boilers.

The EP currently limits the number of hours of operation of the boilers and CHP engines. The proposed variation is to allow all items of plant to operate continually. Therefore, this assessment considers the impact of emissions to air of the following scenarios:

1. The Facility as currently permitted (the Permitted Facility), with the CHP engines and two boilers operating at full load from Monday to Friday and the remaining boiler operating Saturday and Sunday; and
2. Continual operation of the CHP engines and all three boilers at full load (the Proposed Facility).

In addition, Boiler 1 will have to comply with the conditions of the Medium Combustion Plant Directive (MCPD) by 1 January 2025. The contribution of Boiler 1 alone to pollutant concentrations has also been assessed.

The assessment has been carried out in a number of stages.

1. Review of Legislation

In the UK, the levels of pollution in the atmosphere are controlled by the National Air Quality Strategy and a number of European Directives which have been fully implemented. These have led to the setting of a number of Air Quality Assessment Levels (AQALs) for pollutants. The AQALs are set at a level below those at which significant adverse health effects have been observed in the general population and in particularly sensitive groups.

In addition, Critical Levels have been set for the protection of ecosystems. Deposition of nitrogen and acid gases can cause nitrification and acidification of habitats. The Air Pollution Information System (APIS) provides Critical Loads for different habitats which consider the existing pollution loading for the site.

2. Review of Ambient Air Quality

Monitoring information collected by the UK Government and by local authorities has been used to assess the current levels of pollutants in the atmosphere close to the Facility.

3. Identification of Sensitive Receptors

When assessing the impact of the Facility, the assessment considers the point of maximum impact as a worst-case. In addition, the impact has been assessed at a number of identified sensitive receptors including the closest residential properties and ecologically sensitive receptors, and reference has been made to plot files to assess the impacts at broader areas of relevant exposure.

4. Dispersion Modelling

The ADMS dispersion model is routinely used for air quality assessments to the satisfaction of local authorities and the Environment Agency. The model uses weather data from the local area to predict the spread and movement of the exhaust gases from the stack for each hour over a five-year period. The model takes account of wind speed, wind direction, temperature, humidity and the amount of cloud cover, as all of these factors influence the dispersion of emissions. The model also takes account of the effects of buildings and terrain on the movement of air.

To set up the model, it has been assumed that the boilers and engines that comprise the energy centre release emissions at the emission limit for the maximum number of hours per year permitted in each scenario. The model inputs have been derived from the most recent emissions monitoring report for the Facility. The model has been used to predict the ground level concentration of pollutants on a long-term and short-term basis across a grid of points. In addition, concentrations have been predicted at the identified sensitive receptors.

5. Assessment of Impact on Air Quality – Protection of Human Health

The impact of air quality on human health has been assessed using a standard approach based on Environment Agency guidance.

Using this approach, the following can be concluded from the assessment:

1. No exceedance of any AQAL is predicted.
1. The change in impact of all long-term and short-term process emissions between the Proposed Facility and the Permitted Facility is either screened out as ‘insignificant’, or can be considered ‘not significant’ when the total concentration (predicted environmental concentration, “PEC”) is considered, at all receptor locations and areas of relevant exposure.
2. The overall impact of all long-term and short-term process emissions from the Proposed Facility is either ‘insignificant’, or ‘not significant’ when the PEC is considered, at all areas of relevant exposure.

Based on the above results, no significant air quality effects on human health are predicted as a result of the proposed variation.

6. Assessment of Impact on Air Quality – Protection of Ecosystems

The impact of emissions on atmospheric air quality in sensitive ecosystems has been assessed using a standard approach based on Environment Agency. No European or UK designated sites have been identified within the relevant screening distances, so only the impacts on local nature sites have been considered. If the change in process contribution within a local nature site is less than 100% of the long- or short-term assessment level, the emissions are ‘insignificant’.

Three local nature sites have been identified as requiring consideration within this assessment. The results of the assessment show that, at the identified sensitive ecological sites, the process contribution to airborne concentrations and nitrogen and acid deposition from the Proposed Facility is screened out as ‘insignificant’. It follows that the change in process contribution is also ‘insignificant’.

7. MCPD Compliance

The contribution of emissions from Boiler 1 alone have been considered. The impact on human and ecological receptors of Boiler 1 operating at the maximum emission limit for oxides of nitrogen permitted under the MCPD is ‘insignificant’.

8. Summary

A comprehensive assessment of emissions from the Facility has shown that emissions from the Facility following the proposed variation to the EP would not have a significant impact on local air quality, the general population or the local community. As such there should be no air quality constraint in granting the EP variation.

Contents

1 Introduction

1.1 Background

Fichtner Consulting Engineers Ltd ("Fichtner") has been engaged to undertake a Dispersion Modelling Assessment to support the Environmental Permit (EP) variation application for the Britvic Soft Drinks Installation at Rugby (the Facility). The Facility lies within the administrative area of Rugby Borough Council (RBC). The location of the Facility is shown in Figure 1 of Appendix A.

The EP (Ref: EPR/QP3434SH) currently permits the operation of an energy centre comprising the following items of plant:

- Two natural gas fired combined heat and power (CHP) engines with a net thermal input of 11.4 MWth each; and
- Three natural gas fired boilers of net thermal input 12.3 MWth each.

In addition, two standby diesel generators are permitted which are used in the event of failure of the CHP engines and/or electricity supply from the National Grid. As these are only intended for emergency use they have not been considered further in this assessment.

The natural gas supply to the site is restricted such that aggregated maximum supply to combustion plant is 47.5 MWth.

The CHP engines and boilers are currently not permitted to run continually. Both CHP engines and two of the boilers are permitted to operate Monday to Friday for 52 weeks of the year, and the other boiler is permitted to run on Saturdays and Sundays for 52 weeks of the year. The purpose of the variation is to allow continual operation of all items of plant, albeit limited to a total net rated thermal input of 47.5 MWth. Boiler 3 is currently mothballed but remains permitted, and may be brought back into operation in the future.

Boiler 1, which shares a stack with the CHP engines, is not currently subject to any emission limit values (ELVs), although it is listed as an emission source with monitoring requirements in the EP. This boiler became operational prior to 20 December 2018 and is classed as an existing medium combustion plant, regulated under the Medium Combustion Plant Directive (MCPD). As the thermal input of Boiler 1 is between 5 MWth and 50 MWth, it must comply with the requirements of the MCPD by 1 January 2025. The EA would initiate an EP variation to include the requirements of the MCPD during 2024; however, Britvic proposes to include this in the current variation application. As such, the dispersion modelling includes emissions of oxides of nitrogen from Boiler 1 operating continually at the maximum ELV permitted under the MCPD.

A detailed description of the proposals is contained in the documentation submitted to support the EP variation applications.

1.2 Scope of assessment

This Dispersion Modelling Assessment considers the impact of emissions to air of the following scenarios:

1. The Facility as currently permitted (the Permitted Facility), with the CHP engines and two boilers operating at full load from Monday to Friday and the remaining boiler operating Saturday and Sunday; and
2. Continual operation of the CHP engines and all three boilers at full load (the Proposed Facility).

Scenario 2 is highly conservative, as there is not sufficient natural gas supply to the site to power all items of combustion plant to full load at the same time. Nonetheless this scenario has been included as an absolute worst-case.

A comparison of the impact of annual mean emissions has been made between scenarios 1 and 2, representing the change in impact, and the overall impact of emissions in scenario 2 has also been assessed.

Modelling of emissions from all items of plant at full load is likely to be the most conservative scenario. However, the boilers typically operate at partial load. This results in lower pollutant emission rates, but also less buoyancy and momentum to aid dispersion. A sensitivity analysis has been run to confirm that the full load scenario is representative of the worst-case scenario.

The CHP engines and boilers 2 and 3 already comply with the requirements of the MCPD. Boiler 1 is not currently subject to any ELVs. By including emissions of oxides of nitrogen from boiler 1 at the maximum ELV permitted under the MCPD, this assessment also serves to demonstrate that emissions from boiler 1 will not result in an unacceptable air quality effect. To assess this, a third scenario has been assessed with emissions of oxides of nitrogen from boiler 1 set to zero. The difference between scenario 2 and scenario 3 represents the impact of the continual operation of boiler 1 at full load, at the maximum ELV permitted under the MCPD.

1.3 Structure of the report

This report has the following structure.

- National and international legislation and guidance are considered in Sections 2 and 3.
- The assessment criteria are presented in Section 4.
- The background levels of ambient air quality are described in Section 5.
- Section 6 highlights the residential properties and ecological receptors which are sensitive to changes in air quality associated with the Facility.
- The inputs used for the dispersion model are contained within Section 7
- Details of the sensitivity analyses carried out is presented in section 8.
- Section 9 presents the results of the assessment of the impact of emissions on human health.
- Section 10 presents the results of the assessment of the impact of emissions at ecological sites.
- The conclusions of the assessment can be found in Section 11.
- The Appendices include illustrative figures and supplementary details.

2 Legislation

2.1 Legislation

European air quality legislation is consolidated under Directive 2008/50/EC, which came into force on 11 June 2008. This Directive consolidates previous legislation which was designed to deal with specific pollutants in a consistent manner.

The Air Quality Standards Regulations (2010) seek to transpose Directive 2008/50/EC within the UK. The regulations also extend powers, under Section 85(5) of the Environment Act (1995), for the Secretary of State to give directions to local authorities for the implementation of these Directives.

The UK Air Quality Strategy (2007)[1] (the AQS) is the method of implementation of the AAD Limit Values and Targets in England, Scotland, Wales and Northern Ireland. This document builds on the previous Strategy, published in 2000, and a 2003 Addendum. The UK Clean Air Strategy (2019) builds on the UK Air Quality Strategy but does not update any of the AAD Limit Values and Targets.

The Air Quality Strategy defines "standards" and "objectives" in paragraph 17:

"For the purposes of the strategy:

- *standards are the concentrations of pollutants in the atmosphere which can broadly be taken to achieve a certain level of environmental quality. The standards are based on assessment of the effects of each pollutant on human health including the effects on sensitive subgroups or on ecosystems; and*
- *objectives are policy targets often expressed as a maximum ambient concentration not to be exceeded, either without exception or with a permitted number of exceedances, within a specified timescale."*

The status of the objectives is clarified in paragraph 22, which also emphasises the importance of European Directives:

"The air quality objectives in the Air Quality Strategy are a statement of policy intentions or policy targets. As such, there is no legal requirement to meet these objectives except in as far as these mirror any equivalent legally binding limit values in EU legislation. Where UK standards or objectives are the sole consideration, there is no legal obligation upon regulators, to set Emission Limit Values (ELVs) any more stringent than the emission levels associated with the use of Best Available Techniques (BAT) in issuing permits under the PPC Regulations. This aspect is dealt with fully in the PPC Practical Guides."

2.2 Industrial pollution regulation

Atmospheric emissions from industrial processes are controlled in England through the Environmental Permitting (England and Wales) Regulations (2016), as amended. The Facility has an EP to operate which includes conditions to minimise the environmental impact by limiting emissions to air. The ELVs for the boilers are based on those prescribed under the MCPD.

[1] The Air Quality Strategy for England, Scotland, Wales and Northern Ireland, CM 7169 NIA 61/06-07, July 2007, Defra – para 17 of Volume 1.

3 Air Quality Standards, Objectives and Guidelines

In the UK, AAD Limit Values, Targets, and air quality standards and objectives (collectively referred to in this report as Air Quality Assessment Levels, "AQALs") for major pollutants are described in the AQS. Those relevant to this project are summarised in the following section.

3.1 Nitrogen dioxide

All combustion processes produce nitric oxide and nitrogen dioxide, known by the general term of oxides of nitrogen. In general, the majority of the oxides of nitrogen released is in the form of nitric oxide, which then reacts with ozone in the atmosphere to form nitrogen dioxide. Of the two compounds, nitrogen dioxide is associated with adverse effects on human health, principally relating to respiratory illness. The World Health Organisation has stated that "many chemical species of nitrogen oxides exist, but the air pollutant species of most interest from the point of view of human health is nitrogen dioxide".

The AQS includes two objectives, both of which are included in the Air Quality Directive:

- A limit for the one-hour mean of 200 µg/m³, not to be exceeded more than 18 times a year (equivalent to the 99.79th percentile).
- A limit for the annual mean of 40 µg/m³.

The Air Quality Directive includes objectives for the protection of sensitive vegetation and ecosystems of 30 µg/m³ for the annual mean nitrogen oxides. This is also transposed within the AQS. The Environment Agency's guidance "Air emissions risk assessment for your EP[2]" (the Air Emissions Guidance) also defines the daily mean Critical Level as 75 µg/m³ for nitrogen oxides, or 200 µg/m³ where ozone is below the AOT40 Critical Level and sulphur dioxide is below the lower Critical Level of 10 µg/m³.

3.2 Carbon monoxide

Carbon monoxide is produced by the incomplete combustion of fuels containing carbon. Although there are no ELVs for carbon monoxide prescribed in the EP or MCPD, the operator is required to monitor emissions of carbon monoxide.

Concentrations in the UK are well below levels at which health effects can occur. The AQS includes the following objective for the control of carbon monoxide, which is also included in the Air Quality Directive:

- A limit for the 8-hour running mean of 10 mg/m³.

The Air Emissions Guidance also defines the hourly EAL as 30 mg/m³.

3.3 Application of AQALs

The AQALs apply at areas of relevant exposure relevant to the assessment level. The following table extracted from Local Authority Air Quality Technical Guidance (2022) (LAQM.TG(22)) explains where the AQALs apply.

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

Table 1: Guidance on where AQALs apply

Averaging period	Objectives should apply at:	Objectives should generally not apply at:
Annual mean	All locations where members of the public might be regularly exposed. Building façades of residential properties, schools, hospitals, care homes etc.	Building façades of offices or other places of work where members of the public do not have regular access. Hotels, unless people live there as their permanent residence. Gardens of residential properties. Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short-term.
24-hour mean and 8-hour mean	All locations where the annual mean objective would apply, together with hotels. Gardens of residential properties.	Kerbside sites (as opposed to locations at the building façade), or any other location where public exposure is expected to be short-term.
1-hour mean	All locations where the annual mean and 24 and 8-hour mean objectives apply. Kerbside sites (for example, pavements of busy shopping streets). Those parts of car parks, bus stations and railway stations etc. which are not fully enclosed, where members of the public might reasonably be expected to spend one hour or more. Any outdoor locations where members of the public might reasonably be expected to spend one hour or longer.	Kerbside sites where the public would not be expected to have regular access.

3.4 Summary

The following tables summarise the AQALs and Critical Levels used in this assessment.

