Environmental Permit Variation Application – Scarborough Plant

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McCain Foods (GB) Ltd

Scarborough Plant Facility Renewal Project
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Jacobs U.K. Limited

7th Floor, 2 Colmore Square
38 Colmore Circus, Queensway
Birmingham, B4 6BN
United Kingdom

T +44 (0)121 237 4000
www.jacobs.com

Executive summary

McCain Foods (GB) Ltd (hereafter referred to as 'McCain Foods') operates a food production facility at the Havers Hill Industrial Estate, situated between the town of Eastfield and village of Cayton, Scarborough.

McCain Foods is proposing to install a Wastewater Treatment Plant (WwTP) at its food production facility at Scarborough (hereafter the 'site') including:

- installing a new biogas fuelled JGC 316 GS-B.L (D225) combined heat and power (CHP) engine (with a thermal input capacity of 1.8 MWth);
- installing a new natural gas fuelled 28 tonne (T) (with a thermal input capacity of 18.1 MWth);
- installing a new natural gas fuelled 15 T (with a thermal input capacity of 9.8 MWth);
- removing an existing Beel steam boiler (with a thermal input capacity of 17.8 MWth); and
- removing two existing Maxicon steam boilers (each with a thermal input capacity of 10.7 MWth).

Therefore, McCain Foods is required to submit an application to vary the site's existing Environmental Permit (EP).

Two scenarios have been modelled to represent the existing and proposed configuration of the site. The scenarios are as follows:

- Existing Scenario – existing site layout with the thermal oxidiser, Beel and Maxicon boilers all utilising natural gas.
- Proposed Scenario - proposed site layout with the proposed CHP engine utilising biogas and the thermal oxidiser and proposed steam boilers utilising natural gas.

The Air Quality Impact Assessment presented within this report is required to support the new EP variation application and assesses the potential for significant air quality effects from the operation of the existing and proposed configuration of the site.

The potential impacts were determined for the following aspect:

- the potential impact on human health due to emissions of pollutants. The pollutants considered include nitrogen dioxide (NO_2); carbon monoxide (CO); sulphur dioxide (SO_2), total volatile organic compounds (TVOC's) and particulate matter (PM_{10}, particles with an aerodynamic diameter of 10 microns or less and $PM_{2.5}$, particles with an aerodynamic diameter of 2.5 microns or less); and
- the potential impact on vegetation and ecosystems due to emissions of oxides of nitrogen (NOx) and SO_2.

Human receptors

The assessment indicates that the predicted modelled off-site concentrations and predicted concentrations at sensitive human receptors do not exceed any relevant long-term or short-term air quality objective or guideline, irrespective of the modelled scenario.

Furthermore, the proposed site configuration is likely to result in slight increases in long-term and short-term modelled concentrations at off-site and sensitive human receptor locations.

For the Proposed Scenario, the removal of the existing boilers and installation of the CHP engine and new steam boilers increases the maximum annual mean NO_2 process contribution (PC) at the nearby assessed human receptors from 3.9 $\mu g/m^3$ to 5.5 $\mu g/m^3$, which equates to 13.9% of the EQS. The corresponding PEC is well below 70% of the relevant environmental quality standard (EQS) (i.e. 30.7%).

For the Existing Scenario, the maximum annual mean NO_2 PC was predicted at R2, which represents a residential property approximately 180 m north-northeast of the thermal oxidiser. The maximum annual mean NO_2 PC at R2 increases from 3.9 $\mu g/m^3$ to 4.7 $\mu g/m^3$ when removing the existing boilers and installing the CHP engine and new steam boilers. The corresponding PEC is well below 70% of the EQS (i.e. 28.6%).

For the Proposed Scenario, the maximum annual mean NO_2 PC was predicted at R7, which represents a residential property approximately 220 m southeast of the thermal oxidiser and approximately 170 m east of the proposed CHP engine. The maximum annual mean NO_2 PC at R7 increases by 3.8 $\mu g/m^3$ from 1.7 $\mu g/m^3$ to 5.5 $\mu g/m^3$ when removing the existing boilers and installing the CHP engine and new steam boilers.

This indicates that the pollutant contribution from the CHP engine is considerably greater than the existing assessed combustion units or indeed the proposed steam boilers.

Further analysis indicates that emissions from the CHP engine accounted for approximately 67% of the maximum process contribution predicted at R7.

It is noted that the annual mean NO_2 PC as a percentage of the EQS is relatively high. However, this assessment assumes that all assessed combustion units operate continuously at maximum load throughout the year (i.e. 8,760 hours). In practice, the thermal oxidiser is regularly shut-down (usually for two days once a fortnight for cleaning purposes) and the remaining assessed combustion units will have periods of shut-down and maintenance and may not always operate at maximum load. Furthermore, the site typically closes for two weeks over the summer months. Therefore, the results presented are likely to be higher than would reasonably be expected.

For the remaining long-term and short-term concentrations for both modelled scenarios, the impact is considered 'not significant'.

For TVOCs (Proposed Scenario only), the predicted annual mean and 24-hour mean concentrations were found to be exceeding the relevant EQS for C_6H_6. However, this assessment assumes all TVOCs emitted by the assessed combustion plant are C_6H_6. This is an unrealistic assumption, and C_6H_6, if present in the exhaust gases, would constitute only a very small proportion of total TVOC emissions (e.g. less than 1%). Therefore, for emissions of TVOCs, the impact is considered 'not significant'.

Protected conservation areas

For critical levels, the increase in annual mean NOx PC between the Existing and Proposed Scenario at the assessed Flamborough and Filey Coast SPA and Cayton, Cornelian and South Bays SSSI is less than 0.1 $\mu g/m^3$. For both modelled scenarios the annual mean NOx PCs at the assessed SPA and SSSI are just above 1% (i.e. <1.4%) of the long-term environmental standard. However, the respective PECs are less than 70% of the critical level and based on professional judgement, the emissions are not likely to have a significant effect.

For annual mean SO_2 concentrations (Proposed Scenario only), the respective PCs for the assessed SPA and SSSI are less than 1% of the long-term environmental standard and the impact can be described as 'insignificant' as per Environment Agency guidance (Environment Agency, 2022).

For maximum 24-hour mean NOx concentrations at the assessed SPA and SSSI, the increase in short-term NOx PCs between the Existing and Proposed Scenario is less than 1.1 $\mu g/m^3$. The respective PCs are less than 10% of the short-term environmental standard, irrespective of the modelled scenario, and can be described as 'insignificant'.

For all assessed local nature sites, the respective annual mean NOx and SO_2 and short-term NOx PCs are less than 100% of the relevant environmental standard and can be described as 'insignificant' as per Environment Agency guidance (Environment Agency, 2022).

For critical loads, the results indicate that for the assessed Cayton, Cornelian and South Bays SSSI (short vegetation) and Flamborough and Filey Coast SPA, the PCs for acid and nutrient nitrogen deposition, where relevant, are less than 1% of the relevant long-term environmental standard, irrespective of the modelled scenario, and the impact can be described as 'insignificant'. At Cayton, Cornelian and South Bays SSSI (tall vegetation), the PCs for nutrient nitrogen deposition are just above 1% (i.e. <1.3%) of the relevant long-term environmental standard, irrespective of the modelled scenario.

The increase in PCs for acid deposition and nutrient nitrogen deposition between the Existing and Proposed Scenario at the assessed SPA and SSSI is less than 0.02 kEqH+/ha/year and 0.03 kgN/ha-year, respectively.

For the assessed local nature sites, the respective PCs for acid and nutrient nitrogen deposition are less than 100% of the relevant long-term environmental standard for protected conservation areas and the impact can be described as 'insignificant' as Environment Agency guidance (Environment Agency, 2022).

The conservative approach adopted throughout this assessment means that based on professional judgement, it is not considered likely that there would be unacceptable impacts at the assessed protected conservation areas as a consequence of the proposed site configuration.

Summary

Based on the findings of this assessment, it is concluded that the proposed site configuration is acceptable from an air quality perspective.

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1. Introduction

1.1 Background

McCain Foods (GB) Ltd (hereafter referred to as 'McCain Foods') operates a food production facility at the Havers Hill Industrial Estate, situated between the town of Eastfield and village of Cayton, Scarborough.

McCain Foods is proposing to install a Wastewater Treatment Plant (WwTP) at its food production facility at Scarborough (hereafter the 'site') including:

- installing a new biogas fuelled JGC 316 GS-B.L (D225) combined heat and power (CHP) engine (with a thermal input capacity of 1.8 MWth);
- installing a new natural gas fuelled 28 tonne (T) (with a thermal input capacity of 18.1 MWth);
- installing a new natural gas fuelled 15 T (with a thermal input capacity of 9.8 MWth);
- removing an existing Beel steam boiler (with a thermal input capacity of 17.8 MWth); and
- removing two existing Maxicon steam boilers (each with a thermal input capacity of 10.7 MWth).

Therefore, McCain Foods is required to submit an application to vary the site's existing Environmental Permit (EP).

Jacobs UK Limited (hereafter 'Jacobs') carried out an Air Quality Impact Assessment (AQIA) on behalf of McCain Foods to assess the change in potential air quality impacts associated with these proposed changes and support the EP variation application.

1.2 Study Outline

Under the existing EP (Permit Reference EPR/BO7732IZ), the site operates several combustion units including a thermal oxidiser (to remove odour from the food manufacturing process), an existing Beel steam boiler and two Maxicon steam boilers (to be removed).

This AQIA is required to support the EP variation application and assesses the likely significant air quality effects of emissions to air from the proposed biogas fuelled CHP engine and proposed two steam boilers.

The existing Beel boiler and two Maxicon boilers will be removed from the site prior to the installation of the new steam boilers. However, existing operations at the site will also be modelled to allow comparison with proposed operations.

It should be noted the existing closed loop hot water boiler, which will remain on-site, is not considered in the assessment as it does not operate simultaneously with the thermal oxidiser.

The air quality assessment has been carried out following the relevant Environment Agency guidance (Environment Agency, 2021; 2022).

- The potential impact on human health due to emissions of pollutants. The pollutants considered include nitrogen dioxide (NO2), carbon monoxide (CO), sulphur dioxide (SO_2), total volatile organic compounds (TVOC's) and particulate matter (PM_{10}, particles with an aerodynamic diameter of 10 microns or less and $PM_{2.5}$, particles with an aerodynamic diameter of 2.5 microns or less); and
- The potential impact on vegetation and ecosystems due to emissions of oxides of nitrogen (NOx) and SO_2.

The site boundary (represented by the approximate planning application boundary) and permit boundary is presented in Figure 1.

This report draws upon information provided from the following parties:

- McCain Foods;
- ADM Ltd;
- Eco Steam and Heating Solutions (Eco);
- Bosch;
- Centre for Ecology and Hydrology (CEH);
- Scarborough Borough Council; and
- Department for Environment, Food and Rural Affairs (Defra).

This report includes a description of the emission sources and modelling scenarios, description of methodology and significance criteria, a review of the baseline conditions including an exploration of the existing environment of the site and surrounding area, an evaluation of results and the potential impact of emissions on human health and protected conservation areas during operation and, finally, conclusions of the assessment.

2. Emission Sources

2.1 Emission Sources to Air

The location of the existing thermal oxidiser (emission point reference T03), existing Beel and Maxicon boilers (emission point reference BH5[1] and BH6), permitted CHP engine (emission point A147) and proposed steam boilers (emission point reference A151a and A151b) are presented in Figure 2 and Figure 3.

The CHP engine will be fuelled by biogas generated from the site's anaerobic digestion process and emissions were modelled on this basis. All remaining assessed combustion units are fuelled by natural gas and were modelled accordingly.

The modelling only considers emissions from the combustion units described above and no other emission points to air at the site have been included in the assessment.

As discussed previously, two scenarios have been modelled to represent the existing and proposed configuration of the site. The scenarios are as follows:

- Existing Scenario – existing site layout with the thermal oxidiser, Beel and Maxicon boilers all utilising natural gas.
- Proposed Scenario - proposed site layout with and the existing thermal oxidiser and proposed steam boilers utilising natural gas and the proposed CHP engine utilising biogas.

Table 1 presents the emission sources to be considered in this assessment.

Table 1. Combustion plant to be assessed

Parameters	Thermal oxidiser (13.9 MWth)	Combined Beel boiler (17.8 MWth) and Maxicon boiler (10.7 MWth)	Maxicon boiler 10.7 MWth	JGC 316 GS-B.L (D225) CHP engine (1.8 MWth)	28 T steam boiler (18.1 MWth)	15 T steam boiler (9.8 MWth)
Status	Existing	Existing (to be removed)	Existing (to be removed)	Proposed	Proposed	Proposed
Modelled fuel	Natural gas	Natural gas	Natural gas	Biogas	Natural gas	Natural gas
Emission point	T03	BH5	BH6	A147	A151a	A151b

This assessment has been carried out on the assumption that all assessed combustion units would operate continuously at maximum load throughout the year (i.e. 8,760 hours). This is a conservative assumption as in practice, the thermal oxidiser is regularly shut-down (usually for two days once a fortnight for cleaning purposes) and the remaining assessed combustion units will have periods of shut-down and maintenance and may not always operate at maximum load. Furthermore, the site typically closes for two weeks over the summer months. This approach ensures that the worst-case or maximum long-term (i.e. annual mean) and short-term modelled concentrations are quantified (further consideration of this is provided in Appendix A).

2.2 Emissions Data

For the existing assessed combustion units, the emission concentrations were taken from historical AQIAs to support previous EP variation applications (Jacobs, 2018).

For the CHP engine, the NOx and SO_2 emission concentrations were derived from the Medium Combustion Plant Directive (MCPD) EU/2015/2193[2] (European Union, 2015) for new engines. For CO and TVOC, in the absence of a specific emission limit value, the emission concentrations were derived from the Environment Agency's '*Guidance for monitoring landfill gas engine emissions*' (Environment Agency, 2010). For particulates, in the

[1] Waste gases from one of the Maxicon boilers and Beel steam boiler exit into the atmosphere via a shared stack.

[2] European Parliament and the Council of the European Union, Medium Combustion Plant Directive EU/2015/2193 of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants and as transposed into Schedule 25A of The Environmental Permitting (England and Wales) (Amendment) Regulations 2018 (United Kingdom (UK) Government, 2018)).

absence of a specific emission limit value, the emission concentration was derived from a previous study of landfill gas engines (Land Quality Management Ltd, 2002).

For the proposed steam boilers, as a worst-case approach to the assessment, the NOx emission concentration is based on the emission limit values for new MCP other than engines and gas turbines as regulated under the MCPD[2]. For CO, the emission concentration was obtained from the value for natural gas from Defra's Process Guidance Note 1/3,'*Statutory Guidance for Boilers and Furnaces 20-50MW thermal input*' (Defra, 2012).

2.3 Other emission parameters

For the existing assessed combustion units, the emission parameters were taken from historical AQIAs to support previous EP variation applications (Jacobs, 2018).

For the CHP engine, the exhaust gas volumetric flow was determined using stoichiometric calculations based on the combustion of biogas at the maximum thermal input rating of the CHP engine. In the absence of information regarding exhaust gas temperature, oxygen and moisture content of the CHP engine, the data used in the model was estimated based on professional judgement acquired from previous work involving biogas fuelled CHP engines of a similar thermal input capacity.

For the proposed steam boilers, the exhaust gas volumetric flow, stack gas temperature and moisture content were obtained from the steam boiler manufacturer (Bosch, 2023) (Eco, 2022). The oxygen content applied in the model was estimated based on professional judgement.

The emissions inventory of releases to air from the CHP engine, thermal oxidiser and boilers is provided in Appendix A.

3. Assessment Methodology

This section presents a summary of the methodology used for the assessment of the potential impacts of the site. A full description of the study inputs and assumptions are provided in Appendix A.

3.1 Assessment Location

For this assessment, 26 of the closest sensitive human receptors (such as residential properties including a static caravan, a school and a sports field) near the site were identified for modelling purposes. The location of these receptors are presented in Figure 3.

In line with the Environment Agency guidance '*Air emissions risk assessment for your environmental permit*' (Environment Agency, 2022), it is necessary to identify protected conservation areas within the following distances from the site:

- European sites (i.e. Special Area of Conservation (SAC), Special Protection Area (SPA) and Ramsar sites) within 10 km; and
- Site of Special Scientific Interest (SSSI) and local nature sites (i.e. ancient woodlands, local wildlife sites (LWS) and national and local nature reserves (NNR and LNR)) within 2 km.

Based on these criteria; Flamborough and Filey Coast SPA; Cayton, Vornelian and South Bays SSSI; The Dell LNR; Cayton Meadow LWS; Burton Riggs Gravel Pits LWS; and High Deepdale LWS have been included in the assessment.

The location of the assessed protected conservation areas are presented in Figure 4 and further details are set out in Appendix A.

3.2 Overall Methodology

The assessment was carried out using an atmospheric dispersion modelling technique. Atmospheric Dispersion Modelling System (ADMS) version 5.2.4 was used to model releases of the identified substances. The ADMS model predicts the dispersion of operational emissions from a specific source (e.g. a stack), and the subsequent concentrations over an identified area (e.g. at ground level across a grid of receptor points) or at specified points (e.g. a residential property). ADMS was selected because this model is fit for the purpose of modelling the emissions from the type of sources on-site (i.e. point source emissions from a combustion source) and is accepted as a suitable assessment tool by the Environment Agency.

The modelling assessment was undertaken in accordance with the Environment Agency guidance '*Air emissions risk assessment for your environmental permit*' (Environment Agency, 2022).

A summary of the dispersion modelling procedure is set out below.

1) Information on the proposed plant location, stack parameters and proposed new buildings to support the WwTP were supplied by McCain Foods (McCain Foods, 2021). Information on the assessed combustion plant were obtained from various sources as described in Section 2.1.
2) Five years of hourly sequential data recorded at the Bridlington meteorological station (2016 – 2020 inclusive) were used for the assessment (ADM Ltd, 2022).
3) Information on the existing main buildings located on-site, which could influence dispersion of emissions from assessed combustion plant were estimated from Defra's environmental open-data applications and datasets (Defra, 2022) and Google Earth (Google Earth, 2023). Due to the complexity of the site layout in terms of varied building height, where appropriate, an average height has been applied to individual buildings included in the model.
4) The maximum predicted concentrations (at a modelled height of 1.5 m or 'breathing zone') at the assessed sensitive human receptor locations R1 – R22 (representing long-term exposure at residential properties, a static caravan and George Pindar School) were considered for the assessment of annual mean, 24-hour mean, 8-hour mean, 1-hour mean and 15-minute mean pollutant concentrations within the study area. For receptors R23 - R26 (representing George Pindar School sports facilities and nearby sports field), only the 1-hour mean and 15-minute mean concentrations were considered. The maximum predicted concentrations at an off-site location in the vicinity of the site were considered for the assessment of short-term (1-hour and 15-minute mean) concentrations. For this assessment, an off-site location is considered a location outside the planning application boundary (see Figure 1).
5) The above information was entered into the dispersion models.

6) The dispersion models were run to provide the Process Contributions (PC). The PC is the estimated maximum environmental concentration of substances due to releases from the process alone. The results were then combined with baseline concentrations (see Section 4) to provide the total Predicted Environmental Concentration (PEC) of the substances of interest.
7) The PECs were then assessed against the appropriate environmental standards for air emissions for each substance set out in the Environment Agency's guidance (Environment Agency, 2022) document to determine the nature and extent of any potential adverse effects.
8) Modelled concentrations were processed using geographic information system (GIS) software (ArcMap 10.8.1) to produce contour plots of the model results. These are provided for illustrative purposes only; assessment of the model results was based on the numerical values outputted by the dispersion model on the model grid (see Figure 3) and at the specific receptor locations and were processed using Microsoft Excel.
9) The predicted concentrations of NOx and SO_2 were also used to assess the potential impact on critical levels and critical loads (i.e. acid and nutrient nitrogen deposition) (see Section 3.3.2) at the assessed protected conservation area. Details of the deposition assessment methodology are provided in Appendix B.

In addition to the above, a review of existing ambient air quality in the area was undertaken to understand the baseline conditions at the site and at receptors within the study area. These existing conditions were determined by reviewing the monitoring data already available for the area and other relevant sources of information. The review of baseline air quality is set out in Section 4.

Where appropriate, a conservative approach has been adopted throughout the assessment to increase the robustness of the model predictions. In addition, an analysis of various sensitivity scenarios has also been carried out (see Section 5.3) to determine how changes to model parameters (e.g. differing surface roughness values or modelling without considering buildings) may impact on predicted concentrations at sensitive human receptors and off-site locations.

3.3 Assessment Criteria

3.3.1 Environmental Quality Standards: Human Receptors

In the UK, the focus on local air quality is reflected in the air quality objectives (AQOs) set out in the Air Quality Strategy for England, Scotland, Wales and Northern Ireland (AQS) (Defra and the Devolved Administrations, 2007). The AQS stipulates a number of air quality objectives for nine main air pollutants with respect to ambient levels of air quality (Defra, 2007). The AQOs are similar to the limit values that were transposed from the relevant EU directives into UK legislation by The Air Quality Standards Regulations 2010 (UK Government, 2010). The objectives are based on the current understanding of health effects of exposure to air pollutants and have been specified to control health and environmental risks to an acceptable level. They apply to places where people are regularly present over the relevant averaging period. The objectives set for the protection of human health and vegetation of relevance to the project are summarised in Table 2. Relevant Environmental Assessment Levels (EALs) set out in the Environment Agency guidance (Environment Agency, 2022) are also included in Table 2 where these supplement the AQOs.

For the purposes of reporting, the AQOs and EALs have been collectively termed as Environmental Quality Standards (EQSs).

Table 2. Air quality objectives and environmental assessment levels

Pollutant	EQS ($\mu g/m^3$)	Concentration measured as
NO_2	40	Annual mean
	200	1-hour mean, not to be exceeded more than 18 times a year (99.79th percentile)
CO	10,000	Maximum daily 8 hour running mean (100th percentile)
	30,000	Maximum 1-hour mean (100th percentile)
SO_2	125	24-hour mean not to be exceeded more than 3 times a year (99.18th percentile)
	350	1-hour mean not to be exceeded more than 24 times a year (99.73rd percentile)
	266	15-minute mean not to be exceeded more than 35 times a year (99.9th percentile)
PM_{10}	40	Annual mean
	50	24-hour mean, not to be exceeded more than 35 times a year (90.41st percentile)
$PM_{2.5}$	20[3]	Annual mean

Pollutant	EQS (µg/m^3)	Concentration measured as
TVOC[1]	5[2]	Annual mean
	30	Maximum 24-hour mean (100th percentile)

Note 1: VOCs may contain a wide range of organic compounds and it is often difficult to determine or identify each and every compound present. The TVOC emissions from the assessed combustion plant will largely comprise methane which is not directly harmful to human health.
Note 2: For the purposes of this assessment, the annual mean and 24-hour mean AQO for benzene (C_6H_6) has been applied as it is a standard substitute that adequately represents a worst-case scenario for VOCs.
Note 3: Amendment to the Air Quality Standards Regulations 2010 as per the Environment (Miscellaneous Amendments) (EU Exit) Regulations 2020 (UK Government, 2020).

For the assessment of long-term average concentrations (i.e. the annual mean concentrations) at human receptors, impacts were described using the following criteria:

- if the PC is less than 1% of the long-term EQS, the contribution can be considered as 'insignificant' and not representative of a significant effect (i.e. 'not significant') (Environment Agency, 2022);
- if the PC is greater than 1% of the EQS but the PEC is less than 70% of the long-term air quality objective, based on professional judgement, this would be classed as 'not significant'; and
- where the PC is greater than 1% of the EQS and the PEC is greater than 70% of the EQS, professional judgement is used to determine the overall significance of the effect (i.e. whether the effect would be 'not significant' or 'significant'), taking account of the following:
  - the scale of the changes in concentrations;
  - whether or not an exceedance of an EQS is predicted to arise in the study area where none existed before, or an exceedance area is substantially increased as a result of the development; and
  - uncertainty, including the influence and validity of any assumptions adopted in undertaking the assessment.

For the assessment of short-term average concentrations (e.g. the 1-hour mean NO_2 concentrations, and the 15-minute, 1-hour and 24-hour mean SO_2 concentrations etc.), impacts were described using the following criteria:

- if the PC is less than 10% of the short-term EQS, this would be classed as 'insignificant' and not representative of a significant effect (i.e. not significant) (Environment Agency, 2022);
- if the PC is greater than 10% of the EQS but less than 20% of the headroom between the short-term background concentration and the EQS, based on professional judgement, this can also be described as not significant; and
- where the PC is greater than 10% of the EQS and 20% of the headroom, professional judgement is used to determine the overall significance of the effect (i.e. whether the effect would be not significant or significant) in line with the approach specified above for long-term average concentrations.

Environment Agency guidance recommends that further action will not be required if proposed emissions comply with Best Available Techniques Associated Emission Levels (BAT AELs) and resulting PECs do not exceed the relevant EQS (Environment Agency, 2022).

3.3.2 Environmental Quality Standards: Protected Conservation Areas

Critical levels

The environmental standards set for protected conservation areas of relevance to the project are summarised in Table 3 (Environment Agency, 2022).

Table 3. Air Quality Objectives and Environmental Assessment Levels for protected conservation areas

Pollutant	EQS (µg/m^3)	Concentration measured as
NOx	30	Annual mean limit value for the protection of vegetation (referred to as the "critical level")
	75	Maximum 24-hour mean for the protection of vegetation (referred to as the "critical level")
SO_2	10	Annual mean limit value for the protection of vegetation (referred to as the "critical level") where lichens or bryophytes are present
	20	Annual mean limit value for the protection of vegetation (referred to as the "critical level") where lichens or bryophytes are not present

Critical loads

Critical loads for pollutant deposition to statutorily designated habitat sites in the UK and for various habitat types have been published by the CEH and are available from the APIS website. Critical loads are defined on the APIS website (Centre for Ecology and Hydrology, 2023) as:

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

Compliance with these benchmarks is likely to result in no significant adverse effects on the natural environment at these locations. The critical loads for the designated habitat sites considered in this assessment are set out in Table 4. For the assessed European designated sites and SSSI, the *Site Relevant Critical Load* tool function on the APIS website was used to determine the relevant critical loads for the assessed protected conservation area based on the most sensitive vegetation type likely to inhabit the protected conservation area.

For the assessed local nature sites, the *Search by Location* function on the APIS website was used. Where both short and tall vegetation type is assumed to inhabit the assessed local nature sites, the acid grassland and coniferous woodland habitat feature was selected on the APIS website, which are generally the most sensitive short and tall vegetation type to nutrient nitrogen and acid deposition.

Table 4. Critical loads for modelled protected conservation areas

Rec ref	Protected conservation area	Habitat feature applied	Vegetation type (for deposition velocity)	Critical load			
				Acid deposition (kEqH+/ha/year)			Nitrogen deposition (kg N/ha/year)
				CLMax S	CLMin N	CLMax N	Minimum
H1	Flamborough and Filey Coast SPA	Maritime Cliff and Slopes (Alpine and subalpine grasslands)	Short	No critical load data available			5
H2	Cayton, Cornelian and South Bays SSSI	Acid grassland (Festuca ovina - Agrostis capillaris - Galium saxatile grassland)	Short	4.100	0.223	4.323	10
		Broad-leaved, mixed and yew woodland	Tall	10.793	0.142	10.935	15
H3	The Dell LNR	Acid grassland	Short	4.100	0.223	4.323	5
		Coniferous woodland	Tall	10.778	0.142	10.920	5
H4	Cayton Meadow LWS	Acid grassland	Short	4.100	0.223	4.323	5
		Coniferous woodland	Tall	10.774	0.142	10.916	5
H5	Burton Riggs Gravel Pits LWS	Acid grassland	Short	0.850	0.223	1.073	5
		Coniferous woodland	Tall	1.562	0.142	1.704	5
H6	High Deepdale LWS	Acid grassland	Short	0.430	0.223	0.653	5
		Coniferous woodland	Tall	1.002	0.142	1.144	5

Critical load functions for acid deposition are specified on the basis of both nitrogen and sulphur derived acid. The critical load function contains a value for sulphur derived acid and two values for nitrogen derived acid deposition (a minimum and maximum value). The APIS website provides advice on how to calculate the process contribution (PC – emissions from the modelled process alone) and the predicted environmental concentrations (PEC – the PC added to the existing deposition) as a percentage of the acid critical load function and how to determine exceedances of the critical load function. This guidance was adopted for this assessment. The minimum of the range of nitrogen critical loads was used for the assessment in line with the advice on the APIS website (Centre for Ecology and Hydrology, 2023).