Table 2: Air Quality Assessment Levels (AQALs)

Pollutant	AQAL (µg/m³)	Averaging Period	Frequency of Exceedances	Source
Nitrogen dioxide	200	1 hour	18 times per year (99.79th percentile)	AAD Limit Value
	40	Annual	-	AAD Limit Value
Carbon monoxide	30,000	8 hours, running	-	AAD Limit Value
	10,000	1 hour	-	Air Emissions Guidance

Table 3: Critical Levels for the Protection of Vegetation and Ecosystems

Pollutant	Concentration (µg/m³)	Measured as	Source
Nitrogen oxides (as nitrogen dioxide)	75 / 200*	Daily mean	Air Emissions Guidance
	30	Annual mean	AQS Objective

Note:
**only for detailed assessments where the ozone is below the AOT40 Critical Level and sulphur dioxide is below the lower Critical Level of 10 µg/m³*
The *AOT40 for ozone is 6,000 µg/m³ calculated from accumulated hourly ozone concentrations – AOT40 means the sum of the difference between each hourly daytime (08:00 to 20:00 Central European Time (CET))) ozone concentration greater than 80 µg/m³ (40 ppb) and 80 µg/m³, for the period between 01 May and 31 July.*

In addition to the Critical Levels set out in the table above, APIS provides habitat specific Critical Loads for nitrogen and acid deposition. Full details of the applicable Critical Loads can be found in Section 10.2.

4 Assessment Criteria

4.1 Human health

The Air Emissions Guidance states that to screen out 'insignificant' process contributions:

- *the long-term PC must be less than 1% of the long-term environmental standard; and*
- *the short-term PC must be less than 10% of the short-term environmental standard.*

As part of this assessment, predicted process contributions have been compared to the AQALs provided in Section 3.

If the above criteria are achieved, it can be concluded that it is not likely that emissions would lead to significant environmental impacts and the process contributions can be screened out.

The long-term 1% process contribution threshold is based on the judgement that:

- it is unlikely that an emission at this level will make a significant contribution to air quality; and
- the threshold provides a substantial safety margin to protect health and the environment.

The short-term 10% process contribution threshold is based on the judgement that:

- spatial and temporal conditions mean that short-term process contributions are transient and limited in comparison with long-term process contributions; and
- the threshold provides a substantial safety margin to protect health and the environment.

For the purpose of this assessment, if the impact can be screened out as 'insignificant' at the point of maximum impact, further assessment is not required. If process contributions cannot be screened out, assessment will be undertaken for the following:

- the Predicted Environmental Concentration (PEC, defined as the process contribution plus the background concentration) at the point of maximum impact; and
- the process contribution and PEC at areas of public exposure.

If the long-term PEC is below 70% of the AQAL, or the short-term process contribution is less than 20% of the headroom[3], it can be concluded that "there is little risk of the PEC exceeding the AQAL", and the impact can be considered to be 'not significant'.

4.2 Ecology

The Air Emissions Guidance states that to screen out impacts as 'insignificant' at European and UK statutory designated sites:

- the long-term PC must be less than 1% of the long-term environmental standard (i.e. the Critical Level or Load); and
- the short-term PC must be less than 10% of the short-term environmental standard.

If the above criteria are met, no further assessment is required. If the long-term PC exceeds 1% of the long-term environmental standard, the PEC must be calculated and compared to the standard. If the resulting PEC is less than 70% of the long-term environmental standard, the Air Emissions Guidance states that the emissions are 'insignificant' and further assessment is not required. In accordance with the guidance, calculation of the PEC for short-term standards is not required.

[3] Calculated as the AQAL minus twice the long-term background concentration.

The Air Emissions Guidance states further that to screen out impacts as 'insignificant' at local nature sites[4]:

- the long-term PC must be less than 100% of the long-term environmental standard; and
- the short-term PC must be less than 100% of the short-term environmental standard.

In accordance with the guidance, calculation of the PEC for local nature sites is not required.

[4] National Nature Reserves (NNRs), Local Nature Reserves (LNRs), Local Wildlife Sites (LWSs) and ancient woodlands

5 Baseline Air Quality

The Facility is located in Rugby, within RBC's area of jurisdiction. Reference should be made to Figure 1 of Appendix A which shows the location of the Facility.

In this section the existing air quality monitoring and mapped background datasets has been reviewed and the appropriate concentrations to be used in the assessment have been determined.

5.1 Air quality review and assessment

Under Section 82 of the Environment Act (1995) (Part IV), local authorities are required to undertake an ongoing exercise to review air quality within their area of jurisdiction. As part of the review and assessment exercise, local authorities are required to identify areas of poor air quality and, if necessary, declare Air Quality Management Areas (AQMAs) and publish Air Quality Action Plans (AQAPs). RBC has declared an AQMA covering the entire urban area of Rugby due to recorded exceedances of the annual mean AQAL for nitrogen dioxide. This does not mean that AQAL has been exceeded or is currently exceeded across the entire area covered by the AQMA.

The Facility lies within the Rugby AQMA, so the impact on concentrations of nitrogen dioxide within the AQMA has been considered as part of this assessment. No other AQMAs lie within 5 km of the Facility.

The extent of the AQMA in the area surrounding the Facility is shown in Figure 2 of Appendix A.

5.2 Mapped background data

In order to assist local authorities with their responsibilities under Local Air Quality Management, the Department for the Environment Food and Rural Affairs (Defra) provides modelled background concentrations of pollutants throughout the UK on a 1 km by 1 km grid. This model is based on known pollution sources and background measurements and is used by local authorities in lieu of suitable monitoring data. Mapped background concentrations have been downloaded for the grid squares containing the Facility and the immediate surroundings.

The mapped background data is calibrated against monitoring data. For instance, the 2018 mapped background concentrations are based on 2018 meteorological data and are calibrated against monitoring undertaken in 2018. As a conservative approach, where mapped background data is used the concentration for the year against which the data was validated has been used. This eliminates any potential uncertainties over anticipated trends in future background concentrations.

Concentrations will vary over the modelling domain area, which extends up to 3 km from the Facility. Therefore, the maximum mapped background concentrations within the modelling domain (i.e., within 3 km) have been calculated. These are presented in Table 4 alongside the concentration for the grid square containing the Facility.

Table 4: Mapped Background Analysis

Pollutant	Concentration (µg/m³)		Dataset
	At Facility	Max in modelling domain	
Nitrogen dioxide	12.71	17.93	Defra 2018 Dataset
Carbon monoxide	340	343	Defra 2001 Dataset

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5.3 AURN and LAQM monitoring data

The UK Automatic Urban and Rural Network (AURN) is a country-wide network of air quality monitoring stations operated on behalf of Defra. The closest monitoring sites are well over 10 km from the Facility and not considered representative of baseline pollutant concentrations in the study area, so data from the AURN has not been considered in this assessment.

In addition to the national AURN, local authorities undertake monitoring of a range of pollutants as part of the LAQM review process. A review of RBC's 2022 Air Quality Annual Status Report (ASR) shows that in 2021 the council operated 53 non-automatic (nitrogen dioxide diffusion tube) locations. No continuous monitoring of nitrogen dioxide was undertaken. RBC is not required to monitor carbon monoxide.

Monitoring locations are broadly classified into 'roadside' and 'background' locations. 'Background' locations are typically sited so that no single pollutant source is dominant and are intended to be representative of background concentrations over several square kilometres. 'Roadside' sites are dominated by road traffic emissions and only representative of concentrations in the immediate vicinity of the analyser. Data from monitoring sites within 3 km of the Facility has been considered. The results from these locations are provided in Table 5 and the monitoring locations shown on Figure 2 of Appendix A. Any exceedances of the annual mean AQAL for nitrogen dioxide are highlighted.

Table 5: RBC Nitrogen Dioxide Monitoring Results

Ref	Distance from Facility (km)	Annual mean concentration (µg/m³)					
		Mapped Bg – 2018	2017	2018	2019	2020	2021
Background monitoring							
S3	3.0	10.0	12.2	14.2	13.1	9.5	9.3
S6	2.7	11.6	14.1	14.9	13.6	10.4	11.5
S12	1.5	13.4	21.3	19.6	20.9	14.3	13.3
S29	1.1	14.6	18.7	19.8	21.0	16.3	18.4
Roadside/kerbside monitoring							
S1	1.0	12.7	17.8	17.6	16.2	13.5	15.6
S8	2.0	17.9	29.3	30.0	28.0	26.9	24.3
S9	2.5	12.9	15.9	15.8	16.3	11.8	12.3
S10	2.5	17.9	34.8	30.8	35.7	25.7	26.4
S11	2.3	13.2	21.8	21.8	22.6	16.2	17.4
S13	1.3	15.6	36.5	34.8	33.5	26.7	26.5
S15	2.3	13.2	25.6	26.9	25.1	22.1	20.7
S20	1.7	17.9	26.7	27.8	26.0	19.5	20.2
S26	2.2	12.6	18.3	19.1	18.7	14.5	14.9
S27	2.0	13.2	21.3	18.2	21.2	14.4	14.9
S28	1.5	14.6	16.1	17.2	16.7	11.7	11.1
S30	2.0	12.9	32.3	34.5	33.0	20.8	25.9
S31	1.9	17.9	26.1	27.3	24.7	21.3	20.8

Ref	Distance from Facility (km)	Annual mean concentration (µg/m³)					
		Mapped Bg – 2018	2017	2018	2019	2020	2021
S32	2.1	17.9	28.2	29.3	27.4	21.1	21.2
S33	2.2	17.9	21.6	22.4	22.2	15.7	16.6
S34	2.2	17.9	25.5	24.8	23.1	15.2	17.1
S35	2.3	17.9	28.4	31.7	31.0	19.9	22.0
S36	2.6	17.9	29.5	28.9	29.8	24.2	26.8
S37	2.6	17.9	24.1	23.9	25.2	20.7	22.7
S38	2.8	12.9	25.7	26.5	25.1	17.1	19.5
S39	2.6	17.9	25.9	27.9	26.2	19.6	21.0
S40	2.5	17.9	30.5	26.5	28.3	22.1	23.9
S41	2.5	12.3	23.0	25.7	24.8	17.8	20.4
S43	2.6	12.3	25.2	25.9	26.3	19.1	20.0
S47	2.1	17.9	30.8	32.6	29.5	20.2	22.6
S48	2.2	17.9	34.3	31.0	34.1	23.1	22.3
S49	2.8	12.3	**43.7**	34.0	30.0	20.6	23.2
S54	2.5	12.3	**43.3**	38.7	**41.6**	28.5	31.8

Source: Rugby Borough Council 2022 ASR and

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Monitoring data from 2020 and 2021 will have been affected by the Covid-19 pandemic so less weighting has been given to monitoring results from these years.

None of these monitoring locations are close enough to the Facility to be significantly affected by any existing on-site sources, with the closest being approximately 1 km away. For 2017 – 2019, prior to the Covid-19 pandemic, the maximum monitored concentrations at background-type sites (i.e. away from significant road sources) were higher than the mapped background concentrations, indicating that the mapped background data might underestimate the background concentrations.

At roadside sites the monitored concentrations of nitrogen dioxide were much higher than the mapped background concentrations, although this is expected as they are affected by traffic emissions. Monitored concentrations exceeded the AQAL at roadside site S49 in 2017, and at roadside site S54 in 2017 and 2019.

5.4 Summary

5.4.1 Nitrogen dioxide

As shown in Table 4, the maximum mapped background concentration of nitrogen dioxide from within the modelling domain is 17.93 µg/m³, while Table 5 shows that the maximum from the last 5 years of monitoring at a local-authority background-type monitoring location within 5 km of the Facility was 21.3 µg/m³ (recorded S12 in 2017). As a conservative measure the maximum monitored background concentration from within the modelling domain (21.3 µg/m³) has been used as the baseline concentration for this assessment.

5.4.2 Carbon monoxide

As shown in Table 4, the maximum mapped background concentration from within the modelling domain is 343 µg/m³. The background data is for a base year of 2001 so likely over-estimates the concentrations. In lieu of any site-specific monitoring data or more recent background mapped data, this value has been used as the baseline concentration for this assessment.

5.4.3 Summary table

The baseline concentrations to be used in this assessment are summarised in Table 6 below.

Table 6: Summary of Baseline Concentrations

Pollutant	Concentration (µg/m³)	Justification
Nitrogen dioxide	21.3	Maximum monitored background concentration within modelling domain 2017 - 2021
Carbon monoxide	343	Maximum mapped background concentration within modelling domain – Defra 2001 dataset.

Further consideration will be given to the appropriate baseline concentrations at areas of relevant exposure where the impacts cannot be screened out as ‘insignificant’.

6 Sensitive Receptors

The general approach of this assessment is to evaluate the highest predicted process contribution to ground level concentrations, known as the point of maximum impact. In addition, the predicted process contribution at a number of sensitive receptors has been evaluated.

6.1 Human sensitive receptors

The human sensitive receptors identified for assessment are displayed in Figure 2 of Appendix A and listed in Table 7. These are the same receptors as used in the 2017 EP application for the energy centre.

Table 7: Human Sensitive Receptors

ID	Receptor Name	Location (m)		Distance from site (km)
		X	Y	
R1	Quarry Close	449815	277031	0.5
R2	Monarch Close	450645	277376	0.7
R3	Brownsover Hall	450707	277530	0.7
R4	Plantolf Place	449335	277215	0.7
R5	Oulton Road	450838	277054	1.0
R6	Riverside Academy	449370	276753	1.0
R7	Swift Avenue	450963	277824	1.0
R8	The Avon Valley School	449557	276545	1.1
R9	Lower Lodge Avenue	450953	278081	1.1
R10	Lower Lodge Farm	450937	278311	1.2
R11	Boughton Leigh School	451437	277172	1.5
R12	Cosford Hall Farm	449804	278990	1.5
R13	Rugby College	450872	276237	1.5
R14	Avocet Close	451370	278399	1.6
R15	Brownsover Community School	451765	277653	1.8
R16	Ashtree Farm	451186	279435	2.3
R17	Rugby School	450252	274998	2.5
R18	Lawrence Sheriff School	450768	275079	2.6

The impacts of emissions from the Facility have been assessed at these receptor locations and are discussed in Section 9. In addition, reference has been made to the plot files contained in Appendix A to assess the impacts at broader areas of relevant exposure.

6.2 Ecological sensitive receptors

A study was undertaken to identify the following sites of ecological importance in accordance with the Air Emissions Guidance criteria:

- Special Protection Areas (SPAs), Special Areas of Conservation (SACs), or Ramsar sites within 10 km of the Facility; and
- Sites of Special Scientific Interest (SSSIs) within 2 km of the Facility.
- Local nature sites within 2 km of the Facility.

The sensitive ecological sites that have been identified as a result of the study are shown in Figure 3 of Appendix A and listed in Table 8. These are the same receptors as used in the 2017 EP application for the energy centre.

Table 8: Sensitive Ecological Receptors

ID	Site	Designation	Location (closest point to Facility)		Distance from Facility at closest point (km)
			X	Y	
European and UK designated sites					
None identified					
European and UK designated sites					
E1	Swift Valley	LNR	450297	384025	0.3
E2	Newbold Quarry Park	LNR	449520	384600	0.6
E3	Ashlawn Cutting	LNR	451896	382808	2.0

The maximum process contribution at any grid output point within each designated site has been extracted to assess the greatest impact of emissions on each site. Reference should be made to Section 10 for full details of the habitats present at each site and the habitat-specific Critical Loads.