Significance Criteria – SPA and SSSI

With regard to concentrations at the assessed designated habitat sites, the Environment Agency guidance (Environment Agency, 2022) states emissions can be described as 'insignificant' and no further assessment is required (including the need to calculate PECs) if:

- the short-term PC is less than 10% of the short-term environmental standard for protected conservation areas; or
- the long-term PC is less than 1% of the long-term environmental standard for protected conservation areas.

Where appropriate, the significance of the predicted long-term (annual mean) concentrations or deposition at protected conservation areas were determined in line with Environment Agency guidance (Environment Agency, 2022) summarised as follows:

- where the PC is less than 1% of the relevant critical level or critical load, the emission is not likely to have a significant effect alone or in combination irrespective of the existing concentrations or deposition rates;
- where the PC is above 1%, further consideration of existing background concentrations or deposition rates is required, and where the total concentration or deposition is less than 70% of the critical level or critical load, calculated in combination with other committed projects or developments as appropriate, the emission is not likely to have a significant effect; and
- where the contribution is above 1%, and the total concentration or deposition rate is greater than 70% of the critical level or critical load, either alone or in combination with other committed projects or developments, then this may indicate a significant effect and further consideration is likely to be required.

The above approach is used to give a clear definition of what effects can be disregarded as insignificant, and which need to be considered in more detail in relation to the predicted annual mean concentrations or deposition.

For short-term mean concentrations (i.e. the 24-hour mean critical level for NOx) where the PC is less than 10% of the critical level then it would be regarded as 'insignificant'. A potentially significant effect would be identified where the short-term PC from the modelled sources would lead to the total concentration exceeding the critical level. Further consideration is likely to be required in this situation.

Significance Criteria –LNR and LWS

The relevant significance criteria for these protected conservation areas are set out below.

With regard to concentrations or deposition rates at local nature sites, the Environment Agency guidance (Environment Agency, 2022) states emissions can be described as 'insignificant' and no further assessment is required (including the need to calculate PECs) if:

- the short-term PC is less than 100% of the short-term environmental standard for protected conservation areas; or
- the long-term PC is less than 100% of the long-term environmental standard for protected conservation areas.

The above approach is used to give a clear definition of what effects can be disregarded as 'insignificant', and which need to be considered in more detail in relation to the predicted annual mean concentrations or deposition.

4. Existing Environment

4.1 Site Location

The site is situated between the town of Eastfield and village of Cayton, approximately 5 km south-southeast of Scarborough, North Yorkshire. The area surrounding the site generally comprises residential properties and industrial premises. George Pindar School is located approximately 100 m from the western boundary of the site.

There are several sensitive human receptors in the vicinity of the site in respect of potential air emissions from the process. The most relevant sensitive receptors have been identified from local mapping and are summarised in Appendix A and presented in Figure 3. The nearest modelled residential property is approximately 120 m west-northwest of the thermal oxidiser stack.

4.2 Local Air Quality Management

A review of baseline air quality was carried out prior to undertaking the air quality assessment. This was carried out to determine the availability of baseline air quality data recorded in the vicinity of the site and also if data from other regional or national sources such as the UK Air Information Resource (UK-AIR) (Defra, 2023) website could be used to represent background concentrations of the relevant pollutants in the vicinity of the site.

As part of the Local Air Quality Management (LAQM) process, Scarborough Borough Council has declared a single Air Quality Management Area (AQMA) termed 'Scarborough AQMA'. This AQMA was declared in 2004 (amended in 2018) for elevated concentrations of 15-minute and 24-hour mean SO_2 and annual mean and 24-hour mean PM_{10}. As this AQMA is approximately 43 km northwest of the site, it is not considered further in the assessment.

Scarborough Borough Council also carries out regular assessments and monitoring of air quality within its administrative boundary as part of the LAQM process. The most recent Air Quality Annual Status Report available (Scarborough Borough Council, 2021) was reviewed to determine concentrations of NO_2 in the vicinity of the site. It should be noted that none of the other assessed pollutants are monitored by Scarborough Borough Council. Table 5 presents information on the nearest monitoring location to the site. The 2019 monitored annual mean NO_2 concentration is presented as this dataset is the latest available representative data not affected by the Covid pandemic and related travel restrictions.

Table 5. Nearest monitoring location to the site

Site ID	Description	Site type	Location	Distance and direction from Thermal Oxidiser stack (km)	Pollutants monitored	2019 Annual mean concentration (μg/m^3)
Automatic monitoring (continuous)						
Scarborough Borough Council does not undertake automatic monitoring						
Non-automatic monitoring (diffusion tubes)						
DT4	Cayton	Roadside	E 505466 N 483378	0.57 km, SE	NO_2	15.0 μg/m^3

This monitoring location is not considered representative of the site and surrounding area due to the roadside monitoring location being adjacent to the B1261 (Main Road) and the junction at North Lane.

For the assessed pollutants, information on background air quality in the vicinity of the site was obtained from Defra background map datasets (Defra, 2023). The 2018-based background maps by Defra are estimates based upon the principal local and regional sources of emissions and ambient monitoring data. For SO_2 and CO concentrations, the 2001-based background maps were used. For TVOC concentrations, the 2010-based background maps for benzene were used. These background concentrations are presented in Table 6.

As it is necessary to determine the potential impact of emissions from the site on the assessed protected conservation areas, the background concentrations of NOx and SO_2 were also identified for the assessed protected conservation areas. These background concentrations were also obtained from Defra background map datasets (Defra, 2023) and are displayed in Table 6.

Table 6. Background concentrations: adopted for use in assessment for assessed human receptors and protected conservation areas

Pollutant	Annual mean concentration (µg/m^3)	Description
Human receptors		
NO_2	6.7 – 12.1	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2023 map concentration
CO	97 - 99	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, scaled from 2001-based map to 2023 concentration
PM_{10}	12.1 – 13.0	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2023 map concentration
$PM_{2.5}$	7.0 – 7.5	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2023 map concentration
SO_2	3.6 – 4.4	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2001 map concentration
C_6H_6	0.16 – 0.17	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2010 map concentration for benzene
Protected conservation areas		
NOx	6.5 – 16.4	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2023 map concentration
SO_2	3.1 – 4.5	Defra 1 km x 1 km background map value for the assessed sensitive human receptor locations, 2001 map concentration

The long-term background concentrations were doubled to estimate the short-term background concentrations in line with the Environment Agency guidance (Environment Agency, 2022).

4.3 Existing Deposition Rates

Existing acid and nutrient nitrogen deposition levels were obtained from APIS (Centre for Ecology and Hydrology, 2023). As a conservative approach to the assessment, it is assumed the vegetation type selected is present at the specific modelled location within the assessed protected conservation area.

The existing deposition values at the assessed ecological designations are set out in Table 7.

Table 7. Existing deposition at modelled habitat sites

Receptor ref	Protected conservation area	Vegetation type (for deposition velocity)	Existing deposition rates		
			Acid deposition (kEqH+/ha/year)		Nutrient N deposition (kg N/ha/year)
			Nitrogen	Sulphur	Nitrogen
H1	Flamborough and Filey Coast SPA	Short	1.58	0.14	22.12
H2	Cayton, Cornelian and South Bays SSSI	Short	1.53	0.14	21.45
		Tall	2.61	0.18	36.53
H3	The Dell LNR	Short	1.54	0.14	21.56
		Tall	2.61	0.18	36.54
H4	Cayton Meadow LWS	Short	1.54	0.14	21.56
		Tall	2.61	0.18	36.54
H5	Burton Riggs Gravel Pits LWS	Short	1.54	0.14	21.56
		Tall	2.61	0.18	36.54
H6	High Deepdale LWS	Short	1.60	0.16	22.40
		Tall	2.69	0.19	37.66

5. Results

5.1 Human Receptors

The results presented below are the maximum modelled concentrations predicted for both modelled scenarios, at any of the 26 assessed sensitive human receptor locations and the maximum modelled concentration at any off-site location, for the five years of meteorological data used in the study.

The results of the dispersion modelling are set out in Table 8 and present the following information:

- EQS (i.e. the relevant air quality standard);
- estimated annual mean background concentration (see Section 4) that is representative of the baseline;
- PC, the maximum modelled concentrations due to the emissions from the assessed combustion plant;
- PEC, the maximum modelled concentration due to process emissions combined with estimated baseline concentrations;
- PC and PEC as a percentage of the EQS; and
- PC as a percentage of headroom (i.e. the PC as a percentage of the difference between the short-term background concentration and the EQS, for short-term predictions only).

To enable direct comparison between the modelled scenarios, Table 8 also presents the maximum modelled concentrations at those receptors where the highest concentrations were predicted to occur in the alternate scenario.

The full results at assessed human receptor locations for both considered scenarios are presented in Appendix C.

Table 8. Results of detailed assessment

Pollutant	Averaging period	Assessment location	Receptor where maximum PC predicted	EQS (µg/m^3)	Baseline air quality level (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC / EQS (%)	PEC / EQS (%)	PC as a percentage of headroom (%)
Existing Scenario										
CO	Maximum 8-hour running mean	Sensitive locations	R1	10,000	193	32.8	225.9	0.3%	2.3%	0.3%
		Sensitive locations	R12	10,000	193	19.0	212	0.2%	2.1%	0.3%
	Maximum 1-hour mean	Maximum off-site	-	30,000	198	139.9	338.4	0.5%	1.1%	0.5%
		Sensitive locations	R14	30,000	193	57.7	250.7	0.2%	0.8%	0.2%
Proposed Scenario										
CO	Maximum 8-hour running mean	Sensitive locations	R1	10,000	193	54.9	248	0.5%	2.5%	0.6%
		Sensitive locations	R12	10,000	193	201.7	394.7	2.0%	3.9%	2.1%
	Maximum 1-hour mean	Maximum off-site	-	30,000	193	1,007.7	1,200.7	3.4%	4.0%	3.4%
		Sensitive locations	R14	30,000	193	527.6	720.7	1.8%	2.4%	1.8%
Existing Scenario										
NO_2	Annual mean	Sensitive locations	R2	40	6.7	3.9	10.7	9.9%	26.7%	-
		Sensitive locations	R7	40	6.7	1.7	8.4	4.2%	21.1%	-
	1-hour mean (99.79th percentile)	Maximum off-site	-	200	13.8	31.6	45.4	15.8%	22.7%	17.0%
		Sensitive locations	R14	200	13.5	23.0	36.5	11.5%	18.2%	12.3%
Proposed Scenario										
NO_2	Annual mean	Sensitive locations	R2	40	6.7	4.7	11.4	11.8%	28.6%	-
		Sensitive locations	R7	40	6.7	5.5	12.3	13.9%	30.7%	-
	1-hour mean (99.79th percentile)	Maximum off-site	-	200	13.5	73.5	87.0	36.8%	43.5%	39.4%
		Sensitive locations	R14	200	13.5	30.4	43.9	15.2%	21.9%	16.3%
SO_2	24-hour mean (99.18th percentile)	Sensitive locations	R14	125	7.2	7.0	14.2	5.6%	11.4%	5.9%
	1-hour mean (99.73rd percentile)	Maximum off-site	-	350	7.2	42.6	49.8	12.2%	14.2%	12.4%
		Sensitive locations	R14	350	7.2	14.6	21.8	4.2%	6.2%	4.3%

Pollutant	Averaging period	Assessment location	Receptor where maximum PC predicted	EQS (µg/m³)	Baseline air quality level (µg/m³)	PC (µg/m³)	PEC (µg/m³)	PC / EQS (%)	PEC / EQS (%)	PC as a percentage of headroom (%)
	15-minute mean (99.9th percentile)	Maximum off-site	-	266	7.2	67.4	74.6	25.4%	28.1%	26.1%
		Sensitive locations	R14	266	7.2	22.5	29.7	8.5%	11.2%	8.7%
PM_{10}	Annual mean	Sensitive locations	R7	40	12.1	0.07	12.2	0.2%	30.6%	-
	24-hour mean (90.41st percentile)	Sensitive locations	R7	50	24.3	0.21	24.5	0.4%	49.0%	0.8%
$PM_{2.5}$	Annual mean	Sensitive locations	R7	20	7.0	0.07	7.1	0.4%	35.3%	-
TVOC	Annual mean	Sensitive locations	R7	5 (Benzene)	0.2	10.3	10.5	206.7%	209.9%	-
	Maximum 24-hour mean	Sensitive locations	R14	30 (Benzene)	0.3	75.9	76.2	253.0%	254.0%	255.7%

Note 1: For the Existing Scenario, the assessed existing combustion units utilise natural gas and therefore, emissions of SO_2, particulates and TVOCs are not considered.

Note 2: For annual mean NO_2, PM_{10} and $PM_{2.5}$ and TVOC concentrations, 24-hour mean PM_{10} and SO_2 concentrations and 8-hour mean CO concentrations, R23 to R26 have been omitted from analysis as these receptor locations represent George Pindar School sports facilities and nearby sports field (i.e. short-term exposure only). The full results are presented in Appendix C.

Results discussion

The results in Table 8 indicate that the predicted off-site concentrations and predicted concentrations at sensitive human receptors do not exceed any relevant long-term or short-term air quality objective or guideline irrespective of the modelled scenario.

For the Proposed Scenario, the removal of the existing boilers and installation of the CHP engine and new steam boilers increases the maximum PC at the nearby assessed human receptors from 3.9 µg/m^3 to 5.5 µg/m^3, which equates to 13.9% of the EQS. The corresponding PEC is well below 70% of the EQS (i.e. 30.7%).

For the Existing Scenario, the maximum annual mean NO_2 PC was predicted at R2, which represents a residential property approximately 180 m north-northeast of the thermal oxidiser. The maximum annual mean NO_2 PC at R2 increases from 3.9 µg/m^3 to 4.7 µg/m^3 when removing the existing boilers and installing the CHP engine and new steam boilers. The corresponding PEC is well below 70% of the EQS (i.e. 28.6%).

For the Proposed Scenario, the maximum annual mean NO_2 PC was predicted at R7, which represents a residential property approximately 220 m southeast of the thermal oxidiser and approximately 170 m east of the proposed CHP engine. The maximum annual mean NO_2 PC at R7 increases by 3.8 µg/m^3 from 1.7 µg/m^3 to 5.5 µg/m^3 when removing the existing boilers and installing the CHP engine and new steam boilers.

This indicates that the pollutant contribution from the CHP engine is considerably greater than the existing assessed combustion units or indeed the proposed steam boilers.

Further analysis indicates that emissions from the CHP engine accounted for approximately 67% of the maximum process contribution predicted at R7.

It is noted that for both modelled scenarios, the annual mean NO_2 PC as a percentage of the EQS is relatively high. However, this assessment assumes that all assessed combustion units operate continuously at maximum load throughout the year (i.e. 8,760 hours). In practice, the thermal oxidiser is regularly shut-down (usually for two days once a fortnight for cleaning purposes) and the remaining assessed combustion units will have periods of shut-down and maintenance and may not always operate at maximum load. Furthermore, the site typically closes for two weeks over the summer months. Therefore, the results presented are likely to be higher than would reasonably be expected.

For 1-hour mean NO_2 (99.79th percentile) concentrations, the maximum PC for both scenarios was predicted at R14, which represents a residential property approximately 330 m south of the thermal oxidiser. When removing the existing boilers and installing the CHP engine and new steam boilers, the maximum PC increases from 23.0 µg/m^3 to 30.4 µg/m^3, which equates to 15.2% of the EQS. However, the corresponding PEC is well below 70% of the EQS (i.e. 21.9%).

For PM_{10} and $PM_{2.5}$ annual mean concentrations (Proposed Scenario only), the respective PCs are less than 1% of the relevant long-term EQS and the impact is considered 'insignificant' as per Environment Agency guidance (Environment Agency, 2022) and therefore 'not significant'.

For short-term CO and NO_2 concentrations, the PCs for the Proposed Scenario are either less than 10% of the relevant EQS or where the PC is greater than 10%, the corresponding PEC is below 70% of the short-term EQS and the impact is considered 'not significant'. It is noted that short-term concentrations are predicted to increase under the proposed operations.

For short-term SO_2 and particulate concentrations (Proposed Scenario only), the PCs are either less than 10% of the relevant EQS or where the PC is greater than 10%, the PEC is below 70% of the short-term EQS and the impact is considered 'not significant'.

For annual mean TVOC concentrations at a sensitive human receptor location (Proposed Scenario only), the maximum PC of 10.3 µg/m^3 is predicted at R7, which represents a residential property approximately 220 m southeast of the thermal oxidiser stack. The PEC exceeds the annual mean EQS for C_6H_6.

For maximum 24-hour mean TVOCs concentrations at a sensitive human receptor location, the maximum PEC of 76.2 µg/m^3 is predicted at R12, which represents a residential property approximately 330 m south of the thermal oxidiser stack. The PEC exceeds the short-term EQS for C_6H_6.

This assessment assumes all TVOCs emitted by the combustion plant are C_6H_6 in the absence of EQSs for TVOC. This is an unrealistic assumption and C_6H_6 if present in the exhaust gases, would constitute only a very small proportion of total TVOC emissions (i.e. less than 1%). Therefore, based on professional judgement, the emissions of TVOCs is considered 'not significant'.

Isopleths (see Figures 5 - 8) have been produced for annual mean and 1-hour mean (99.79th percentile) NO_2 concentrations for both scenarios. The figures are based on the year of meteorological data which resulted in the highest PC at a sensitive human receptor location for the relevant scenario.

5.2 Protected Conservation Areas

5.2.1 Assessment against Critical Levels

The environmental effects of releases from the site at the assessed protected conservation areas have been determined by comparing predicted concentrations of released substances with the EQSs for the protection of vegetation (critical levels) (see Table 3). The results of the detailed modelling at the assessed protected conservation areas are shown in Table 9 and Table 10. The results presented are the maximum predicted concentration at each assessed protected conservation area for the five years of meteorological data used in the study.

For SO_2, the relevant EQS was based on the assumption that lichens and bryophytes were present at each site, therefore adopting a further conservative approach as the EQS reduces from 20 µg/m^3 to 10 µg/m^3.

Table 9. Results of detailed assessment at assessed protected conservation sites for annual mean NOx and maximum 24-hour mean NOx concentrations (Existing Scenario)

Ref	Protected Conservation Area	EQS (µg/m^3)	Background concentration (µg/m^3)	PC (µg/m^3)	PEC (µg/m^3)	PC/EQS (%)	PEC/EQS (%)
Annual mean NOx concentrations							
H1	Flamborough and Filey Coast SPA	30	6.5	0.3	6.9	1.1%	22.9%
H2	Cayton, Cornelian and South Bays SSSI		7.7	0.8	8.4	2.6%	28.2%
H3	The Dell LNR		16.4	1.1	17.5	3.6%	58.2%
H4	Cayton Meadow LWS		7.5	0.2	7.7	0.8%	25.6%
H5	Burton Riggs Gravel Pits LWS		13.6	0.1	13.8	0.5%	45.9%
H6	High Deepdale LWS		7.6	0.2	7.8	0.8%	26.1%
Maximum 24-hour mean NOx concentrations							
H1	Flamborough and Filey Coast SPA	75	13.1	2.0	15.0	2.6%	20.1%
H2	Cayton, Cornelian and South Bays SSSI		15.3	5.2	20.5	6.9%	27.4%
H3	The Dell LNR		32.7	15.6	48.3	20.8%	64.4%
H4	Cayton Meadow LWS		14.9	4.8	19.7	6.4%	26.3%
H5	Burton Riggs Gravel Pits LWS		27.3	2.5	29.8	3.4%	39.7%
H6	High Deepdale LWS		15.2	2.5	17.7	3.4%	23.7%

Table 10. Results of detailed assessment at assessed protected conservation sites for annual mean NOx and SO_2 concentrations and for maximum 24-hour mean NOx concentrations (Proposed Scenario)

Ref	Protected Conservation Area	EQS (μg/m^3)	Background concentration (μg/m^3)	PC (μg/m^3)	PC difference between Existing Scenario (μg/m^3)	PEC (μg/m^3)	PC/EQS (%)	PEC/EQS (%)
Annual mean NOx concentrations								
H1	Flamborough and Filey Coast SPA	30	6.5	0.4	0.06	6.9	1.3%	23.1%
H2	Cayton, Cornelian and South Bays SSSI		7.7	0.9	0.09	8.5	2.9%	28.5%
H3	The Dell LNR		16.4	1.2	0.07	17.5	3.9%	58.5%
H4	Cayton Meadow LWS		7.5	0.3	0.03	7.7	0.9%	25.7%
H5	Burton Riggs Gravel Pits LWS		13.6	0.2	0.01	13.8	0.5%	46.0%
H6	High Deepdale LWS		7.6	0.2	0.01	7.8	0.8%	26.1%
Annual mean SO_2 concentrations								
H1	Flamborough and Filey Coast SPA	10	3.1	0.02	n/a	3.1	0.2%	31.3%
H2	Cayton, Cornelian and South Bays SSSI		3.4	0.04		3.4	0.4%	34.4%
H3	The Dell LNR		4.4	0.05		4.5	0.5%	44.7%
H4	Cayton Meadow LWS		3.3	0.01		3.3	0.1%	32.7%
H5	Burton Riggs Gravel Pits LWS		4.5	0.01		4.5	0.1%	45.2%
H6	High Deepdale LWS		3.4	0.01		3.4	0.1%	34.2%
Maximum 24-hour mean NOx concentrations								
H1	Flamborough and Filey Coast SPA	75	13.1	2.9	1.0	16.0	3.9%	21.3%
H2	Cayton, Cornelian and South Bays SSSI		15.3	5.7	0.5	21.1	7.7%	28.1%
H3	The Dell LNR		32.7	16.4	0.8	49.2	21.9%	65.6%
H4	Cayton Meadow LWS		14.9	5.3	0.5	20.3	7.1%	27.0%
H5	Burton Riggs Gravel Pits LWS		27.3	2.7	0.1	29.9	3.6%	39.9%
H6	High Deepdale LWS		15.2	3.0	0.5	18.2	4.0%	24.3%

Results discussion

For critical levels, the increase in annual mean NOx PC between the Existing and Proposed Scenario at the assessed Flamborough and Filey Coast SPA and Cayton, Cornelian and South Bays SSS is less than 0.1 μg/m^3. For both scenarios, the annual mean NOx PCs at the SPA and SSSI are just above 1% (i.e. <1.4%) of the long-term environmental standard. However, the respective PECs at both protected conservation areas are well below 70% of the critical level value. When taking into consideration the conservative approach to the assessment, based on professional judgement, the emissions are not likely to have a significant effect.

For annual mean SO_2 concentrations (Proposed Scenario only), the respective PCs for the assessed SPA and SSSI are less than 1% of the long-term environmental standard and the impact can be described as 'insignificant' as per Environment Agency guidance (Environment Agency, 2022).

For maximum 24-hour mean NOx concentrations at the assessed SPA and SSSI, the increase in short-term NOx PCs between the Existing and Proposed Scenario is less than 1.1 μg/m^3. The respective PCs for both scenarios for are less than 10% of the short-term environmental standard and the impact can be described as 'insignificant'.

For all assessed local nature sites, the respective annual mean NOx (both scenarios) and SO_2 (Proposed Scenario only) and short-term NOx PCs (both scenarios) are less than 100% of the relevant environmental standard and can be described as 'insignificant' as per Environment Agency guidance (Environment Agency, 2022).

The conservative approach adopted throughout this assessment means that, based on professional judgement, it is not considered likely that there would be unacceptable impacts to air quality at the assessed protected conservation areas, as a consequence of the proposed site configuration with regard to ambient concentrations of NOx and SO_2.

5.2.2 Assessment against Critical Loads

The rate of deposition of acidic compounds and nitrogen containing species have been estimated at the assessed protected conservation areas. This allows the potential for adverse effects to be evaluated by comparison with critical loads for acid and nutrient nitrogen deposition. The assessment took account of emissions of NOx and SO_2 only.

Critical load functions for acid deposition are specified on the basis of both nitrogen-derived acid and sulphur-derived acid. This information, including existing deposition levels at habitat sites, is available from APIS (Centre for Ecology and Hydrology, 2023). Further information on the assessment of deposition is provided in Appendix B. The full detailed modelled results are displayed in Table 11 to Table 14.

Table 11. Modelled acid deposition at assessed protected conservation areas (Existing Scenario)

Ref	Habitat	Vegetation type (for deposition velocity)	Critical load (CL) (kEqH+/ha/year)			Existing acid deposition (kEqH+/ha/year)		PC	PEC	PC/CL (%)	PEC/CL(%)
			CLMaxS	CLMinN	CLMaxN	Existing deposition (N)	Existing deposition (S)				
H1	Flamborough and Filey Coast SPA	Short	No critical load data available			1.58	0.14	0.002	1.72	-	-
H2	Cayton, Cornelian and South Bays SSSI	Short	4.100	0.223	4.323	1.53	0.14	0.006	1.68	0.1%	39%
		Tall	10.793	0.142	10.935	2.61	0.18	0.011	2.80	0.1%	26%
H3	The Dell LNR	Short	4.100	0.223	4.323	1.54	0.14	0.008	1.69	0.2%	39%
		Tall	10.778	0.142	10.920	2.61	0.18	0.016	2.81	0.1%	26%
H4	Cayton Meadow LWS	Short	4.100	0.223	4.323	1.54	0.14	0.002	1.68	0.0%	39%
		Tall	10.774	0.142	10.916	2.61	0.18	0.003	2.79	0.0%	26%
H5	Burton Riggs Gravel Pits LWS	Short	0.850	0.223	1.073	1.54	0.14	0.001	1.68	0.1%	157%
		Tall	1.562	0.142	1.704	2.61	0.18	0.002	2.79	0.1%	164%
H6	High Deepdale LWS	Short	0.430	0.223	0.653	1.60	0.16	0.002	1.76	0.2%	270%
		Tall	1.002	0.142	1.144	2.69	0.19	0.003	2.88	0.3%	252%

Table 12. Modelled nitrogen deposition at assessed protected conservation areas (Existing Scenario)

Ref	Habitat	Vegetation type (for deposition velocity)	Existing nutrient deposition (kgN/ha-year)		PC	PEC	PC/CL (%)	PEC/CL(%)
			Minimal Critical Load (CL)	Existing deposition				
H1	Flamborough and Filey Coast SPA	Short	5	22.12	0.033	22.15	0.7%	443%
H2	Cayton, Cornelian and South Bays SSSI	Short	10	21.45	0.079	21.53	0.8%	215%
		Tall	15	36.53	0.157	36.69	1.0%	245%
H3	The Dell LNR	Short	5	21.56	0.110	21.67	2.2%	433%
		Tall	5	36.54	0.220	36.76	4.4%	735%
H4	Cayton Meadow LWS	Short	5	21.56	0.023	21.58	0.5%	432%
		Tall	5	36.54	0.046	36.59	0.9%	732%
H5	Burton Riggs Gravel Pits LWS	Short	5	21.56	0.014	21.57	0.3%	431%
		Tall	5	36.54	0.029	36.57	0.6%	731%
H6	High Deepdale LWS	Short	5	22.40	0.023	22.42	0.5%	448%
		Tall	5	37.66	0.045	37.71	0.9%	754%

Table 13. Modelled acid deposition at assessed protected conservation areas (proposed scenario)

Ref	Habitat	Vegetation type (for deposition velocity)	Critical load (CL) (kEqH+/ha/year)			Existing acid deposition (kEqH+/ha/year)		PC	PEC	PC/CL (%)	PEC/CL(%)
			CLMaxS	CLMinN	CLMaxN	Existing deposition (N)	Existing deposition (S)				
H1	Flamborough and Filey Coast SPA	Short	No critical load data available			1.58	0.14	0.005	1.73	-	-
H2	Cayton, Cornelian and South Bays SSSI	Short	4.100	0.223	4.323	1.53	0.14	0.011	1.68	0.2%	39%
		Tall	10.793	0.142	10.935	2.61	0.18	0.022	2.81	0.2%	26%
H3	The Dell LNR	Short	4.100	0.223	4.323	1.54	0.14	0.014	1.69	0.3%	39%
		Tall	10.778	0.142	10.920	2.61	0.18	0.028	2.82	0.3%	26%
H4	Cayton Meadow LWS	Short	4.100	0.223	4.323	1.54	0.14	0.003	1.68	0.1%	39%
		Tall	10.774	0.142	10.916	2.61	0.18	0.007	2.80	0.1%	26%

Ref	Habitat	Vegetation type (for deposition velocity)	Critical load (CL) (kEqH+/ha/year)			Existing acid deposition (kEqH+/ha/year)		PC	PEC	PC/CL (%)	PEC/CL(%)
			CLMaxS	CLMinN	CLMaxN	Existing deposition (N)	Existing deposition (S)				
H5	Burton Riggs Gravel Pits LWS	Short	0.850	0.223	1.073	1.54	0.14	0.002	1.68	0.2%	157%
		Tall	1.562	0.142	1.704	2.61	0.18	0.004	2.79	0.2%	164%
H6	High Deepdale LWS	Short	0.430	0.223	0.653	1.60	0.16	0.003	1.76	0.4%	270%
		Tall	1.002	0.142	1.144	2.69	0.19	0.006	2.89	0.5%	252%

Table 14. Modelled nitrogen deposition at assessed protected conservation areas (proposed scenario)

Ref	Habitat	Vegetation type (for deposition velocity)	Existing nutrient deposition (kgN/ha-year)		PC	PEC	PC/CL (%)	PEC/CL(%)
			Minimal Critical Load (CL)	Existing deposition				
H1	Flamborough and Filey Coast SPA	Short	5	22.12	0.038	22.16	0.8%	443%
H2	Cayton, Cornelian and South Bays SSSI	Short	10	21.45	0.088	21.53	0.9%	215%
		Tall	15	36.53	0.176	36.71	1.2%	245%
H3	The Dell LNR	Short	5	21.56	0.118	21.68	2.4%	434%
		Tall	5	36.54	0.235	36.78	4.7%	736%
H4	Cayton Meadow LWS	Short	5	21.56	0.026	21.59	0.5%	432%
		Tall	5	36.54	0.052	36.59	1.0%	732%
H5	Burton Riggs Gravel Pits LWS	Short	5	21.56	0.015	21.58	0.3%	432%
		Tall	5	36.54	0.031	36.57	0.6%	731%
H6	High Deepdale LWS	Short	5	22.40	0.024	22.42	0.5%	448%
		Tall	5	37.66	0.048	37.71	1.0%	754%

Results discussion

For both modelled scenarios, the results indicate that for the assessed Cayton, Cornelian and South Bays SSSI (short vegetation) and Flamborough and Filey Coast SPA, the PCs for acid and nutrient nitrogen deposition, where relevant, are less than 1% of the relevant long-term environmental standard and the impact can be described as 'insignificant' as per Environment Agency guidance (Environment Agency, 2022).