7 Dispersion Modelling Methodology

The Facility includes the following emissions points to air which are relevant to this assessment:

1. 30 m tall stack containing flues for Boiler 2 and Boiler 3 (A1); and
2. 40 m tall stack containing flues for Boiler 1 and the two CHP engines (A9)

Emissions from these sources have been included in the dispersion model.

7.1 Selection of dispersion model

Detailed dispersion modelling was undertaken using the model ADMS 6, developed and supplied by Cambridge Environmental Research Consultants (CERC). This is a new generation dispersion model, which characterises the atmospheric boundary layer in terms of the atmospheric stability and the boundary layer height. In addition, the model uses a skewed Gaussian distribution for dispersion under convective conditions, to take into account the skewed nature of turbulence. The model also includes modules to take account of the effect of buildings and complex terrain. ADMS is routinely used for modelling of emissions for planning and environmental permitting purposes to the satisfaction of the Environment Agency and local authorities.

7.2 Model inputs

7.2.1 Source and emissions data

Britvic has provided the 2022 emissions testing report which includes the flue temperature, moisture and oxygen content, volumetric flow rate and concentrations of oxides of nitrogen and carbon monoxide. During the emissions testing the CHP engines were operating close to full load. However, the boilers were not operating at full load. Details of the exact load or thermal input of the boilers during testing is not available. To determine the emission parameters at maximum load a combustion calculation has been undertaken based on the thermal input of the boilers (12.3 MWth each). The flow rate at reference conditions has been used to calculate the pollutant release rate, and the flue gas temperature and oxygen and moisture content from the monitoring report has been used to calculate the flow rate at actual conditions at full load.

Boiler 3 is currently mothballed but may be put into operation in the future. As Boiler 2 and Boiler 3 are identical, the emissions parameters from the monitoring of Boiler 2 have been used for Boiler 3. It has conservatively been assumed that all sources emit oxides of nitrogen at the maximum permitted ELVs detailed in the EP (or the MCDP, for Boiler 1). Carbon monoxide emissions have been modelled at the monitored values for the CHP engines. The monitoring report shows that carbon monoxide emissions from the boilers are below the limit of detection and will be negligible. Therefore, emissions of carbon monoxide from the boilers have been assumed to be zero.

The relevant pages of the emissions monitoring report are presented in Appendix B. The model input parameters are presented in Table 8.

Table 9: Source Data – 100% Load

Item	Unit	CHP 1	CHP 2	Boiler 1	Boiler 2	Boiler 3 [(1)]
Stack Data						
Stack height	m	40	40	40	30	30
Internal diameter	m	0.8	0.8	0.8	0.9	0.9
Permit emission point	N/A	A9			A1	
Location (centre point of stack)	m,m	449934,277517			449994,277513	
Flue Gas Conditions						
Temperature	^oC	219.2	186.6	100.3	92.4	92.4
Moisture content	% v/v	8.0%	8.0%	8.0%	8.0%	8.0%
Oxygen content	% v/v dry	10.7%	10.4%	3.8%	5.8%	5.8%
Reference oxygen content	% v/v dry	15%	15%	3%	3%	3%
Volume at actual conditions	Am^3/s	7.30	6.70	5.36	5.95	5.95
Volume at reference conditions [(1)]	Nm^3/s	6.30	6.40	3.45	3.45	3.45
Flue gas exit velocity	m/s	14.58	13.40	10.66	9.35	9.35
Pollutant Emissions Parameters						
NOx emission concentration	mg/Nm^3	95	95	200	100	100
Carbon monoxide emission concentration	mg/Nm^3	296	207	-	-	-
NOx emission rate	g/s	0.599	0.608	0.691	0.345	0.345
Carbon monoxide emission rate	g/s	1.865	1.324	-	-	-

Notes:

[(1)] Boiler 3 mothballed so no monitoring data available. Emissions parameters assumed to be the same as Boiler 2.

[(2)] Reference conditions 273K, 101.3 kPa, dry gas, reference oxygen content (3% for boilers, 15% for engines)

The emissions parameters in Table 9 are representative of each item of plant operating at full load. As detailed in section 1.2 the boilers typically operate at a much lower load. A sensitivity analysis has been run with the boilers operating at the parameters taken from the monitoring report in Appendix B. The source data for the boilers for this scenario (where different from Table 9) are presented in Table 10.

Table 10: Boiler Source Data – As Monitored

Item	Unit	Boiler 1	Boiler 2	Boiler 3[(1)]
Flue Gas Conditions				
Volume at actual conditions	Am^3/s	2.50	1.90	1.90
Volume at reference conditions[(1)]	Nm^3/s	1.60	1.10	1.10
Flue gas exit velocity	m/s	5.00	3.06	3.06
Pollutant Emissions Parameters				
NOx emission concentration	mg/Nm^3	200	100	100
NOx emission rate	g/s	0.32	0.11	0.11

Notes:
(1) Boiler 3 mothballed so no monitoring data available. Emissions parameters assumed to be the same as Boiler 2.
(2) Reference conditions 273K, 101.3 kPa, dry gas, 3% oxygen content.

The flues are grouped into two stacks. The CHP engines and Boiler 1 share one stack and Boiler 2 and Boiler 3 share another stack. The emissions points for each stack have been combined into a single source in the dispersion model using the ‘combine multiple flues’ option.

7.2.2 Operational hours

The Permitted Facility scenario has been run with a time varying emissions file, as detailed in Table 11. The Proposed Facility scenario has been run assuming continual operation of all three boilers and both CHP engines.

Table 11: Operational Hours Modelled

Item of Plant	Permitted Facility Run Hours	Proposed Facility Run Hours
Boiler 1	Monday – Friday (24/5 operation)	Continuous
Boiler 2	Monday – Friday (24/5 operation)	Continuous
Boiler 3	Saturday + Sunday (24/2 operation)	Continuous
CHP Engine 1	Monday – Friday (24/5 operation)	Continuous
CHP Engine 2	Monday – Friday (24/5 operation)	Continuous

7.2.3 Modelling domain

Modelling has been undertaken over a grid 6 x 6 km with grid spacing of 60 m, which is the same grid size a resolution used in the original EP application for the energy centre. The grid parameters are detailed in Table 12 and a visual representation of the modelling domain shown in Figure 4of Appendix A.

Table 12: Modelling Domain

Parameter	Value
Grid spacing (m)	60
Grid start X	447000
Grid finish X	453000
Grid start Y	274500
Grid finish Y	280500

The sensitivity of the model results to the choice of grid spacing has been considered in section 8.4.

7.2.4 Meteorological data and surface characteristics

The impact of meteorological data was taken into account by using weather data from the Church Lawford meteorological station for the years 2018 – 2022. Church Lawford is located approximately 5 km to the west of the Facility. This site has been selected as it is the closest and most representative site in the vicinity. The data was obtained from Air Pollution Services Limited. Five years of data have been used to take into account inter-annual fluctuations in weather conditions. Wind roses from Church Lawford for each year are presented in Figure 5 of Appendix A.

7.2.4.1 Surface roughness

The surface roughness length can be selected in ADMS for both the dispersion and the meteorological site. The surface roughness length varies considerably in the vicinity of the dispersion site, ranging from open pasture and grassland to built-up urban areas. To account for the varying surface roughness length a spatially-varying surface roughness file have been generated. The land-use class for each point in the file has been extracted from the CORINE Land Cover database[5] and cross-referenced with the most likely surface roughness length value[6].

The variable surface roughness file parameters are presented in Table 13 and Table 14 and a visual representation of the file shown in Figure 6 of Appendix A.

Table 13: Variable Surface Roughness File

Parameter	Value
Modelled resolution	64 x 64
Grid spacing (m)	50
Grid points	142
Grid Start X (m)	446475

5 https://land.copernicus.eu/pan-european/corine-land-cover

6 Taken from "Roughness length classification of Corine Land Cover classes", Megajoule Consultants, 2007.

Parameter	Value
Grid Finish X (m)	453525
Grid Start Y (m)	273975
Grid Finish Y (m)	281025

Table 14: Surface Roughness Lengths Used for Different Land Use Classes

Land use classification	Corine 2018 land use codes	Surface roughness length (m)
Continuous urban fabric	111	1.2
Broad-leafed forest, coniferous forest	311, 312	0.75
Discontinuous urban fabric	112	0.5
Non-irrigated arable land, inland marshes	211, 411	0.05
Natural grassland	323	0.03
Water(1)	511	0.0001
Notes: *(1) The 'most likely' value for water is given as zero. ADMS cannot model a surface roughness length of zero, so areas of water have been assigned a roughness length of 0.0001 m which is the value recommended by CERC for 'sea'.*		

The surface roughness length has been set to 0.3 m for the meteorological site. The value of 0.3 m is appropriate for agricultural areas and is suitable for the surroundings of the Church Lawford meteorological site. The sensitivity of the model results to the choice of dispersion site surface roughness length for the modelling domain has been considered in Section 8.1.

7.2.4.2 Monin-Obukhov length

The minimum Monin-Obukhov length for the dispersion site and the meteorological site can be specified in ADMS. This provides a measure of the stability of the atmosphere and indicates the height above which convective turbulence (i.e., thermal) is more important than mechanical (i.e., friction). This allows for the effect of the urban heat island, to prevent the atmosphere from ever becoming very stable, to be simulated within the model.

The minimum Monin-Obukhov length has been set to 30 m for the dispersion site and 1 m for the meteorological site. The value of 30 m is recommended by CERC as suitable for cities and large towns and is considered appropriate for the location of the dispersion site in Rugby. The value of 1 m is recommended for rural areas and is therefore considered appropriate for the Church Lawford meteorological site.

7.2.5 Terrain

It is recommended that, where gradients within 500 m of the modelling domain are greater than 1 in 10, the complex terrain module within ADMS (FLOWSTAR) should be used. A review of the local area indicates that these gradients are be present within the modelling domain. A terrain file has been produced with the same grid parameters as the surface roughness file detailed in Table 13. A visual representation of the terrain file is presented in Figure 7 of Appendix A. The sensitivity of the results to the inclusion of terrain effects has been considered in section 7.2.5.

7.2.6 Buildings

The presence of adjacent buildings can significantly affect the dispersion of the atmospheric emissions in the following ways.

- Wind blowing around a building distorts the flow and creates zones of turbulence. The increased turbulence can cause greater plume mixing.
- The rise and trajectory of the plume may be depressed slightly by the flow distortion. This downwash leads to higher ground level concentrations closer to the stack than those which would be present without the building.

The Environment Agency recommends that buildings should be included in the modelling if both:

- The buildings are within 5L of the stack (where L is the smaller of the building height and maximum projected width of the building); and
- The stack height is less than 2.5 times the height of the building.

The buildings included in the model are the same as for the EP application for the energy centre. The details of the buildings included within the model are presented in Table 15 and a site plan showing their location is presented in Figure 8 of Appendix A.

Table 15: Building Details

Buildings	Centre point		Height (m)	Width (m)	Length (m)	Angle (°)
	X (m)	Y (m)				
A	449978	277517	8.5	14	28.5	341
B	449978	277509	8.5	2	22	341
C	449981	277484	9	46	13	341
D	449995	277498	9	30	21	341
E	450001	277475	20	16	17	341
F	449994	277447	20	32	52	341
G	450009	277403	9	62	54	341
H	450029	277347	10.5	57.5	52	341
I	449948	277401	9.5	220	65	341
J	449959	277487	9.5	65	11	341
K	449903	277378	9.5	205	36	341
L	449826	277431	32	124	51	341
M	449851	277358	15	31	51	341
Silo	449942	277520	26	3.5	3.5	-

The “main building” in ADMS is that which is likely to have the greatest effect on emissions from the stack. The exact building geometry is input into the model. The model then assumes an effective building for each wind direction by taking the geometry from all the buildings inputted by the user and creates a single effective building. The height of this effective building is then set as the main building height. However, an alternative main building is automatically selected if for a certain wind direction the main building is too far from the plume centreline.

The warehouse to the west of the site (building L on Figure 8) has been chosen as the main building for emission point A9 and the 20m building (building F on Figure 8) as the main building for the emission point A1. These buildings are located up wind of the relevant stack for the prevailing winds. It is noted that this means that the model may be overestimating the effect from certain directions. However, the prevailing wind direction would mean that for the majority of the time these buildings would be the greatest influence on emissions from the stacks.

7.3 Chemistry

The plant will release nitric oxide (NO) and nitrogen dioxide (NO_2) which are collectively referred to as NO_x. In the atmosphere, a proportion of nitric oxide will be converted to nitrogen dioxide in a reaction with ozone which is influenced by solar radiation. Since the AQALs are expressed in terms of nitrogen dioxide, it is important to define the conversion rate of nitric oxide to nitrogen dioxide.

Ground level NO_x concentrations have been predicted through dispersion modelling. Nitrogen dioxide concentrations reported in the results section assume 70% conversion from NO_x to nitrogen dioxide for annual means and a 35% conversion for short-term (hourly) concentrations, based upon the worst-case scenario in the Environment Agency's methodology where the primary nitrogen dioxide to oxide of nitrogen ratio is less than 10%, as is the case for the boilers at the Facility. Given the short travel time to the areas of maximum concentrations, this approach is considered conservative.

7.4 Baseline concentrations

Background concentrations for the assessment have been derived from monitoring and national mapping as presented in section 5. For short term averaging periods, the background concentration has been assumed to be twice the long term ambient concentration in accordance with the Air Emissions Guidance methodology.

8 Sensitivity Analysis

8.1 Surface roughness length

The sensitivity of the results to surface roughness length has been considered by running the model with a range of surface roughness lengths for the dispersion site.

The following parameters were kept constant:

- model – ADMS 6;
- scenario - Proposed Facility at maximum load;
- grid spacing – 60 m;
- buildings – included;
- terrain – included at 64 x 64 resolution;
- meteorological site surface roughness – 0.3 m;
- dispersion site Minimum Monin-Obukhov length – 30 m;
- meteorological site Minimum Monin-Obukhov length – 1 m;
- meteorological data used – Church Lawford 2020.

Table 16 presents the concentration of oxides of nitrogen at the ground level point of maximum impact and at the maximum impacted receptor for each surface roughness value.

Table 16: Choice of Surface Roughness Length

Dispersion site surface roughness length (m)	Process contribution (µg/m³)					
	Point of maximum impact			Maximum impacted receptor		
	Annual mean	99.79%ile of 1-hour	Max 1-hour	Annual mean	99.79%ile of 1-hour	Max 1-hour
Spatially varying	**8.71**	**53.58**	**73.11**	**3.16**	**28.42**	**32.08**
0.2	9.11	59.17	82.94	3.18	29.21	37.07
0.3	8.68	56.37	76.84	3.17	26.65	35.56
0.5	8.29	51.83	56.95	3.18	24.85	33.47
0.7	8.24	49.05	57.03	3.18	24.09	31.78
1.0	8.22	49.29	57.13	3.18	23.41	29.96
% Change from spatially varying						
0.2	4.6%	10.4%	13.4%	0.5%	2.8%	15.5%
0.3	-0.4%	5.2%	5.1%	0.3%	-6.2%	10.8%
0.5	-4.8%	-3.3%	-22.1%	0.7%	-12.6%	4.3%
0.7	-5.4%	-8.4%	-22.0%	0.7%	-15.3%	-0.9%
1.0	-5.7%	-8.0%	-21.8%	0.7%	-17.6%	-6.6%

In general, higher surface roughness lengths result in lower annual mean and short-term concentrations at the point of maximum impact and maximum impacted receptor. The use of the spatially varying surface roughness file results in impacts fairly similar to a constant surface roughness length of 0.3 m. The varying surface roughness length file has been used as the model has been shown to be sensitive to the choice of surface roughness length, and the varying surface roughness length file is most representative of the different surface characteristics surroundings the Facility.