At Cayton, Cornelian and South Bays SSSI (tall vegetation), the PCs for nutrient nitrogen deposition are just above 1% (i.e. <1.3%) of the relevant long-term environmental standard, irrespective of the modelled scenario.

The increase in PCs for acid deposition and nutrient nitrogen deposition between the Existing and Proposed Scenario at the assessed SPA and SSSI is less than 0.02 kEqH+/ha/year and 0.03 kgN/ha-year, respectively.

For the assessed local nature sites, the respective PCs for acid and nutrient nitrogen deposition for both scenarios are less than 100% of the relevant long-term environmental standard for protected conservation areas and the impact can be described as 'insignificant' as Environment Agency guidance (Environment Agency, 2022).

The conservative approach adopted throughout this assessment means the results presented are likely to be higher than would reasonably be expected. Based on professional judgement, it is not considered likely that there would be unacceptable impacts at the assessed protected conservation areas as a consequence of the proposed site configuration.

5.3 Sensitivity Analysis (Proposed Scenario)

A sensitivity study was undertaken to see how changes to the surface roughness and omission of the buildings in the 2017 model (which predicted the highest annual mean and 1-hour mean (99.79th percentile) NO_2 concentrations at a sensitive human receptor location) and 2018 model (which predicted the highest 1-hour mean (99.79th percentile) NO_2 concentrations at a modelled off-site location) may impact on predicted concentrations at sensitive human receptors and off-site locations. The results of the sensitivity analysis are presented in Table 15 to Table 17.

Table 15. Sensitivity analysis - fixed surface roughness of 0.1 m

Pollutant	Averaging period	Assessment location	Original PC (surface roughness 0.5 m) (µg/m^3)	Surface roughness length 0.1 m				
				PC (µg/m^3)	PEC (µg/m^3)	PC/EQS	PEC/EQS	% difference in PC/EQS compared to original
NO_2	Annual mean	Sensitive locations	5.5	4.7	11.5	11.9%	28.7%	-2.0%
	1 hour mean (99.79th percentile)	Maximum off-site	73.5	68.1	81.6	34.1%	40.8%	-2.7%
		Sensitive locations	30.4	35.1	48.5	17.5%	24.3%	2.3%

The results in Table 15 indicate that the change to maximum predicted annual mean concentrations and 1-hour mean (99.79th percentile) concentrations at an off-site location are lower when using a surface roughness value of 0.1 m compared to the original value of 0.5 m. For 1-hour mean (99.79th percentile) NO_2 concentrations at a sensitive human receptor location, the PC is higher. However, a surface roughness of 0.1 m (representing root crops) is not considered representative of the site and surrounding area.

Table 16. Sensitivity analysis - fixed surface roughness of 1 m

Pollutant	Averaging period	Assessment location	Original PC (surface roughness 0.5 m) (µg/m³)	Surface roughness length 1 m				
				PC (µg/m³)	PEC (µg/m³)	PC/EQS	PEC/EQS	% difference in PC/EQS compared to original
NO_2	Annual mean	Sensitive locations	5.5	6.1	12.8	15.1%	32.0%	1.3%
	1 hour mean (99.79th percentile)	Maximum off-site	73.5	103.6	117.1	51.8%	58.5%	15.0%
		Sensitive locations	30.4	33.3	46.8	16.7%	23.4%	1.5%

The results in Table 16 indicate that the maximum predicted annual mean concentrations and 1-hour mean (99.79th percentile) NO_2 concentrations are higher when using a surface roughness value of 1 m compared to the original value of 0.5 m. In the case of 1-hour mean (99.79th percentile) NO_2 concentrations at an off-site location, the PC is considerably higher with an increased surface roughness value of 1 m. However, a surface roughness of 1 m (representing a large city centre location with built up areas and tall buildings) is not considered representative of the site and surrounding area.

Table 17. Sensitivity analysis - no buildings

Pollutant	Averaging period	Assessment location	Original PC (with buildings) (µg/m³)	No buildings				
				PC (µg/m³)	PEC (µg/m³)	PC/EQS	PEC/EQS	% difference in PC/EQS compared to original
NO_2	Annual mean	Sensitive locations	5.5	4.8	11.5	12.0%	28.8%	-1.9%
	1 hour mean (99.79th percentile)	Maximum off-site	73.5	29.0	42.5	14.5%	21.3%	-22.2%
		Sensitive locations	30.4	21.5	35.0	10.8%	17.5%	-4.4%

The results in Table 17 indicate that the differences between the maximum predicted concentrations with and without the buildings is such that including buildings within the model is the preferred option for this study, to maintain a more realistic, and conservative, approach.

6. Conclusions

This report has assessed the potential air quality impacts associated with the operation of the existing and proposed site configuration at the McCain Foods food production facility in Scarborough. The predicted impacts were assessed against the relevant air quality standards and guidelines for the protection of human health (referred to in the report as EQSs) and protected conservation areas (referred to as critical levels and critical loads).

Human receptors

The assessment indicates that the predicted modelled off-site concentrations and predicted concentrations at sensitive human receptors do not exceed any relevant long-term or short-term air quality objective or guideline, irrespective of the modelled scenario.

Furthermore, the proposed site configuration is likely to result in slight increases in long-term and short-term modelled concentrations at off-site and sensitive human receptor locations.

For the Existing Scenario, the maximum annual mean NO_2 PC was predicted at R2, which represents a residential property approximately 180 m north-northeast of the thermal oxidiser. The maximum annual mean NO_2 PC at R2 increases from 3.9 µg/m^3 to 4.7 µg/m^3 when removing the existing boilers and installing the CHP engine and new steam boilers. The corresponding PEC is well below 70% of the EQS (i.e. 28.6%).

For the Proposed Scenario, the maximum annual mean NO_2 PC was predicted at R7, which represents a residential property approximately 220 m southeast of the thermal oxidiser and approximately 170 m east of the proposed CHP engine. The maximum annual mean NO_2 PC at R7 increases by 3.8 µg/m^3 from 1.7 µg/m^3 to 5.5 µg/m^3 when removing the existing boilers and installing the CHP engine and new steam boilers.

This indicates that the pollutant contribution from the CHP engine is considerably greater than the existing assessed combustion units or indeed the proposed steam boilers.

Further analysis indicates that emissions from the CHP engine accounted for approximately 67% of the maximum process contribution predicted at R7.

It is noted that the annual mean NO_2 PC as a percentage of the EQS is relatively high. However, this assessment assumes that all assessed combustion units operate continuously at maximum load throughout the year (i.e. 8,760 hours). In practice, the thermal oxidiser is regularly shut-down (usually for two days once a fortnight for cleaning purposes) and the remaining assessed combustion units will have periods of shut-down and maintenance and may not always operate at maximum load. Furthermore, the site typically closes for two weeks over the summer months. Therefore, the results presented are likely to be higher than would reasonably be expected.

For the remaining long-term and short-term concentrations for both modelled scenarios, the impact is considered 'not significant'.

For TVOCs (Proposed Scenario only), the predicted annual mean and 24-hour mean concentrations were found to be exceeding the relevant EQS for C_6H_6. However, this assessment assumes all TVOCs emitted by the assessed combustion plant are C_6H_6. This is an unrealistic assumption, and C_6H_6, if present in the exhaust gases, would constitute only a very small proportion of total TVOC emissions (e.g. less than 1%). Therefore, for emissions of TVOCs, the impact is considered 'not significant'.

Protected conservation areas

For critical levels, the increase in annual mean NOx PC between the Existing and Proposed Scenario at the assessed Flamborough and Filey Coast SPA and Cayton, Cornelian and South Bays SSSI is less than 0.1 µg/m^3. For both modelled scenarios the annual mean NOx PCs at the assessed SPA and SSSI are just above 1% (i.e. <1.4%) of the long-term environmental standard. However, the respective PECs are less than 70% of the critical level and based on professional judgement, the emissions are not likely to have a significant effect.

For annual mean SO_2 concentrations (Proposed Scenario only), the respective PCs for the assessed SPA and SSSI are less than 1% of the long-term environmental standard and the impact can be described as 'insignificant' as per Environment Agency guidance (Environment Agency, 2022).

For maximum 24-hour mean NOx concentrations at the assessed SPA and SSSI, the increase in short-term NOx PCs between the Existing and Proposed Scenario is less than 1.1 µg/m^3. The respective PCs are less than 10% of the short-term environmental standard, irrespective of the modelled scenario, and can be described as 'insignificant'.

For all assessed local nature sites, the respective annual mean NOx and SO_2 and short-term NOx PCs are less than 100% of the relevant environmental standard and can be described as 'insignificant' as per Environment Agency guidance (Environment Agency, 2022).

For critical loads, the results indicate that for the assessed Cayton, Cornelian and South Bays SSSI (short vegetation) and Flamborough and Filey Coast SPA, the PCs for acid and nutrient nitrogen deposition, where relevant, are less than 1% of the relevant long-term environmental standard, irrespective of the modelled scenario, and the impact can be described as 'insignificant'. At Cayton, Cornelian and South Bays SSSI (tall vegetation), the PCs for nutrient nitrogen deposition are just above 1% (i.e. <1.3%) of the relevant long-term environmental standard, irrespective of the modelled scenario.

The increase in PCs for acid deposition and nutrient nitrogen deposition between the Existing and Proposed Scenario at the assessed SPA and SSSI is less than 0.02 kEqH+/ha/year and 0.03 kgN/ha-year, respectively.

For the assessed local nature sites, the respective PCs for acid and nutrient nitrogen deposition are less than 100% of the relevant long-term environmental standard for protected conservation areas and the impact can be described as 'insignificant' as Environment Agency guidance (Environment Agency, 2022).

The conservative approach adopted throughout this assessment means that based on professional judgement, it is not considered likely that there would be unacceptable impacts at the assessed protected conservation areas as a consequence of the proposed site configuration.

Summary

Based on the findings of this assessment, it is concluded that the proposed site configuration is acceptable from an air quality perspective.

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8. Figures

Figure 1: Existing Scenario - Site permit boundary, modelled stack locations and modelled existing building layout

Figure 2: Proposed Scenario - Site permit boundary, modelled stack locations and modelled proposed building layout

Figure 3: Extent of modelled grid and assessed sensitive human receptor locations

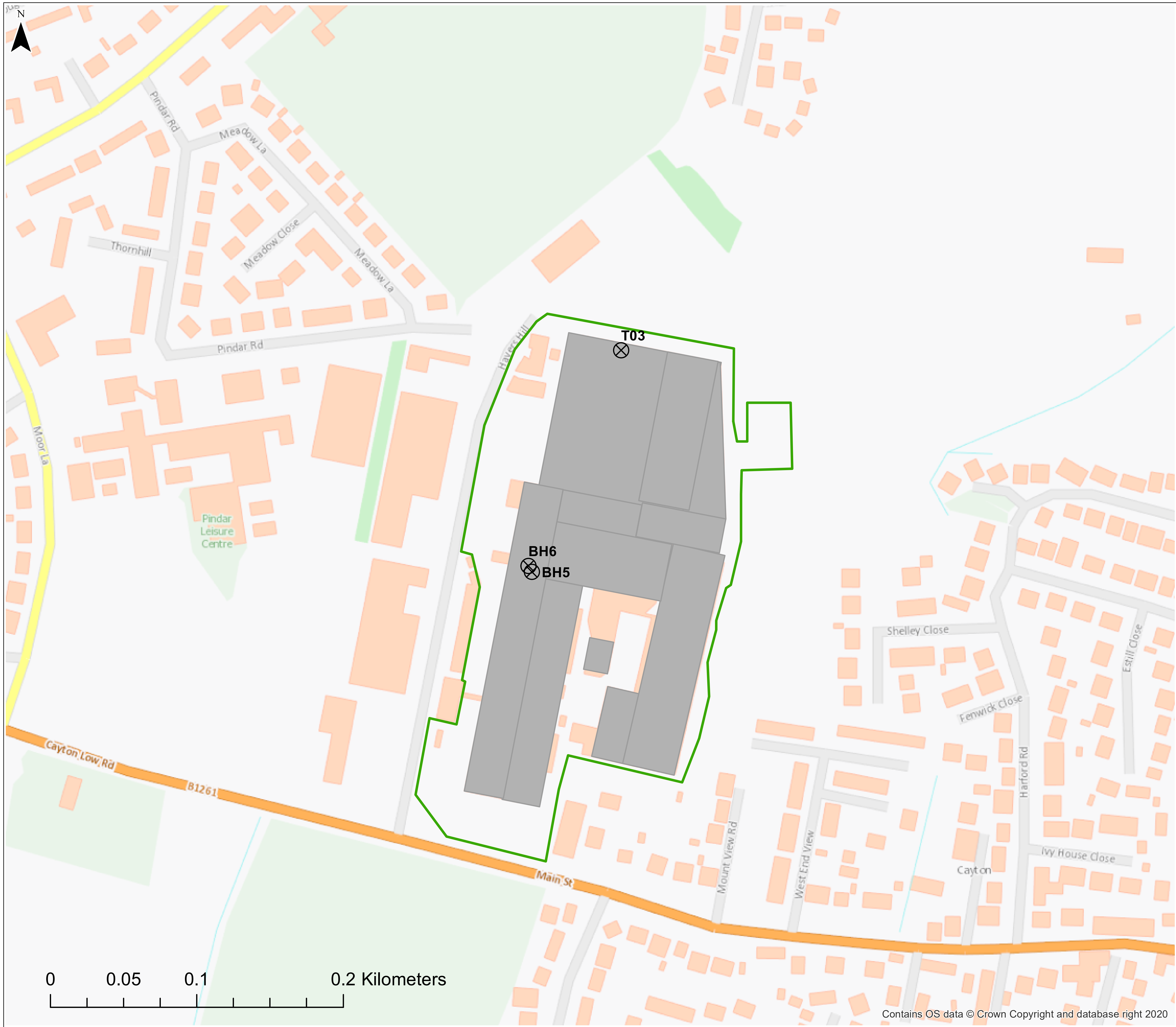
Figure 4: Assessed protected conservation areas