8.2 Terrain

The sensitivity of the results to the effect of terrain has been considered by running the model with and without a complex terrain file.

The following parameters have been kept constant:

- model – ADMS 6;
- scenario - Proposed Facility at maximum load;
- grid spacing – 60 m;
- buildings – included;
- dispersion site surface roughness – spatially varying at 64 x 64 resolution;
- meteorological site surface roughness – 0.3 m;
- dispersion site Minimum Monin-Obukhov length – 30 m;
- meteorological site Minimum Monin-Obukhov length – 1 m;
- meteorological data used – Church Lawford 2020.

The contribution of the Facility to the ground level concentrations of oxides of nitrogen at the point of maximum impact and at the maximum impacted receptor are presented in Table 17 for each scenario.

Table 17: Effect of Terrain

Scenario	Process contribution (µg/m³)					
	Point of maximum impact			Maximum impacted receptor		
	Annual mean	99.79%ile of 1-hour	Max 1-hour	Annual mean	99.79%ile of 1-hour	Max 1-hour
Including terrain	**8.71**	**53.58**	**73.11**	**3.16**	**28.42**	**32.08**
Excluding terrain	9.20	54.09	74.92	3.22	31.84	36.23
% change	5.6%	1.0%	2.5%	1.8%	12.0%	12.9%

Modelling the effect of terrain results in slightly lower concentrations at the point of maximum impact and at the maximum impacted receptor. As the model results show some sensitivity to the effect of terrain, the terrain file has been used in the main model runs as this is the most realistic approach.

8.3 Building parameters

The sensitivity of the results to the effect of buildings has been considered by running the model with and without buildings.

The following parameters were kept constant:

- model – ADMS 6;
- scenario - Proposed Facility at maximum load;

- grid spacing – 60 m;
- terrain – included at 64 x 64 resolution;
- dispersion site surface roughness – spatially varying at 64 x 64 resolution;
- meteorological site surface roughness – 0.3 m
- dispersion site Minimum Monin-Obukhov length – 30 m;
- meteorological site Minimum Monin-Obukhov length – 1 m;
- meteorological data used – Church Lawford 2020.

The contribution of the Facility to the ground level concentrations of oxides of nitrogen at the point of maximum impact and at the maximum impacted receptor are presented in Table 18 for each scenario.

Table 18: Effect of Buildings

Scenario	Process contribution (µg/m³)					
	Point of maximum impact			Maximum impacted receptor		
	Annual mean	99.79%ile of 1-hour	Max 1-hour	Annual mean	99.79%ile of 1-hour	Max 1-hour
Including buildings	**8.71**	**53.58**	**73.11**	**3.16**	**28.42**	**32.08**
Excluding buildings	1.70	28.14	51.91	1.62	15.61	22.64
% change	-80.5%	-47.5%	-29.0%	-48.7%	-45.1%	-29.4%

Modelling the presence of buildings results in higher annual mean and short-term concentrations. Buildings have been included in the dispersion model as this represents a realistic approach.

8.4 Grid resolution

The sensitivity of the results to the choice of output grid resolution has been considered by running the model with the 60 m grid spacing detailed in Table 12 and with a finer resolution of 20 m.

The following parameters were kept constant:

- model – ADMS 6;
- scenario - Proposed Facility at maximum load;
- terrain – included at 64 x 64 resolution;
- buildings – included;
- dispersion site surface roughness – spatially varying at 64 x 64 resolution;
- meteorological site surface roughness – 0.3 m
- dispersion site Minimum Monin-Obukhov length – 30 m;
- meteorological site Minimum Monin-Obukhov length – 1 m;
- meteorological data used – Church Lawford 2020.

The contribution of the Facility to the ground level concentrations of oxides of nitrogen at the point of maximum impact are presented in Table 19 for each scenario.

Table 19: Effect of Grid Resolution

Scenario used in model	Oxides of nitrogen PC (µg/m³)		
	Annual mean	99.79%ile of 1-hour mean	Max 1-hour mean
Point of maximum impact			
60 m grid	**8.71**	**53.58**	**73.11**
20 m grid	9.06	55.11	84.39
% change	4.0%	2.9%	15.4%

Modelling a finer grid of 20 m resolution results in slightly higher maximum annual mean and short-term concentrations being captured. The change for annual mean and 99.79%ile of hourly mean concentrations is negligible. For maximum hourly mean concentrations the finer grid captures a concentration approximately 15% higher; however as there is no AQAL relating to the maximum hourly concentration of oxides of nitrogen or nitrogen dioxide, it is considered that no potentially significant effects would be missed with a grid resolution of 60 m. Therefore, the 60 m resolution is considered fine enough to accurately represent process emissions from the Facility. The choice of grid resolution does not affect the results at individual receptor points.

8.5 Operating below the design point

Dispersion modelling has been undertaken using the emission parameters based on all items of plant continually operating at the maximum thermal input. The CHP engines run close to or at maximum load. However, the load on the boilers is variable. When the load falls, the volumetric flow rate and the exit velocity of the exhaust gases would reduce. The effect of this would be to decrease the quantity of pollutants emitted but also to reduce the buoyancy of the plume due to momentum. The reduction in buoyancy, which would lead to reduced dispersion, would be offset by the decrease in the amount of pollutants being emitted.

To determine whether the impact could be significantly higher at a lower loading on the boilers, the model has been run with the flue gas parameters taken directly from the monitoring report as shown in Appendix B, assuming continual operation of all items of plant. The exact thermal input of the boilers at the time of the monitoring is not known; however, based on the steam pressure setting during the emissions testing and the flow rates compared to the design flow rate, the load on the boilers is estimated to be 40 – 50% of the maximum.

The following parameters were kept constant:

- model – ADMS 6;
- grid spacing – 60 m;
- terrain – included at 64 x 64 resolution;
- buildings – included;
- dispersion site surface roughness – spatially varying at 64 x 64 resolution;
- meteorological site surface roughness – 0.3 m
- dispersion site Minimum Monin-Obukhov length – 30 m;
- meteorological site Minimum Monin-Obukhov length – 1 m;
- meteorological data used – Church Lawford 2020.

The contribution of the Facility to the ground level concentrations of oxides of nitrogen at the point of maximum impact and at the maximum impacted receptor are presented in Table 20 for each scenario.

Table 20: Effect of Boiler Loading

Scenario	Process contribution (µg/m³)					
	Point of maximum impact			Maximum impacted receptor		
	Annual mean	99.79%ile of 1-hour	Max 1-hour	Annual mean	99.79%ile of 1-hour	Max 1-hour
Maximum load	**8.71**	**53.58**	**73.11**	**3.16**	**28.42**	**32.08**
Monitored load	6.11	36.95	54.98	2.14	20.24	22.60
% change	-29.9%	-31.0%	-24.8%	-32.1%	-28.8%	-29.5%

As shown, the impact is higher for the maximum load scenario in all cases. Therefore, the maximum load scenario is considered to be ‘worst-case’ and has been used in the main model runs.

8.6 Summary

In summary, the remainder of this assessment has been based on the following assumptions:

- model – ADMS 6;
- scenarios – Permitted Facility and Proposed Facility at maximum load;
- grid spacing – 60 m;
- terrain – included at 64 x 64 resolution;
- buildings – included;
- dispersion site surface roughness – spatially varying at 64 x 64 resolution;
- meteorological site surface roughness – 0.3 m
- dispersion site Minimum Monin-Obukhov length – 30 m;
- meteorological site Minimum Monin-Obukhov length – 1 m;
- meteorological data used – Church Lawford 2020.

9 Impact on Human Health

The general approach of this assessment is to evaluate the highest predicted process contribution to ground level concentrations over the five modelled years (2018 - 2022), known as the point of maximum impact. In addition, the predicted impacts have been evaluated at the human sensitive receptors presented in Section 6.

Short-term impacts have been assessed as follows:

- As shown in Table 11, when modelling emissions from the Permitted Facility, Boiler 3 is only operational at weekends when all other items of plant are off. Therefore, the maximum permitted short-term nitrogen dioxide impact will be due to the CHP engines and the other two boilers.
- For the Proposed Facility the maximum short-term nitrogen dioxide impact is based on all items of plant operating continually. Therefore, the short-term nitrogen dioxide impact is higher for the Permitted Facility than the Proposed Facility as emissions from Boiler 3 are included.
- Emissions of carbon monoxide from the boilers are shown to be effectively zero (see emissions monitoring report, Appendix B). Therefore, the only source of carbon monoxide emissions is the CHP engines. Under the assumption that the CHP engines are operational during the worst-case weather conditions for dispersion, there is no change in carbon monoxide impact between the Permitted Facility and the Proposed Facility.

9.1 Results

9.1.1 At the point of maximum impact

The modelling results at the point of maximum impact are presented in Table 21. The results presented include emissions from all sources. Any changes in impact that cannot be screened out as ‘insignificant’ are highlighted, as are any predicted exceedances of any AQAL.

Table 21: Dispersion Modelling Results – Point of Maximum Impact

Pollutant	Quantity	Units	AQAL	Bg Conc.	Process contribution (PC)				Change in PC		Max PEC – Proposed Facility	
					Permitted Facility		Proposed Facility		Conc.	% of AQAL	Conc.	% of AQAL
					Conc.	% of AQAL	Conc.	% of AQAL				
Nitrogen dioxide	Annual mean	µg/m³	40	21.3	3.69	**9.23%**	6.10	**15.25%**	2.41	**6.02%**	27.40	68.50%
	99.79th %ile of hourly means	µg/m³	200	42.6	15.63	7.82%	19.55	9.77%	3.91	1.96%	62.15	31.07%
Carbon monoxide	8-hour running mean	µg/m³	10,000	646	57.10	0.57%	57.10	0.57%	0.00	0.00%	743.10	7.43%
	Hourly mean	µg/m³	30,000	646	111.21	0.37%	111.21	0.37%	0.00	0.00%	797.21	2.66%

Note
Based on the maximum PC across the 5 years of modelled weather data. Detailed results for each year of weather data are presented in Appendix C.

As shown in Table 21, the maximum PC and the change in PC can be screened out as 'insignificant' for all pollutants and averaging periods, with the exception of annual mean nitrogen dioxide. Further assessment of annual mean nitrogen dioxide impacts at areas of relevant exposure has been undertaken.

9.1.2 Further assessment

Table 22 sets out the maximum results over the five modelled years (2018 - 2022) at the identified receptor locations. PCs or changes in PCs that do not screen out as 'insignificant' in accordance with Environment Agency guidance are highlighted. The PEC includes the assumed background concentration of 21.3 µg/m³.

Table 22: Receptor Results – Annual Mean Nitrogen Dioxide

Ref	PC – Permitted Facility		PC – Proposed Facility		Change in PC		PEC – Proposed Facility	
	µg/m³	% of AQAL	µg/m³	% of AQAL	µg/m³	% AQAL	µg/m³	% of AQAL
R1	0.17	0.43%	0.28	0.71%	0.11	0.28%	21.58	53.96%
R2	0.21	0.53%	0.35	0.88%	0.14	0.35%	21.65	54.13%
R3	0.35	0.88%	0.55	**1.38%**	0.20	0.51%	21.85	54.63%
R4	0.34	0.86%	0.56	**1.41%**	0.22	0.55%	21.86	54.66%
R5	0.12	0.30%	0.19	0.47%	0.07	0.17%	21.49	53.72%
R6	0.23	0.57%	0.35	0.87%	0.12	0.30%	21.65	54.12%
R7	0.39	0.98%	0.56	**1.41%**	0.17	0.43%	21.86	54.66%
R8	0.13	0.33%	0.20	0.51%	0.07	0.18%	21.50	53.76%
R9	0.45	**1.12%**	0.65	**1.63%**	0.20	0.51%	21.95	54.88%
R10	0.44	**1.10%**	0.64	**1.60%**	0.20	0.51%	21.94	54.85%
R11	0.09	0.24%	0.14	0.36%	0.05	0.13%	21.44	53.61%
R12	0.11	0.28%	0.18	0.44%	0.06	0.16%	21.48	53.69%
R13	0.09	0.23%	0.14	0.36%	0.05	0.13%	21.44	53.61%
R14	0.30	0.74%	0.43	**1.09%**	0.14	0.34%	21.73	54.34%
R15	0.16	0.40%	0.24	0.59%	0.08	0.19%	21.54	53.84%
R16	0.17	0.43%	0.26	0.66%	0.09	0.23%	21.56	53.91%
R17	0.05	0.12%	0.07	0.19%	0.03	0.07%	21.37	53.44%
R18	0.05	0.13%	0.08	0.20%	0.03	0.07%	21.38	53.45%

As shown, at all identified sensitive receptor locations, the change in PC is less than 1% of the AQAL and is screened out as 'insignificant'. The PC from the Proposed Facility exceeds 1% of the AQAL at 6 receptor locations: R3, R4, R7, R9, R10, and R14.

A plot file of the annual mean nitrogen dioxide PC for the Permitted Facility and the Proposed Facility is presented in Figure 9 of Appendix A. As shown, there are no monitoring locations within the area where the PC from the Proposed Facility exceeds 1% of the AQAL. The closest monitoring locations are the roadside site S1 and the urban background sites S29 and S12. The highest concentration recorded at any of these sites in the last 5 years of monitoring data is 21.3 µg/m³ at S12, which is the baseline concentration selected for the assessment as detailed in section 5. Therefore, it is considered that the PECs presented in Table 22 are unlikely to be exceeded at any receptor location or area of relevant exposure where the PC from the Proposed Facility exceeds 1% of the AQAL. As the PEC at all receptors and areas of relevant exposure where the PC exceeds 1% of the AQAL is less than 70% of the AQAL, it is concluded that the impact is 'not significant'.

9.1.3 MCPD compliance

As noted in section 1.2, Boiler 1 is not subject to any ELVs in the current EP. It will be required to comply with the conditions of the MCPD from 1 January 2025. The impact of the boiler operating at the MCPD limit for oxides of nitrogen of 200 mg/Nm³ (for existing boilers of thermal input greater than 5 MWth) has been assessed by running the dispersion model for emission point A9 only (Boiler 1 and the CHP engines). As the CHP engines are anticipated to run almost continuously, the effect of their flue gas flow on the combined buoyancy and momentum from emission point A9 has been retained, but their NOx emissions set to zero to assess the impact of emissions from Boiler 1 alone.

As shown in Table 21, even with all items of plant operating at full load, the short-term nitrogen dioxide PC from the Proposed Facility is less than 10% of the AQAL and can be screened out as 'insignificant'. It therefore follows that the short-term impact of Boiler 1 is also less than 10% of the AQAL and is 'insignificant'. Therefore, this analysis has only considered the annual mean impact.