Figure 5: Existing Scenario - Annual mean nitrogen dioxide process contributions, 2020 meteorological data

Figure 6: Proposed Scenario - Annual mean nitrogen dioxide process contributions, 2017 meteorological data

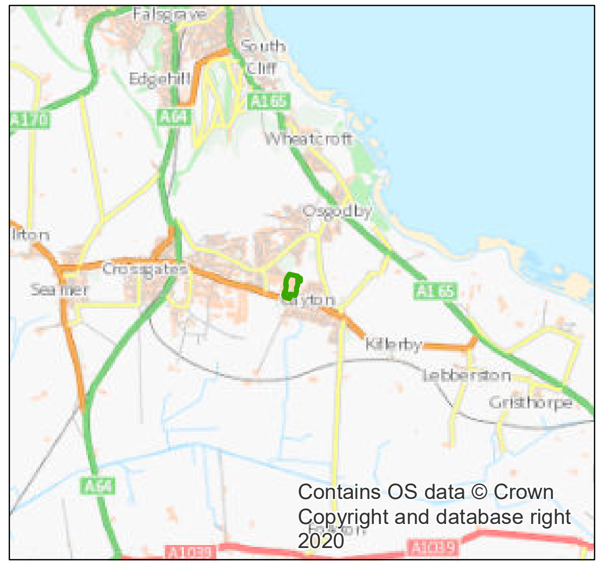
Figure 7: Existing Scenario - 1-hour mean (99.79^{th} percentile) nitrogen dioxide process contributions, 2016 meteorological data

Figure 8: Proposed Scenario - 1-hour mean (99.79^{th} percentile) nitrogen dioxide process contributions, 2017 meteorological data



Legend

- Site permit boundary
- Modelled stack locations (Existing Scenario)
- Modelled buildings (Existing Scenario)



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	31/01/2023	Initial Issue	DH	GW	GW	PLK

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Project

ENVIRONMENTAL PERMIT VARIATION APPLICATION - SCARBOROUGH PLANT FACILITY RENEWAL PROJECT AIR QUALITY IMPACT ASSESSMENT

Drawing Title

EXISTING SCENARIO - SITE PERMIT BOUNDARY, MODELLED STACK LOCATIONS AND MODELLED EXISTING BUILDING LAYOUT

Drawing Status: FINAL

Scale @ A3	1:2,500	DO NOT SCALE	
Jacobs No.	60SG2801	Rev	0
Client No.			

Drawing Number

FIGURE 1

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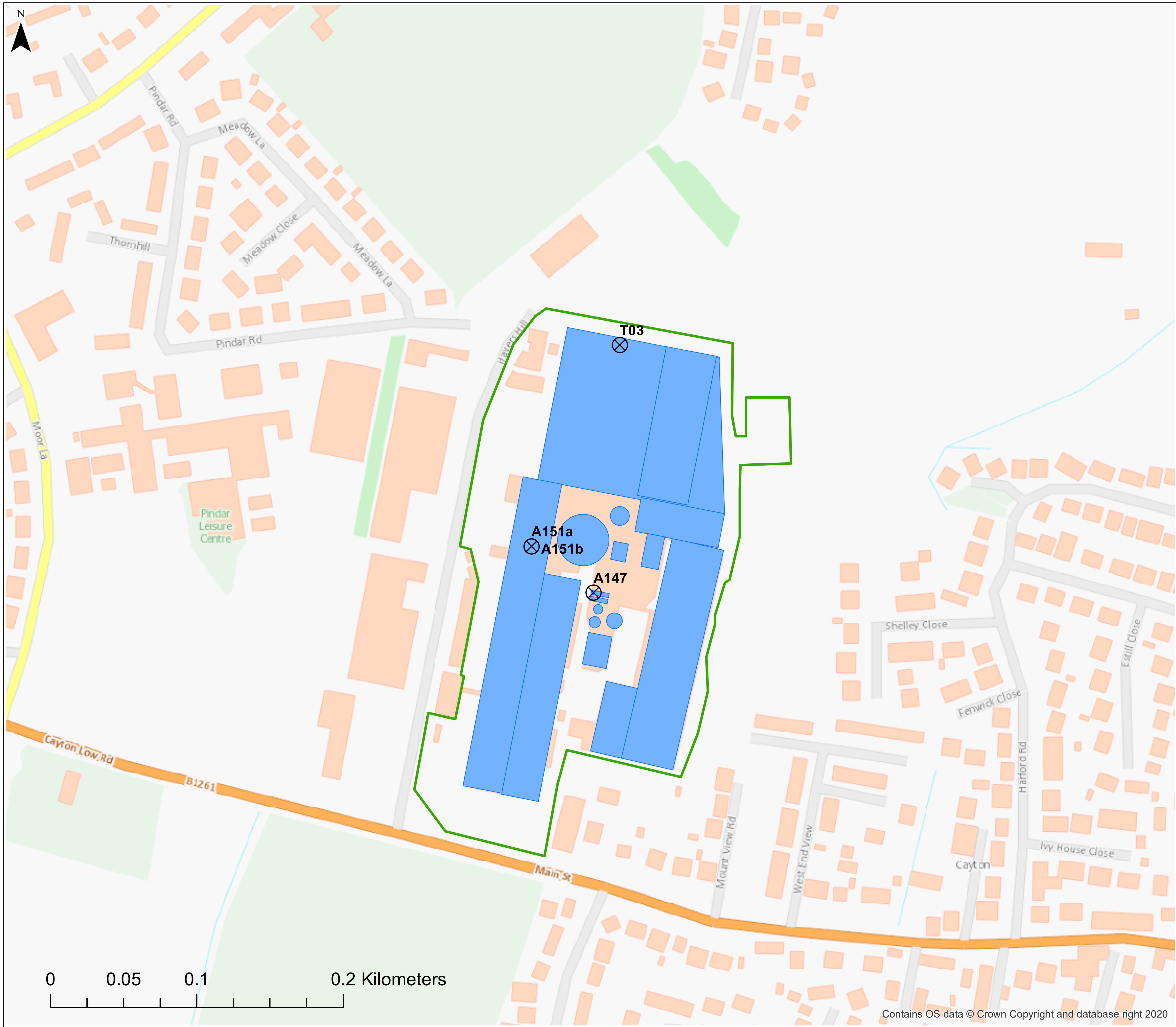
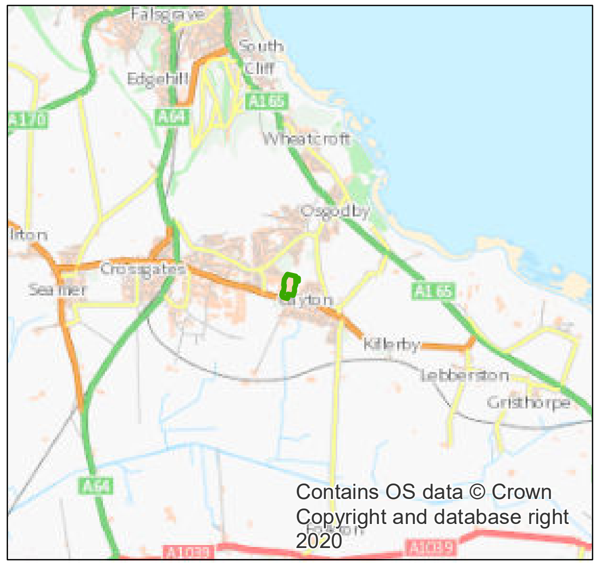


Legend

- Site permit boundary
- Modelled stack locations (Proposed Scenario)
- Modelled buildings (Proposed Scenario)



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ENVIRONMENTAL PERMIT VARIATION APPLICATION - SCARBOROUGH PLANT FACILITY RENEWAL PROJECT AIR QUALITY IMPACT ASSESSMENT

Drawing Title

PROPOSED SCENARIO - SITE PERMIT BOUNDARY, MODELLED STACK LOCATIONS AND MODELLED PROPOSED BUILDING LAYOUT

Drawing Status

FINAL

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Jacobs No.	60SG2801	Rev 0
Client No.		

Drawing Number

FIGURE 2

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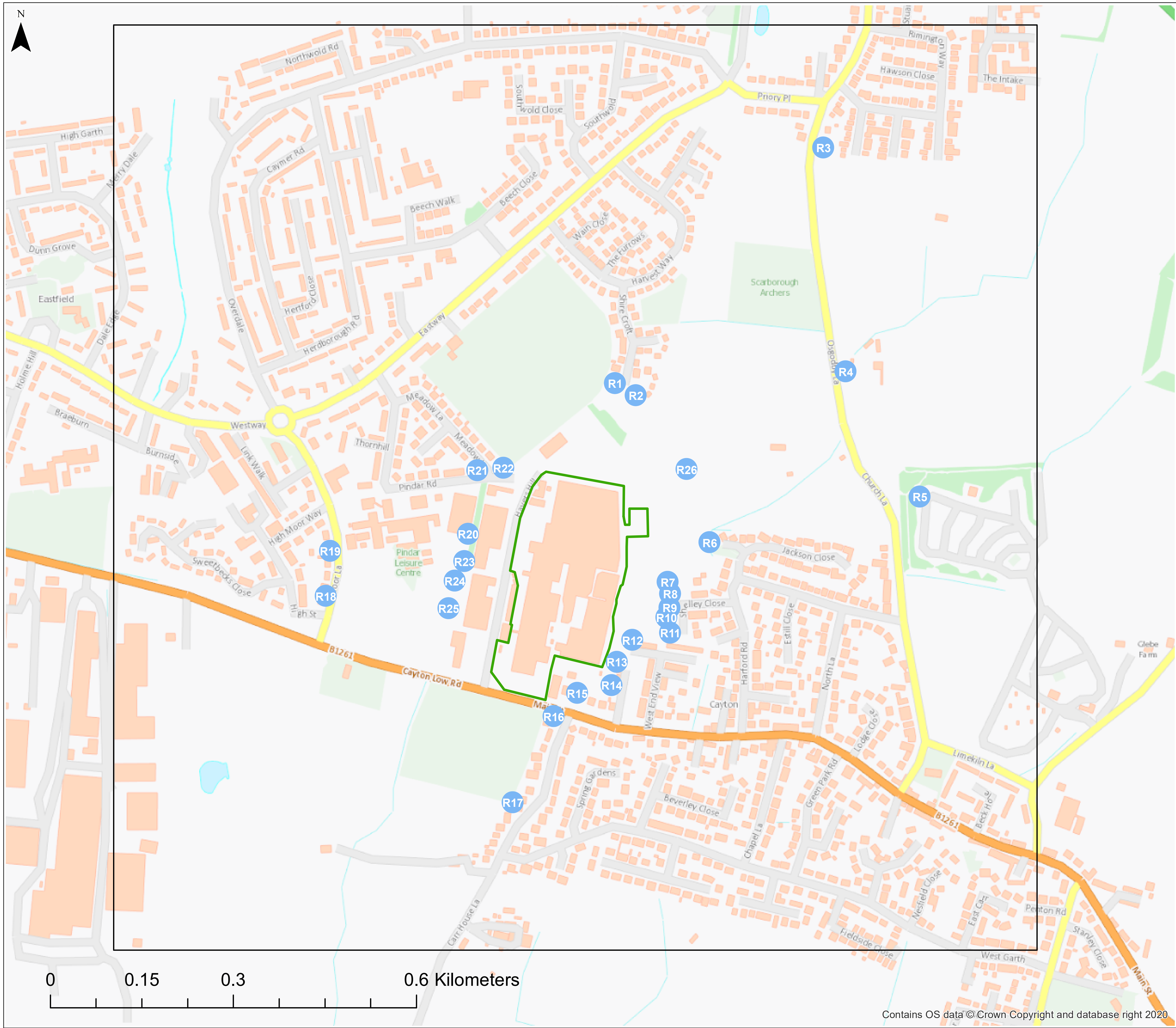
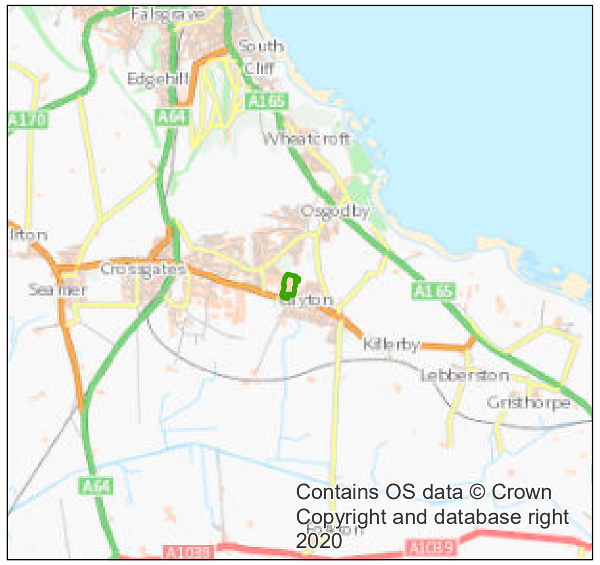


Legend

- Site permit boundary
- Extent of modelled grid
- R1 Assessed sensitive human receptor locations



Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	31/01/2023	Initial Issue	DH	GW	GW	PKL

Jacobs

Client: McCain

Project: ENVIRONMENTAL PERMIT VARIATION APPLICATION - SCARBOROUGH PLANT FACILITY RENEWAL PROJECT AIR QUALITY IMPACT ASSESSMENT

Drawing Title: EXTENT OF MODELLED GRID AND ASSESSED SENSITIVE HUMAN RECEPTOR LOCATIONS

Drawing Status: FINAL

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Jacobs No.	60SG2801	Rev	0
Client No.			

Drawing Number: FIGURE 3

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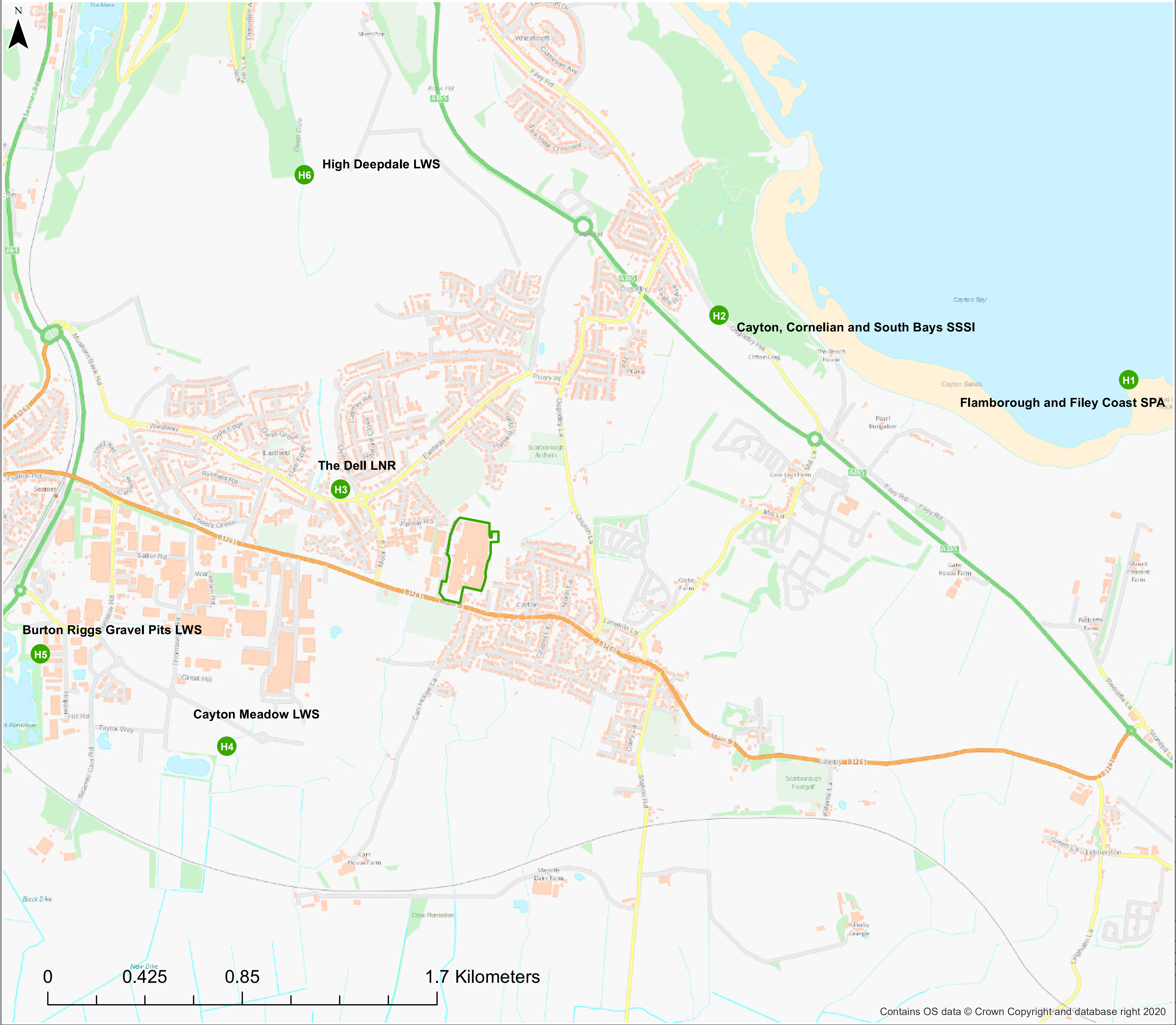

Legend

- Site permit boundary
- H1 Assessed protected conservation areas

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
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Drawing Title

PROTECTED CONSERVATION AREAS

Drawing Status

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Client No.		

Drawing Number

FIGURE 4

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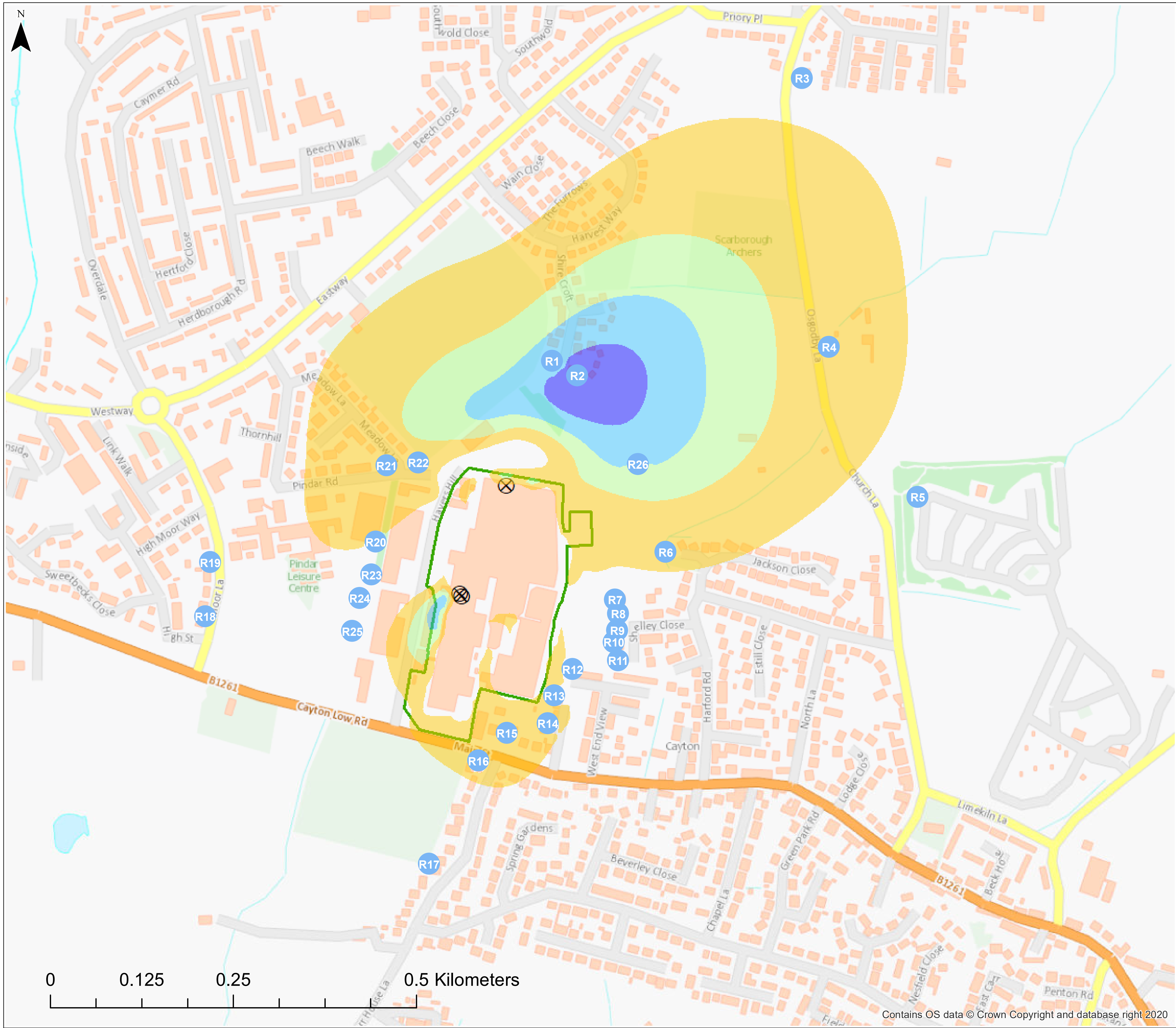

Legend

- Site permit boundary
- Modelled stack locations (Existing Scenario)
- Assessed sensitive human receptor locations

Annual mean nitrogen dioxide process contributions (µg/m³)

- 0 - 1.4
- 1.4 - 2.2
- 2.2 - 2.9
- 2.9 - 3.6
- 3.6 - 5.5

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	02/02/2023	Initial Issue	DH	GW	GW	MM

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Client: McCain

Project
ENVIRONMENTAL PERMIT VARIATION APPLICATION - SCARBOROUGH PLANT FACILITY RENEWAL PROJECT AIR QUALITY IMPACT ASSESSMENT

Drawing Title
EXISTING SCENARIO - ANNUAL MEAN NITROGEN DIOXIDE PROCESS CONTRIBUTIONS, 2020 METEOROLOGICAL DATA

Drawing Status: FINAL

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Jacobs No.	B1958992	Rev 0
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Drawing Number
FIGURE 5

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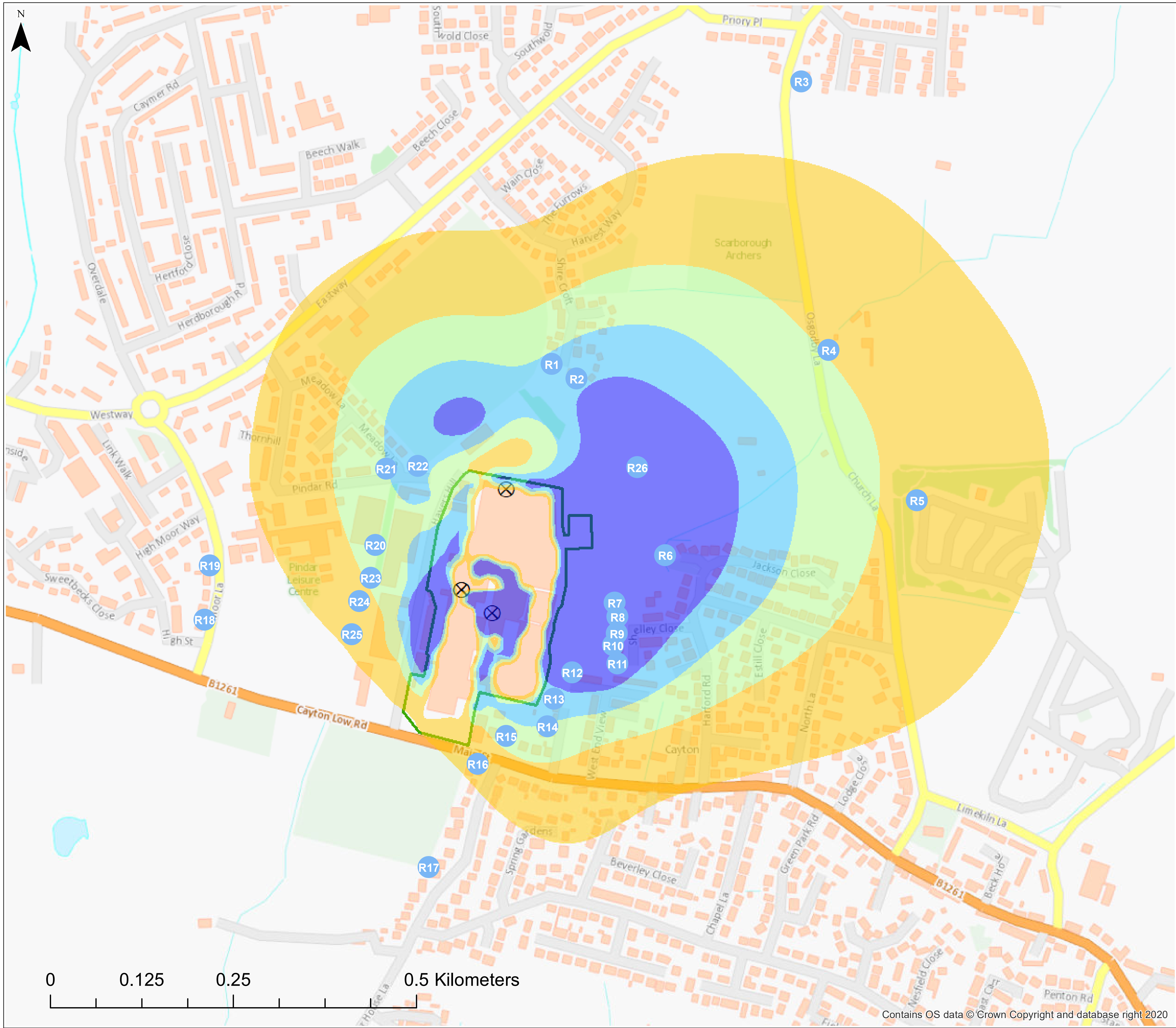

Legend

- Site permit boundary
- Modelled stack locations (Proposed Scenario)
- Assessed sensitive human receptor locations

Annual mean nitrogen dioxide process contributions ($\mu g/m^3$)

- 0 - 1.4
- 1.4 - 2.2
- 2.2 - 2.9
- 2.9 - 3.6
- 3.6 - 36.1

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	02/02/2023	Initial Issue	DH	GW	GW	MM

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Project

ENVIRONMENTAL PERMIT VARIATION APPLICATION - SCARBOROUGH PLANT FACILITY RENEWAL PROJECT AIR QUALITY IMPACT ASSESSMENT

Drawing Title

PROPOSED SCENARIO - ANNUAL MEAN NITROGEN DIOXIDE PROCESS CONTRIBUTIONS, 2017 METEOROLOGICAL DATA

Drawing Status

FINAL

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Jacobs No.	B1958992	Rev 0
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Drawing Number