The results at the point of maximum impact and at receptors are shown in Table 23.

Table 23: Dispersion Modelling Results – Boiler 1 MCPD Compliance

Ref	Annual Mean PC – Boiler 1 Only		PEC – Proposed Facility(1)	
	µg/m³	% of AQAL	µg/m³	% of AQAL
Max	1.28	**3.20%**	27.40	68.50%
R1	0.05	0.13%	21.58	53.96%
R2	0.07	0.18%	21.65	54.13%
R3	0.12	0.29%	21.85	54.63%
R4	0.13	0.32%	21.86	54.66%
R5	0.04	0.10%	21.49	53.72%
R6	0.08	0.21%	21.65	54.12%
R7	0.13	0.33%	21.86	54.66%
R8	0.04	0.11%	21.50	53.76%
R9	0.15	0.39%	21.95	54.88%
R10	0.16	0.39%	21.94	54.85%
R11	0.03	0.08%	21.44	53.61%
R12	0.04	0.10%	21.48	53.69%
R13	0.03	0.08%	21.44	53.61%
R14	0.11	0.27%	21.73	54.34%
R15	0.06	0.14%	21.54	53.84%
R16	0.06	0.16%	21.56	53.91%
R17	0.02	0.04%	21.37	53.44%

Ref	Annual Mean PC – Boiler 1 Only		PEC – Proposed Facility(1)	
	µg/m³	% of AQAL	µg/m³	% of AQAL
R18	0.02	0.05%	21.38	53.45%
Note: *(1) Includes PC from all items of plant operating continuously at maximum load*				

As shown, the PC from Boiler 1 cannot be screened out at the point of maximum impact. However, the PC is less than 1% of the AQAL at receptor locations and can be screened out as ‘insignificant’.

10 Impact at Ecological Receptors

This section provides an assessment of the impact of emissions at the ecological receptors identified in Section 6.2.

10.1 Atmospheric emissions

In addition to the objectives for the protection of human health, the AQS includes Critical Levels for the protection of ecosystems as presented in section 3.1. The predicted contribution to concentrations of oxides of nitrogen has been compared to these Critical Levels.

In accordance with EA guidance, where the change in PC is less than 100% of the long-term or short-term Critical Level at a local nature site, the change in impact can be screened out as 'insignificant' and no further assessment is required. Where the change in PC exceeds these screening criteria, further assessment to has been undertaken to calculate the PEC. No European or UK sites have been identified within the screening criteria.

Using the same approach as detailed in section 9.1, the impact of the Proposed Facility has been compared to the impact of the Permitted Facility. The oxides of nitrogen PC has been calculated based on the maximum predicted using all five years of weather data and the results are shown in Table 24 and Table 25.

Table 24: Annual Mean Oxides of Nitrogen Impact at Ecological Sites

Ref	Site	Annual mean PC				Change in PC	
		Permitted Facility		Proposed Facility		µg/m³	% of CL
		µg/m³	% of CL	µg/m³	% of CL		
E1	Swift Valley LNR	1.96	6.53%	3.16	10.53%	1.20	4.01%
E2	Newbold Quarry Park LNR	0.70	2.34%	1.07	3.58%	0.37	1.24%
E3	Ashlawn Cutting LNR	0.10	0.32%	0.14	0.48%	0.05	0.16%

Table 25: Maximum Daily Oxides of Nitrogen Impact at Ecological Sites

Ref	Site	Max daily mean PC				Change in PC	
		Permitted Facility		Proposed Facility		µg/m³	% of CL
		µg/m³	% of CL	µg/m³	% of CL		
E1	Swift Valley LNR	14.54	19.39%	17.56	23.42%	3.02	4.03%
E2	Newbold Quarry Park LNR	10.92	14.56%	12.51	16.68%	1.58	2.11%
E3	Ashlawn Cutting LNR	1.30	1.74%	1.59	2.12%	0.29	0.38%
Note: The lower Critical Level of 75 mg/m^3 has been applied.							

As shown, both the PC from the Proposed Facility and the change in PC are less than 100% of the Critical Level at all ecological receptors and is screened out as 'insignificant'.

10.2 Deposition of emissions

10.2.1 Critical Loads

APIS provides Critical Loads for nature conservation sites at risk from acidification and nitrogen deposition (eutrophication). The APIS search by location tool has been used to identify the habitat specific Critical Load for the specific grid (i.e. the point of maximum impact with the designated site). Table 26 summarises the Critical Loads for nitrogen and acid deposition as detailed in APIS for 'grassland' habitat types, as identified for the ecological receptors and assessed as part of the 2017 EP application for the energy centre.

Table 26: Nitrogen Deposition Critical Loads

Site	Habitat Type	N Dep (kgN/ha/yr)	Acid Dep (keq/ha/yr)		
			CLminN	CLmaxN	CLmaxS
Swift Valley	Grassland	10	1.071	5.071	4
Newbold Quarry Park		10	1.071	5.071	4
Ashlawn Cutting		10	1.071	5.071	4

10.2.2 Calculation methodology – nitrogen deposition

The impact of deposition has been assessed using the methodology detailed within the Habitats Directive AQTAG 6 (March 2014) modified to only consider impacts of emissions of oxides of nitrogen. The steps to this method are as follows.

1. Determine the annual mean ground level concentrations of nitrogen dioxide at each site.
2. Calculate the dry deposition flux (µg/m^2/s) at each site by multiplying the annual mean ground level concentration by the relevant deposition velocity presented in Table 27.
3. Convert the dry deposition flux into units of kgN/ha/yr using the conversion factors presented in Table 27.
4. Compare this result to the nitrogen deposition Critical Load.

Table 27: Deposition Factors

Pollutant	Deposition Velocity (m/s)		Conversion Factor (µg/m^2/s to kg/ha/year)
	Grassland	Woodland	
Nitrogen dioxide	0.0015	0.003	96.0

10.2.3 Calculation methodology – acidification

Deposition of nitrogen, sulphur, hydrogen chloride and ammonia can cause acidification and should be taken into consideration when assessing the impact of the Facility. However, of these the Facility will only include emissions of oxides of nitrogen. Therefore, the steps have been modified to only consider emissions of oxides of nitrogen.

The steps to determine the acid deposition flux are as follows.

1. Determine the dry deposition rate in kg/ha/yr of nitrogen using the methodology outlined in Section 10.2.2.

2. Apply the conversion factor for N outlined in Table 28 to the nitrogen deposition rate in kg/ha/year to determine the total keq N/ha/year.
3. Plot the results against the Critical Load functions.

Table 28: Deposition Factors

Pollutant	Conversion Factor (kg/ha/year to keq/ha/year)
Nitrogen	Divide by 14

The contribution from the Facility has been calculated using the APIS formula:

Where PEC N Deposition < CLminN:

PC as % of CL function = PC S deposition / CLmaxS

Where PEC N Deposition > CLminN:

PC as % of CL function = (PC S + N deposition) / CLmaxN

10.2.4 Results – deposition of emissions

The results of the deposition analysis are presented in Table 29.

Table 29: Detailed Results – Nitrogen Deposition

Site	Deposition Velocity	Nitrogen Dioxide (µg/m³)	Permitted Facility		Proposed Facility		Change	
			kgN/ha/yr	% of Critical Load	kgN/ha/yr	% of Critical Load	kgN/ha/yr	% of Critical Load
Swift Valley	Grassland	1.37	0.20	1.97%	0.32	3.19%	0.12	1.21%
Newbold Quarry Park	Grassland	0.49	0.07	0.71%	0.11	1.08%	0.04	0.38%
Ashlawn Cutting	Grassland	0.07	0.01	0.10%	0.01	0.15%	0.00	0.05%

Table 30: Detailed Results – Acid Deposition

Site	Deposition Velocity	Nitrogen Dioxide (µg/m³)	Permitted Facility		Proposed Facility		Change	
			keq/ha/yr	% of CLmaxN	keq/ha/yr	% of CLmaxN	keq/ha/yr	% of CLmaxN
Swift Valley	Grassland	1.37	0.014	0.28%	0.023	0.45%	0.01	0.17%
Newbold Quarry Park	Grassland	0.49	0.005	0.10%	0.008	0.15%	0.00	0.05%
Ashlawn Cutting	Grassland	0.07	0.001	0.01%	0.001	0.02%	0.00	0.01%

As shown, both the PC from the Proposed Facility and the change in PC are less than 100% of the Critical Level at all ecological receptors and is screened out as ‘insignificant’.

10.3 MCPD compliance

The contribution from Boiler 1 operating at the maximum ELV permitted under the MCPD has been included in the results presented in sections 10.1 and 10.2.4 which show that the PC from the Proposed Facility is less than 100% of the relevant Critical Levels and Loads and is ‘insignificant’. It follows that the impact of Boiler 1 alone is also less than 100% of the relevant Critical Levels and Loads and is ‘insignificant’.

11 Conclusions

This Dispersion Modelling Assessment has been undertaken to support the EP variation application for the proposed changes to the energy centre at Britvic's Soft Drinks Installation at Rugby. The proposed variation is to allow all items of plant to operate continually. In addition, Boiler 1 will have to comply with the conditions of the MCPD by 1 January 2025. The contribution of Boiler 1 alone to pollutant concentrations has also been assessed.

Dispersion modelling of emissions from the energy centre has been undertaken based on the assumption that the Facility will operate as currently permitted at full load in the Permitted Facility scenario and will operate continually at full load in the Proposed Facility scenario.

This assessment has included a review of baseline pollution levels, dispersion modelling of emissions and quantification of the impact of these emissions on local air quality.

The primary conclusions of the assessment are as follows:

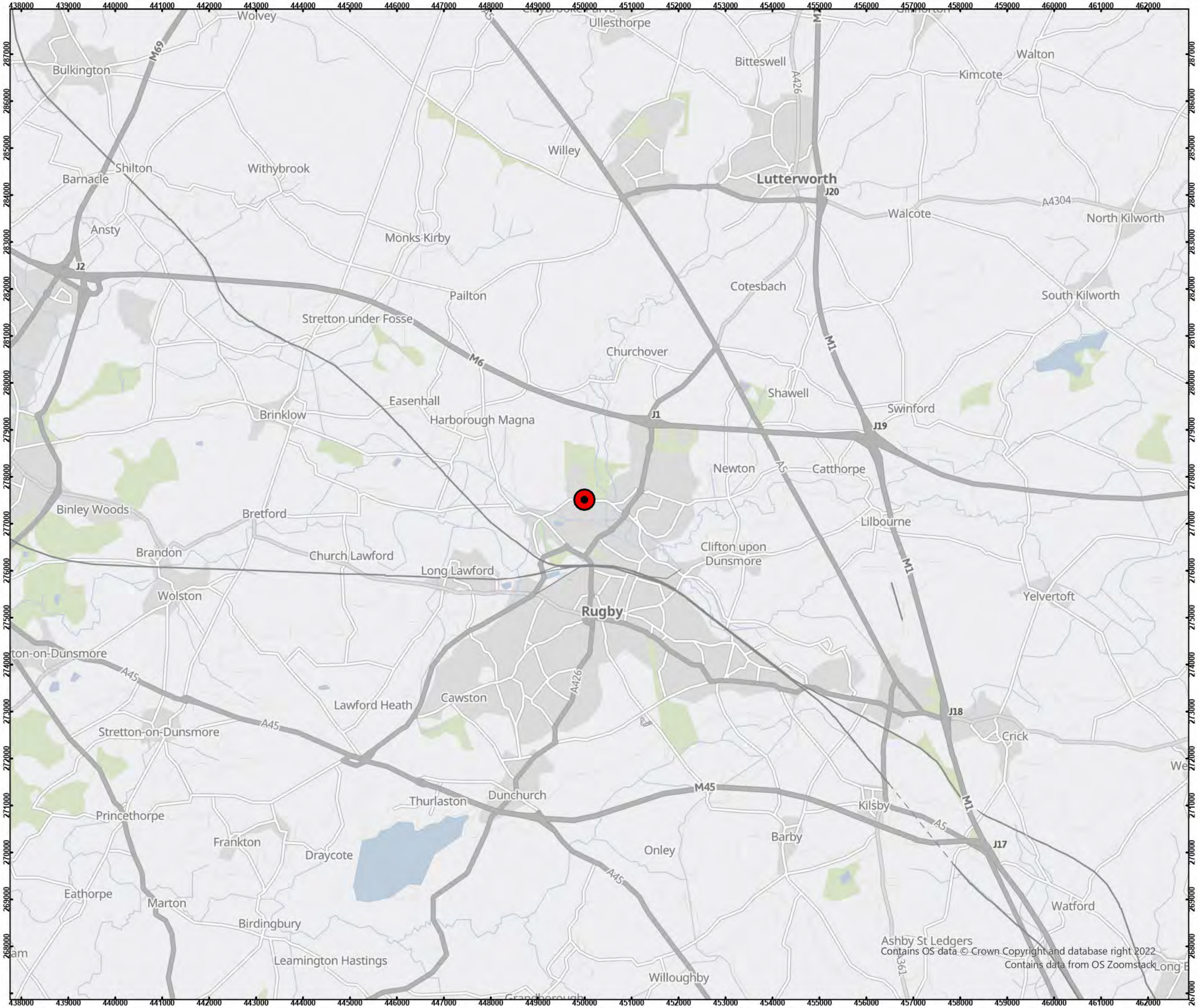
1. No exceedance of any AQAL is predicted.
2. The change in impact of all long-term and short-term process emissions between the Proposed Facility and the Permitted Facility is either screened out as 'insignificant', or can be considered 'not significant' when the PEC is considered, at all receptor locations and areas of relevant exposure.
3. The overall impact of all long-term and short-term process emissions from the Proposed Facility is either 'insignificant', or 'not significant' when the PEC is considered, at all areas of relevant exposure.
4. In relation to the impact at identified sensitive ecological sites, the process contribution to airborne concentrations and nitrogen and acid deposition from the Proposed Facility is screened out as 'insignificant'. It follows that the change in impact is also 'insignificant'.
5. The impact on human and ecological receptors of Boiler 1 operating at the maximum ELV for oxides of nitrogen permitted under the MCPD is 'insignificant'.

As such, based on the conservative assumptions used in the modelling study and the change in impact being 'insignificant' at all areas of relevant exposure for all pollutants and averaging periods, no significant air quality effects are predicted as a result of the proposals.

In summary, emissions from the Facility following the proposed variation to the EP would not have a significant impact on local air quality, the general population or the local community. As such there should be no air quality constraint in granting the EP variation.

Appendices

A Figures



Legend

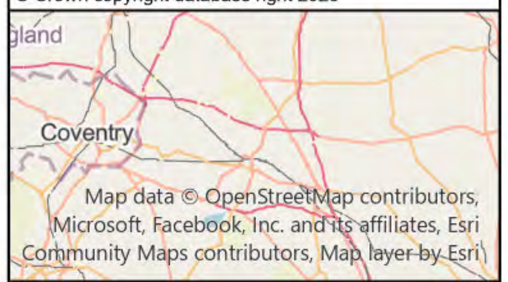
Site Location

Client:	Britvic
Site:	Rugby Soft Drinks Installation
Project:	2319 EP Variation Dispersion Modelling

Title:

Figure 1. Site Location

Drawn by: SMN | Date: 24/05/2023



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Scale: 1:75,307

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Kingsgate, Wellington Road North,
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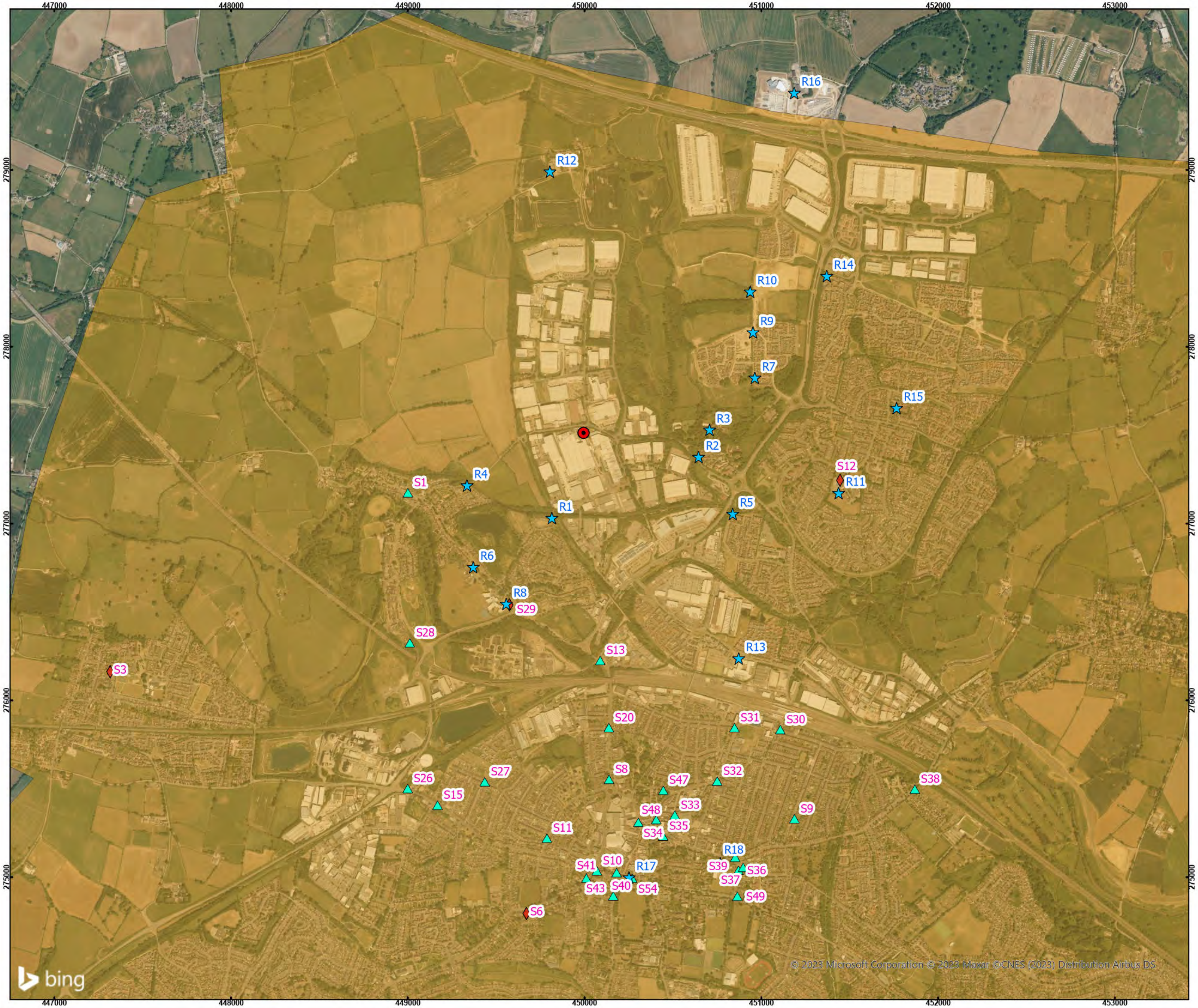
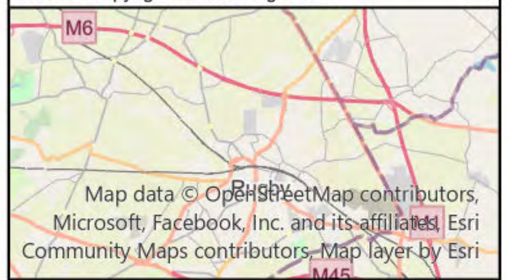


Client:	Britvic
Site:	Rugby Soft Drinks Installation
Project:	2319 EP Variation Dispersion Modelling
Title:	

Figure 2. Human Receptors, Monitoring Locations, and AQMA

Drawn by: SMN | Date: 24/05/2023



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Scale: 1:20,000

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Client:	Britvic
Site:	Rugby Soft Drinks Installation
Project:	2319 EP Variation Dispersion Modelling
Title:	

Figure 3. Ecological Receptors

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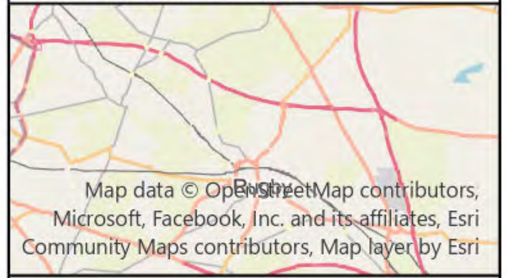
Legend

- A1
- A9
- Output grid extent

Client:	Britvic
Site:	Rugby Soft Drinks Installation
Project:	2319 EP Variation Dispersion Modelling
Title:	

Figure 4. Modelling Domain

Drawn by: SMN	Date: 24/05/2023



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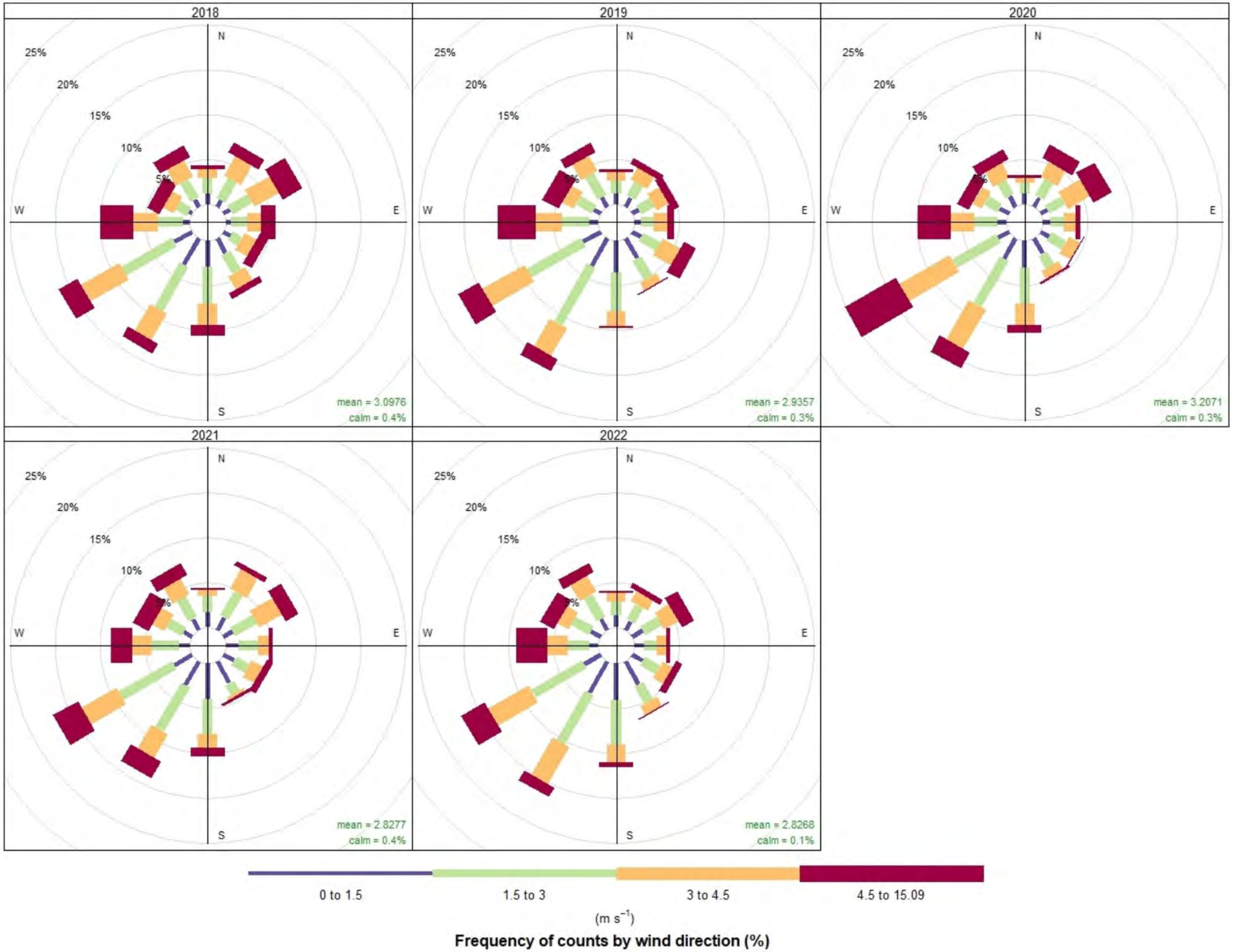

Client:	Britvic
Site:	Rugby Soft Drinks Installation
Project:	2319 EP Variation Dispersion Modelling
Title:	

Figure 5. Wind Roses Church Lawford 2018 - 2022

Drawn by: SMN	Date: 25/05/2023

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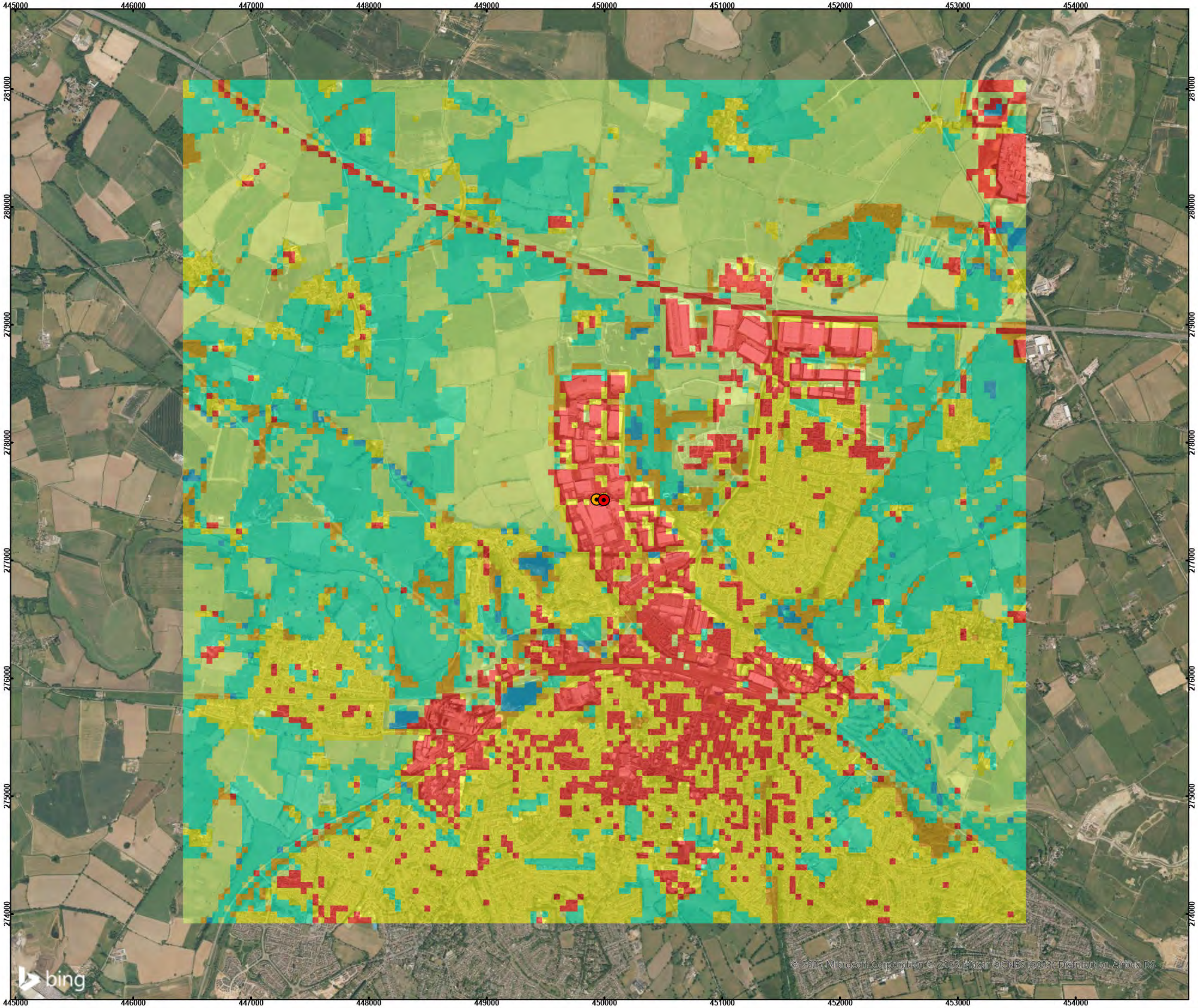


Legend

- A1
- A9

Surface Roughness Length (m)

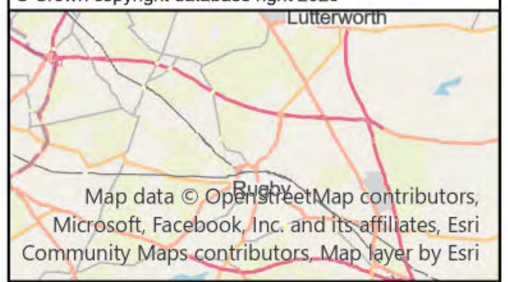
- 1.2
- 0.75
- 0.5
- 0.05
- 0.03
- 0.0001

Client:	Britvic
Site:	Rugby Soft Drinks Installation
Project:	2319 EP Variation Dispersion Modelling

Title:

Figure 6. Spatially Varying Surface Roughness File

Drawn by: SMN	Date: 24/05/2023



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N

Scale: 1:30,000

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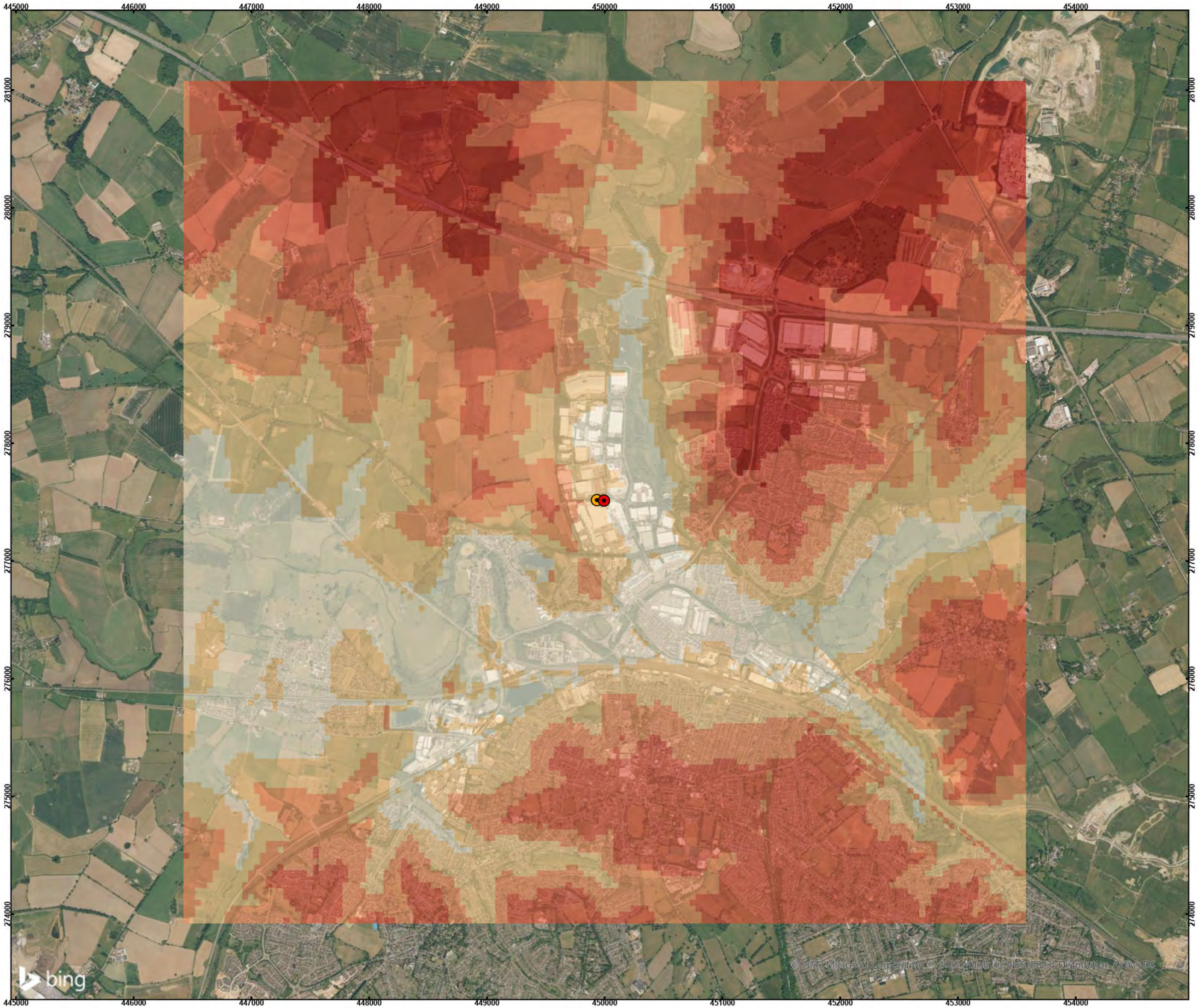


Legend

A1

A9

Terrain File Elevation

<90 m

90 - 100 m

100 - 110 m

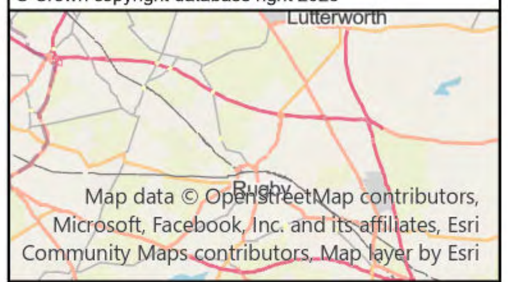
110 - 125 m

>125 m

Client:	Britvic
Site:	Rugby Soft Drinks Installation
Project:	2319 EP Variation Dispersion Modelling
Title:	

Figure 7. Terrain File

Drawn by: SMN | Date: 24/05/2023



0 0.3 0.6 1.2 km

N

Scale: 1:30,000

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Legend

- A1
- A9
- Buildings Modelled

Client:	Britvic
Site:	Rugby Soft Drinks Installation
Project:	2319 EP Variation Dispersion Modelling
Title:	Figure 8. Buildings Modelled
Drawn by: SMN	Date: 24/05/2023

Map data © OpenStreetMap contributors, Microsoft, Facebook, Inc. and its affiliates, Esri Community Maps contributors, Map layer by Esri

0 0.02 0.04 0.07 km

N

Scale: 1:1,700

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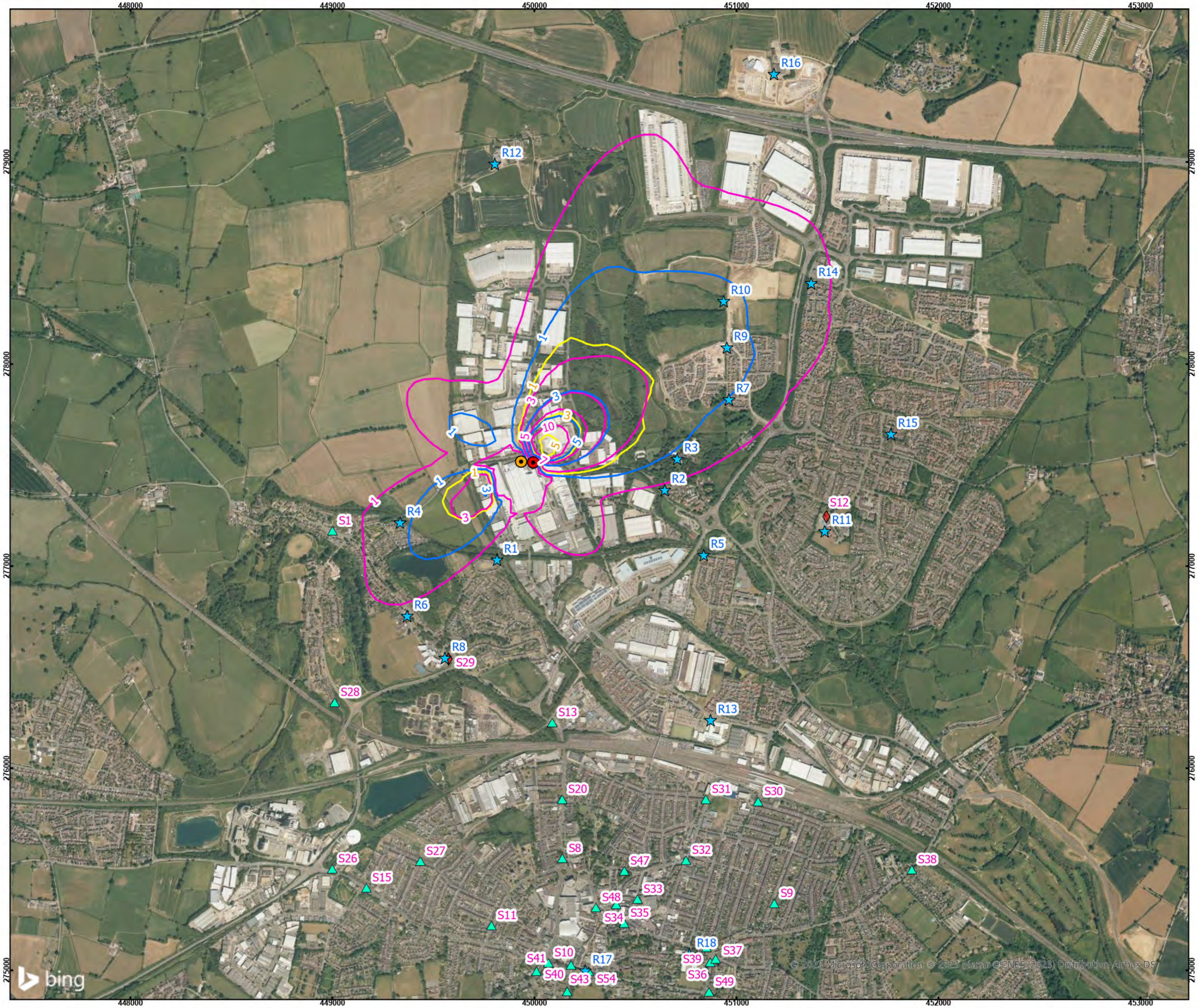

Legend

- A1
- A9
- Human Receptors

Monitoring Type

- Roadside/Kerbside
- Urban Background
- Annual Mean Nitrogen Dioxide as % of AQAL - Permitted Facility
- Annual Mean Nitrogen Dioxide as % of AQAL - Proposed Facility
- Annual Mean Nitrogen Dioxide as % of AQAL - Change

Note: Based on 70% conversion of NOx to NO2

Client:	Britvic
Site:	Rugby Soft Drinks Installation
Project:	2319 EP Variation Dispersion Modelling
Title:	

Figure 9. Annual Mean Nitrogen Dioxide

Drawn by: SMN	Date: 24/05/2023

0 0.17 0.35 0.7 km

N

Scale: 1:17,500

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B Emissions Monitoring Report

The relevant pages from the Emissions Monitoring Report produced by Uniper (ref: ENG/22/PSP/TM/3025/R, September 2022) have been extracted and reproduced below.

There are two inconsistencies in the monitoring report.

- The duct diameter for Boiler 2 is given as 0.634 m. However, the cross-sectional area given as 0.631 m² which is consistent with an effective diameter of 0.9 m, as are monitored velocity of 3.06 m/s and flow of 1.9 m³/s. Therefore, a diameter of 0.9 m has been modelled for Boiler 2 (and Boiler 3, which was not included in the monitoring report but is of identical design).
- The oxygen content for Boiler 2 is reported as 5.4% in the summary table but 5.78% in the detailed results. The value of 5.78% has been used to derive the dispersion model inputs.

Operating Information
Britvic Soft Drinks Energy Centre (Rugby)

Process Type	Description of the process monitored
Process Duration	Description of the plant operating times
Fuel	Fuel used during monitoring period
Feedstock	Details of by-products or materials added to the process as secondary fuels
Abatement	Details of plant processes installed to remove pollutants before emission to air
Load	Details of plant operational condition during monitoring period

Emission Point Reference	Date	Process Type	Process Duration	Fuel	Feedstock	Abatement	Operating Status	Comparison of Operator AMS and Periodic Monitoring Results		
								Substance	AMS Results mg/Nm3 Dry, 15% O2	SRM Results mg/Nm3 Dry, 15% O2
A1 Auxiliary Boiler 2	21-Jun-22	Natural gas fired Boiler	As required	Natural gas	NA	None	Dependant on steam demand of site at the time	NOx (as NO2)	NA	92.8
A1 Auxiliary Boiler 2	21-Jun-22	Natural gas fired Boiler	As required	Natural gas	NA	None	Dependant on steam demand of site at the time	CO	NA	0.9
A1 Auxiliary Boiler 2	21-Jun-22	Natural gas fired Boiler	As required	Natural gas	NA	None	Dependant on steam demand of site at the time	O2	NA	5.4
A9 Auxiliary Boiler 1	21-Jun-22	Natural fired gas Boiler	As required	Natural gas	NA	None	Dependant on steam demand of site at the time	NOx (as NO2)	NA	85.0
A9 Auxiliary Boiler 1	21-Jun-22	Natural fired gas Boiler	As required	Natural gas	NA	None	Dependant on steam demand of site at the time	CO	NA	1.4
A9 Auxiliary Boiler 1	21-Jun-22	Natural fired gas Boiler	As required	Natural gas	NA	None	Dependant on steam demand of site at the time	O2	NA	3.7
A9 CHP Engine 1	22-Jun-22	Natural gas fired CHP Engine	Continuous	Natural gas	NA	None	>80% firing	NOx (as NO2)	NA	52.1
A9 CHP Engine 1	22-Jun-22	Natural gas fired CHP Engine	Continuous	Natural gas	NA	None	>80% firing	CO	NA	296.1
A9 CHP Engine 1	22-Jun-22	Natural gas fired CHP Engine	Continuous	Natural gas	NA	None	>80% firing	O2	NA	10.7
A9 CHP Engine 2	22-Jun-22	Natural gas fired CHP Engine	Continuous	Natural gas	NA	None	>80% firing	NOx (as NO2)	NA	74.4
A9 CHP Engine 2	22-Jun-22	Natural gas fired CHP Engine	Continuous	Natural gas	NA	None	>80% firing	CO	NA	206.9
A9 CHP Engine 2	22-Jun-22	Natural gas fired CHP Engine	Continuous	Natural gas	NA	None	>80% firing	O2	NA	10.4

Worksheet ID: ST_FORM_APT_006_1 pitot   Version: 1

Customer:	**E.ON**
Site:	**Britvic**
Unit/Plant:	**Stack**
Fuel:	**Gas**
Location:	**Stack**
Test:	**Aux Boiler 2**
Date:	**21/06/2022**
Test Operator:	**SE DS**

Duct Details:		
Duct shape:	**Circular**	
Wall thickness:	**0.400**	m
Dimension 1:	**0.634**	m
Dimension 2:		m (blank if circular)
Duct CSA:	**0.631**	m^2
Volume Flow (duct cons):	**1.9**	m^3/s
Mass Flow:	**1.9**	kg/s

Duct Measurements:		
Barometric Pressure:	**1001**	mbar
Static Pressure:	**-1**	mbar
Ref $O_{2\ (dry)}$:	**3**	%Vol
$O_{2\ (dry)}$:	**5.78**	%Vol
$CO_{2\ (dry)}$:	**12.0**	%Vol
H_2O:	**8.0**	%Vol
Density (STP):	**1.303**	kg/m^3

Equipment IDs:			
O_2 analyser:	**T5528**	Conditioner:	**T6258**
Thermocouple:	**T4564**		
Temperature controller:	**T4135**		
Manometer:	**T4137**		
Pitot:	**T4829**	K factor:	**0.676**
No. of sample ports:	**2**	WAF Factor:	**0.99**
Sample points per port:	**2**		

Leak Checks

No.	Start mb	Stop mb	Time	No.	Start mb	Stop mb	Time
No.1	Start mb	Stop mb	12:30	No.2	Start mb	Stop mb	12:35
+ve line	5	5	Pass	+ve line	5	5	Pass
-ve line	5	5	Pass	-ve line	5	5	Pass
No.3	Start mb	Stop mb	12:40	No.4	Start mb	Stop mb	12:45
+ve line	5	5	Pass	+ve line	5	5	Pass
-ve line	5	5	Pass	-ve line	5	5	Pass

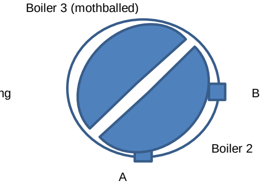
Repeatability Test Traverse Point: **A1**

11:24	ΔP (mbar)	Temp (°C)	Density kg/m^3	Velocity m/s
Reading 1:	0.077	96.0	0.951	3.31
Reading 2:	0.055	98.0	0.946	2.80
Reading 3:	0.067	99.0	0.944	3.10
Reading 4:	0.059	95.0	0.954	2.89
Reading 5:	0.062	92.0	0.962	2.95
Standard Deviation:				0.20

Repeatability Test Fixed Point:

	ΔP (mbar)	Temp (°C)	Density kg/m^3	Velocity m/s
Reading 1:				
Reading 2:				
Reading 3:				
Reading 4:				
Reading 5:				
Standard Deviation:				

Sample Location Schematic



Traverse Port	Traverse Points	Depth From port (m)	Time	Swirl check Null Angle °	Static pressure checks (mb) +ve	-ve	Pass	Pitot as read ΔP (mb) 1	2	3	Average	Temperature (°C) 1	2	3	Average	Duct O_2 % Vol	Duct Density kg/m^3	Velocity m/s	Calculated Flow m3/s Duct	Duct WAF	STP WAF Dry Ref O2	Axial corrected
A	1	0.42	13:05:00		-1	-1	0	0.081	0.055	0.059	0.07	93.6	99.0	89.9	94.2	5.8	0.96	3.03	1.9	1.9	1.1	
A	2	0.21	13:07:00					0.07	0.088	0.071	0.08	93.7	93.0	92.6	93.1	5.9	0.96	3.28	2.1	2.1	1.2	
B	1	0.42	13:15:00		-1	-1	0	0.069	0.081	0.065	0.07	88.0	89.0	90.0	89.0	5.6	0.97	3.16	2.0	2.0	1.1	
B	2	0.21	13:17:00					0.049	0.06	0.055	0.05	93.4	90.0	96.2	93.2	5.7	0.96	2.78	1.8	1.7	1.0	
								Average			**0.07**				**92.4**	**5.8**	**0.96**	**3.06**	**1.9**	**1.9**	**1.1**	

Worksheet ID: ST_FORM_APT_006_1 pitot Version: 1

Customer:	E.ON	**Duct Details:**			**Duct Measurements:**			**Equipment IDs:**				
Site:	Britvic	Duct shape:	Circular		Barometric Pressure:	1001	mbar	O_2 analyser:	T5528	Conditioner:	T6258
Unit/Plant:	Stack	Wall thickness:	0.200	m	Static Pressure:	-1	mbar	Thermocouple:	T4564		
Fuel:	Gas	Dimension 1:	0.800	m	Ref $O_{2\ (dry)}$:	3	%Vol	Temperature controller:	T4135		
Location:	Stack	Dimension 2:		m (blank if circular)	$O_{2\ (dry)}$:	3.75	%Vol	Manometer:	T4137		
Test:	Aux Boiler 1	Duct CSA:	0.503	m^2	$CO_{2\ (dry)}$:	13.0	%Vol	Pitot:	T4829	K factor:	0.676
Date:	21/06/2022	Volume Flow (duct cons):	2.5	m^3/s	H_2O:	8.0	%Vol	No. of sample ports:	2	WAF Factor:	0.99
Test Operator:	SE DS	Mass Flow:	2.4	kg/s	Density (STP):	1.306	kg/m^3	Sample points per port:	2		

Leak Checks

	Start mb	Stop mb	Time		Start mb	Stop mb	Time
No.1			09:50	No.2			11:29
+ve line	5	5	Pass	+ve line	5	5	Pass
-ve line	5	5	Pass	-ve line	5	5	Pass
No.3			12:00	No.4			12:15
+ve line	5	5	Pass	+ve line	5	5	Pass
-ve line	5	5	Pass	-ve line	5	5	Pass

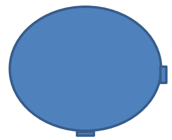
Repeatability Test Traverse Point: B1

11:24	ΔP (mbar)	Temp (°C)	Density kg/m^3	Velocity m/s
Reading 1:	0.135	99.0	0.946	4.39
Reading 2:	0.120	99.3	0.945	4.14
Reading 3:	0.114	100.1	0.943	4.04
Reading 4:	0.127	101.6	0.939	4.28
Reading 5:	0.140	102.3	0.938	4.49
Standard Deviation:				0.18

Repeatability Test Fixed Point:

	ΔP (mbar)	Temp (°C)	Density kg/m^3	Velocity m/s
Reading 1:				
Reading 2:				
Reading 3:				
Reading 4:				
Reading 5:				
Standard Deviation:				

Sample Location Schematic



Traverse Port	Traverse Points	Depth From port (m)	Time	Swirl check Null Angle °	Static pressure checks (mb) +ve	-ve	Pass	Pitot as read ΔP (mb) 1	2	3	Average	Temperature (°C) 1	2	3	Average	Duct O_2 % Vol	Duct Density kg/m^3	Velocity m/s	Calculated Flow m3/s Duct	Duct WAF	STP WAF Dry Ref O2	Axial corrected
A	1	0.68	14:50:00		-1	-1	0	0.23	0.2	0.162	0.20	108.2	107.3	106.1	107.2	4.0	0.93	5.37	2.7	2.7	1.7	
A	2	0.12	14:52:00					0.182	0.177	0.144	0.17	89.0	89.3	91.3	89.9	3.3	0.97	4.83	2.4	2.4	1.6	
B	1	0.68	15:06:00		-1	-1	0	0.23	0.116	0.16	0.17	104.0	104.4	103.8	104.1	3.5	0.93	4.94	2.5	2.5	1.5	
B	2	0.12	15:08:00					0.15	0.177	0.167	0.16	100.0	100.0	100.0	100.0	4.2	0.94	4.86	2.4	2.4	1.5	
								Average			**0.17**				**100.3**	**3.8**	**0.94**	**5.00**	**2.5**	**2.5**	**1.6**	

Worksheet ID: ST_FORM_APT_006_1 pitot   Version: 1

Customer:	E.ON	**Duct Details:**			**Duct Measurements:**			**Equipment IDs:**			
Site:	Britvic	Duct shape:	Circular		Barometric Pressure:	1001	mbar	O_2 analyser:	T5528	Conditioner:	T6258
Unit/Plant:	Stack	Wall thickness:	0.200	m	Static Pressure:	-2	mbar	Thermocouple:	T4564		
Fuel:	Gas	Dimension 1:	0.800	m	Ref $O_{2\ (dry)}$:	15	%Vol	Temperature controller:	T4135		
Location:	Stack	Dimension 2:		m (blank if circular)	$O_{2\ (dry)}$:	10.70	%Vol	Manometer:	T4137		
Test:	CHP 1	Duct CSA:	0.503	m^2	$CO_{2\ (dry)}$:	4.2	%Vol	Pitot:	T4829	K factor:	0.676
Date:	22/06/2022	Volume Flow (duct cons):	7.3	m^3/s	H_2O:	8.0	%Vol	No. of sample ports:	2	WAF Factor:	0.99
Test Operator:	SE DS	Mass Flow:	5.1	kg/s	Density (STP):	1.259	kg/m^3	Sample points per port:	2		

Leak Checks

No.1	Start mb	Stop mb	09:50	No.2	Start mb	Stop mb	11:29
+ve line	4	4	Pass	+ve line	4	4	Pass
-ve line	4	4	Pass	-ve line	4	4	Pass
No.3	**Start mb**	**Stop mb**	**12:00**	**No.4**	**Start mb**	**Stop mb**	**12:15**
+ve line	4	4	Pass	+ve line	4	4	Pass
-ve line	4	4	Pass	-ve line	4	4	Pass

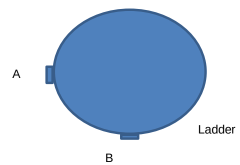
Repeatability Test Traverse Point: A2

11:24	ΔP (mbar)	Temp (°C)	Density kg/m^3	Velocity m/s
Reading 1:	1.013	232.0	0.671	14.28
Reading 2:	1.019	233.0	0.670	14.34
Reading 3:	0.953	232.0	0.671	13.85
Reading 4:	1.058	232.0	0.671	14.60
Reading 5:	0.935	231.0	0.673	13.71
Standard Deviation:				0.37

Repeatability Test Fixed Point:

	ΔP (mbar)	Temp (°C)	Density kg/m^3	Velocity m/s
Reading 1:				
Reading 2:				
Reading 3:				
Reading 4:				
Reading 5:				
Standard Deviation:				

Sample Location Schematic



Traverse Port	Traverse Points	Depth From port (m)	Time	Swirl check Null Angle °	Static pressure checks (mb) +ve	-ve	Pass	Pitot as read ΔP (mb) 1	2	3	Average	Temperature (°C) 1	2	3	Average	Duct O_2 % Vol	Duct Density kg/m^3	Velocity m/s	Calculated Flow m3/s Duct	Duct WAF	STP WAF Dry Ref O2	Axial corrected
A	1	0.68	12:05:00		-2	-2	0	1.27	1.029	1.315	1.20	222.0	226.0	228.0	225.3	10.8	0.68	15.47	7.8	7.7	6.6	
A	2	0.12	12:07:00					0.98	1.13	1.024	1.04	229.0	231.0	232.0	230.7	10.7	0.67	14.48	7.3	7.2	6.1	
B	1	0.68	12:15:00		-2	-2	0	0.921	1.073	0.984	0.99	213.0	213.0	212.0	212.7	10.7	0.70	13.86	7.0	6.9	6.1	
B	2	0.12	12:17:00					1.039	1.09	1.165	1.10	209.0	208.0	207.0	208.0	10.6	0.70	14.51	7.3	7.2	6.4	
								Average			**1.09**				**219.2**	**10.7**	**0.69**	**14.58**	**7.3**	**7.3**	**6.3**	

Worksheet ID: ST_FORM_APT_006_1 pitot   Version: 1

Customer:	**E.ON**
Site:	**Britvic**
Unit/Plant:	**Stack**
Fuel:	**Gas**
Location:	**Stack**
Test:	**CHP 2**
Date:	**22/06/2022**
Test Operator:	**SE DS**

Duct Details:		
Duct shape:	Circular	
Wall thickness:	0.200	m
Dimension 1:	0.800	m
Dimension 2:		m (blank if circular)
Duct CSA:	0.503	m^2
Volume Flow (duct cons):	6.7	m^3/s
Mass Flow:	5.0	kg/s

Duct Measurements:		
Barometric Pressure:	1001	mbar
Static Pressure:	-2	mbar
Ref $O_{2\ (dry)}$:	15	%Vol
$O_{2\ (dry)}$:	10.43	%Vol
$CO_{2\ (dry)}$:	4.3	%Vol
H_2O:	8.0	%Vol
Density (STP):	1.260	kg/m^3

Equipment IDs:			
O_2 analyser:	T5528	Conditioner:	T6258
Thermocouple:	T4564		
Temperature controller:	T4135		
Manometer:	T4137		
Pitot:	T4829	K factor:	0.676
No. of sample ports:	2	WAF Factor:	0.99
Sample points per port:	2		

Leak Checks

	Start mb	Stop mb	Time		Start mb	Stop mb	Time
No.1			09:50	No.2			11:29
+ve line	4	4	Pass	+ve line	4	4	Pass
-ve line	4	4	Pass	-ve line	4	4	Pass
No.3			12:00	No.4			12:15
+ve line	4	4	Pass	+ve line	4	4	Pass
-ve line	4	4	Pass	-ve line	4	4	Pass

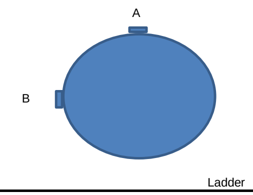
Repeatability Test Traverse Point: A2

11:24	ΔP (mbar)	Temp (°C)	Density kg/m^3	Velocity m/s
Reading 1:	0.933	187.0	0.737	13.08
Reading 2:	1.072	186.0	0.739	14.01
Reading 3:	0.959	186.0	0.739	13.25
Reading 4:	0.940	185.0	0.740	13.10
Reading 5:	0.996	185.0	0.740	13.49
Standard Deviation:				0.38

Repeatability Test Fixed Point:

	ΔP (mbar)	Temp (°C)	Density kg/m^3	Velocity m/s
Reading 1:				
Reading 2:				
Reading 3:				
Reading 4:				
Reading 5:				
Standard Deviation:				

Sample Location Schematic



Traverse Port	Traverse Points	Depth From port (m)	Time	Swirl check Null Angle °	Static pressure checks (mb) +ve	-ve	Pass	Pitot as read ΔP (mb) 1	2	3	Average	Temperature (°C) 1	2	3	Average	Duct O_2 % Vol	Duct Density kg/m^3	Duct Velocity m/s	Calculated Flow m3/s Duct	Duct WAF	STP WAF Dry Ref O2	Axial corrected
A	1	0.68	14:05:00		-2	-2	0	0.876	0.961	1.061	0.97	193.0	189.0	186.0	189.3	10.4	0.73	13.34	6.7	6.6	6.3	
A	2	0.12	14:07:00					1.047	0.873	1.028	0.98	185.0	184.0	183.0	184.0	10.5	0.74	13.38	6.7	6.7	6.4	
B	1	0.68	14:15:00		-2	-2	0	1.027	1.076	0.933	1.01	176.0	177.0	177.0	176.7	10.4	0.75	13.47	6.8	6.7	6.5	
B	2	0.12	14:17:00					0.966	1.064	0.846	0.96	183.0	199.0	207.0	196.3	10.4	0.72	13.39	6.7	6.7	6.2	
								Average			**0.98**				**186.6**	**10.4**	**0.74**	**13.40**	**6.7**	**6.7**	**6.4**	

C Detailed Results

Table 31: Dispersion Modelling Results – Point of Maximum Impact Outside of the Installation Boundary for Each Year of Weather Data

Pollutant	Quantity	Units	AQAL	Bg Conc.	Process Contribution (PC)					Max PC		Max PEC	
					2018	2019	2020	2021	2022	Max Conc.	% of AQAL	Conc.	% of AQAL
Permitted Facility													
Nitrogen dioxide	Annual mean	µg/m³	40	21.3	3.20	3.42	3.69	3.50	3.48	3.69	9.23%	24.99	62.48%
	99.79th %ile of hourly means	µg/m³	200	42.6	15.63	15.50	15.04	15.27	15.57	15.63	7.82%	58.23	29.12%
Carbon monoxide	8-hour running mean	µg/m³	10,000	646	55.95	57.10	53.81	54.80	52.73	57.10	0.57%	743.10	7.43%
	Hourly mean	µg/m³	30,000	646	108.49	81.98	103.84	95.46	105.22	108.49	0.36%	794.49	2.65%
Proposed Facility(1)													
Nitrogen dioxide	Annual mean	µg/m³	40	20.17	4.93	5.38	6.10	5.21	5.43	6.10	15.25%	27.40	68.50%
	99.79th %ile of hourly means	µg/m³	200	40.34	19.34	19.43	18.75	18.82	19.55	19.55	9.77%	62.15	31.07%

Note:
(1) The maximum 8 hourly and maximum hourly carbon monoxide impact does not change between the Permitted Facility and Proposed Facility Scenarios, so the results presented for the Permitted Facility are also applicable to the Proposed Facility. See section 9 for further details.

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