FIGURE 6

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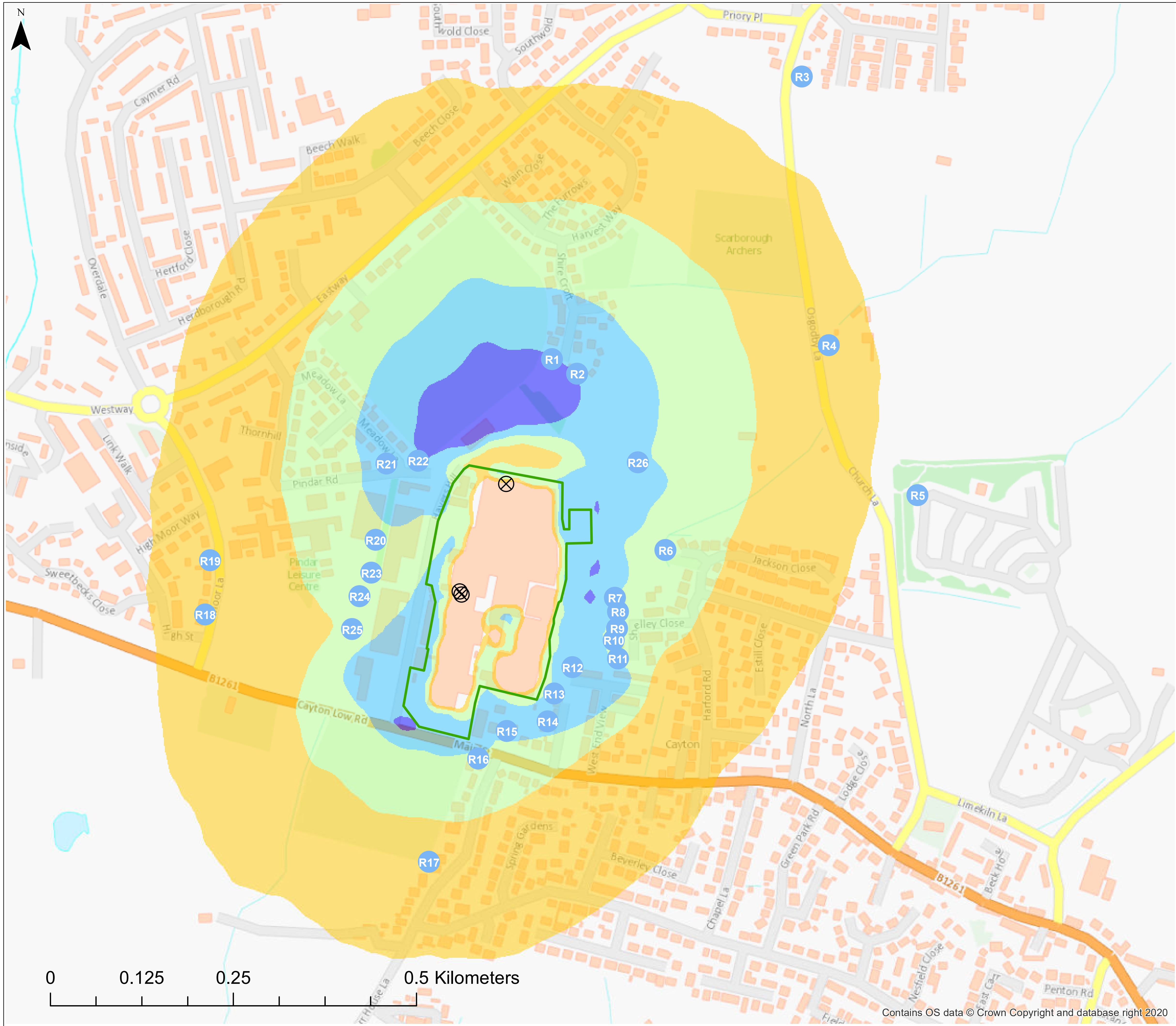


Legend

- Site permit boundary
- Modelled stack locations (Existing Scenario)
- Assessed sensitive human receptor locations

1-hour mean (99.79th percentile) nitrogen dioxide process contributions (µg/m³)

- 0 - 7.6
- 7.6 - 11
- 11 - 15.4
- 15.4 - 21
- 21 - 29.6

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	31/01/2023	Initial Issue	DH	GW	GW	PKL

Jacobs

Client: McCain

Project: ENVIRONMENTAL PERMIT VARIATION APPLICATION - SCARBOROUGH PLANT FACILITY RENEWAL PROJECT AIR QUALITY IMPACT ASSESSMENT

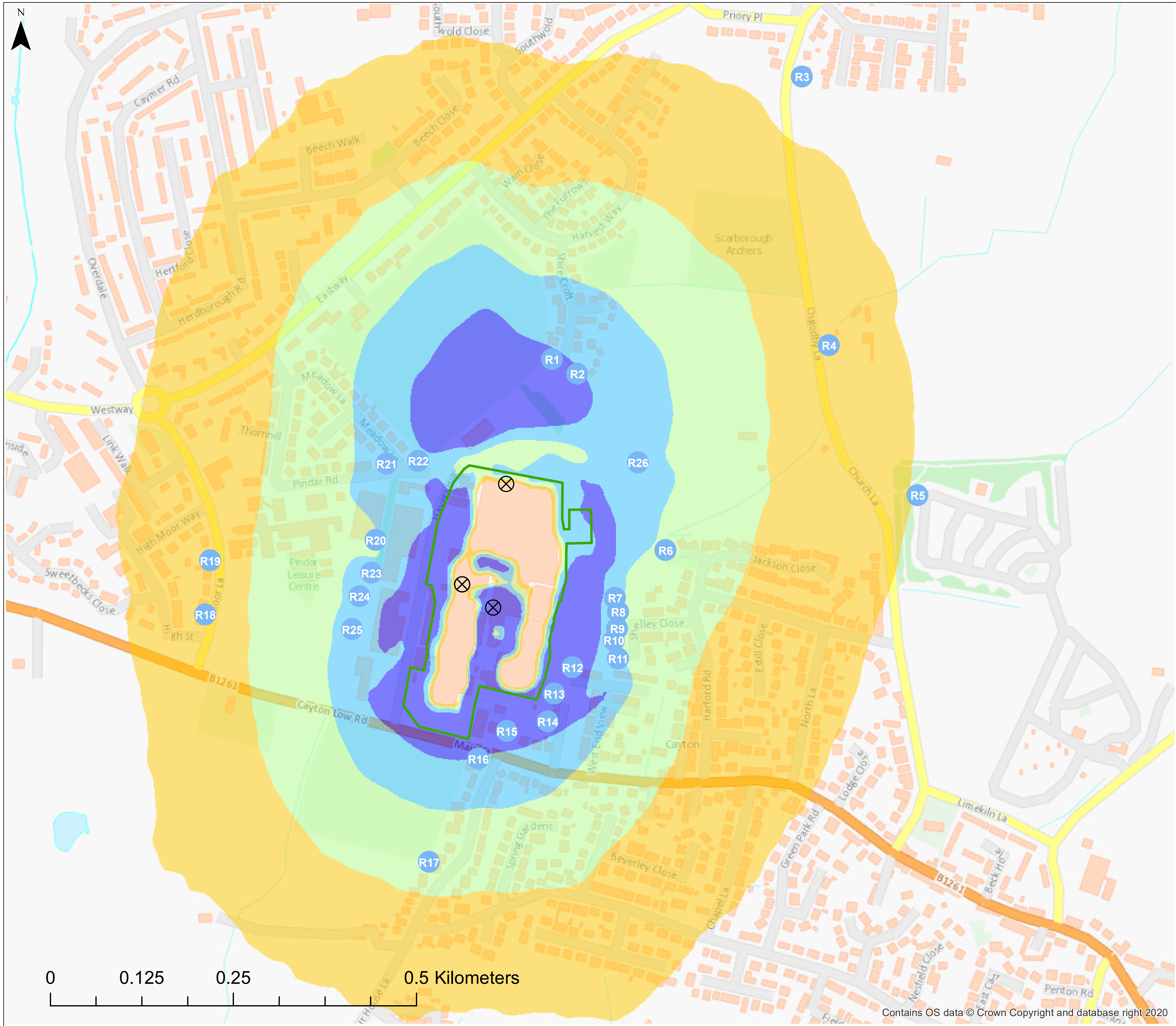
Drawing Title: EXISTING SCENARIO - 1 HOUR MEAN (99.79th PERCENTILE) NITROGEN DIOXIDE PROCESS CONTRIBUTIONS, 2016 METEOROLOGICAL DATA

Drawing Status: FINAL

Scale @ A3	1:5,000	DO NOT SCALE	
Jacobs No.	60SG2801	Rev	0
Client No.			

Drawing Number: FIGURE 7

\\SBRFIL01\Projects\Project Kaye (McCains)\New Boiler Variation (2023 variation)\AQIA\GIS\60SG2801_AQIA_Fig7_Sc1_1hr_NO2_16 v1.mxd



Legend

- Site permit boundary
- Modelled stack locations (Proposed Scenario)
- Assessed sensitive human receptor locations

1-hour mean (99.79th percentile) nitrogen dioxide process contributions (µg/m³)

- 0 - 7.6
- 7.6 - 11
- 11 - 15.4
- 15.4 - 21
- 21 - 75.5

Rev.	Date	Purpose of revision	Drawn	Check'd	Rev'd	Appr'd
0	31/01/2023	Initial Issue	DH	GW	GW	PKL

Jacobs

Client: McCain

Project: ENVIRONMENTAL PERMIT VARIATION APPLICATION - SCARBOROUGH PLANT FACILITY RENEWAL PROJECT AIR QUALITY IMPACT ASSESSMENT

Drawing Title: PROPOSED SCENARIO - 1 HOUR MEAN (99.79th PERCENTILE) NITROGEN DIOXIDE PROCESS CONTRIBUTIONS, 2017 METEOROLOGICAL DATA

Drawing Status: FINAL

Scale @ A3	1:5,000	DO NOT SCALE	
Jacobs No.	60SG2801	Rev	0
Client No.			

Drawing Number: FIGURE 8

\\SBRFIL01\Projects\Project Kaye (McCains)\New Boiler Variation (2023 variation)\AQIA\GIS\60SG2801_AQIA_Fig8_Sc2_1hr_NO2_17 v1.mxd

Appendix A. Dispersion Model Input Parameters

A.1 Emission Parameters

The emissions data used to represent the site for the scenarios described in Section 2 is set out in Table A.1.

Table A.1 Dispersion modelling parameters

Parameters	Unit	JMC 316 (D25) GS-B.L CHP engine (1.8 MWth)	Thermal Oxidizer (13.9 MWth)	28 T Steam boiler (18.139 MWth)	15 T Steam boiler (9.812 MWth)	Maxicon boiler (10.7 MWth)	Beel & Maxicon boiler (17.8 MWth & 10.7 MWth)
Status	-	Proposed	Existing	Proposed	Proposed	Existing	Existing
Modelled fuel	-	Biogas	Natural gas	Natural gas	Natural gas	Natural gas	Natural gas
Emission point	-	A147	T03	A151a	A151b	BH6	BH5
Assessed operation hours	Hours	8,760	8,760	8,760	8,760	8,760	8,760
Stack location	m	E 505057 N 483628	E 505075 N 483797	E 505015 N 4836603[4]		E 505011 N 4836503	E 505014 N 483646[4]
Stack position	-	Vertical	Vertical	Vertical	Vertical	Vertical	Vertical
Stack height	m	7.00	18.00	18.00	18.00	25.00	25.00
Stack diameter	m	0.35	1.10	0.71	0.71	0.80	1.50
Flue gas temperature	°C	180	153	162	160	224	229
Efflux velocity	m/s	25.0	21.3	23.3	12.6	12.8	10.4
Moisture content of exhaust gas	%	11.4	42.6	17.2	17.2	16.5	16.5
Oxygen content of exhaust gas (dry)	%	8.4	12.0	3.0	3.0	2.6	-
Volumetric flow rate (actual)	m^3/s	2.404	20.276	9.232	4.971	6.420	18.444
Volumetric flow rate (normal)	Nm^3/s	2.719[1]	12.994[2]	4.800[1]	2.596[1]	2.9941	7.9741
NOx emission concentration	mg/Nm^3	190[1]	200[2]	100[1]	100[1]	841	1791
NOx emission rate	g/s	0.517	2.599	0.480	0.260	0.251	1.426
CO emission concentration	mg/Nm^3	519[1]	100[2]	100[1]	100[1]	100	100
CO emission rate	g/s	1.413	1.299	0.480	0.260	0.299	0.797
PM_{10} / $PM_{2.5}$ emission concentration	mg/Nm^3	2.7[1]	-				
PM_{10} / $PM_{2.5}$ emission rate	g/s	0.007					
SO_2 emission concentration	mg/Nm^3	40[1]					
SO_2 emission rate	g/s	0.109					
TVOC emission concentration	mg/Nm^3	371[1]					
TVOC emission rate	g/s	1.009					

Note 1: Normalised flows and concentrations presented at 273 K, 101.3 kPa, dry gas and oxygen content of 15% (CHP engine) or 3% (boilers).
Note 2: Normalised flows and concentrations presented at 273 K, 101.3 kPa.
Note 3: As waste exhaust gas from emission source A151a and A151b exit into the atmosphere via a shared stack, an aai file was used in the model to represent the effects of a single plume.
Note 4: As waste exhaust gas from a Beel and Maxicon boiler (emission source BH5) exit into the atmosphere via a shared stack, an aai file was used in the model to represent the effects of a single plume.

A.2 Dispersion Model Inputs

A.2.1 Structural influences on dispersion

The main structures within the site, which have been included in the model to reflect the existing and proposed site layout are identified within Table A.2. A sensitivity study has been carried out to assess the sensitivity of the model to using the buildings module for the Proposed Scenario.

Table A.2: Modelled building parameters

Building	Scenario to be included	Modelled building shapes	Length / diameter (m)	Width (m)	Height (m)	Angle of length to north	Centre point co-ordinates	
							Easting	Northing
Building005	Both	Rectangular	153.70	26.00	7.90	11	505021	483563
Building001	Both	Rectangular	106.00	106.00	8.70	11	505081	483747
Building002	Both	Rectangular	107.00	29.00	11.10	178	505130	483735
Building0071,2	Both	Rectangular	103.50	35.00	11.10	11	505114	483742
Building0041	Both	Rectangular	215.00	27.00	10.10	11	505002	483599
Building006	Both	Rectangular	49.00	22.60	8.90	13	505071	483541
Building008	Both	Rectangular	154.20	36.00	7.60	13	505111	483586
Building009	Both	Rectangular	23.60	58.00	11.10	11	505116	483676
Building010	Both	Rectangular	22.10	16.50	12.70	11	505060	483589
EGSB Tank - WWTP	Proposed	Circular	13.00	13.00	16.80	0	505075	483680
Bioreactor Tank – WW2	Proposed	Circular	35.10	35.10	11.20	0	505050	483664
Biogas holder	Proposed	Circular	10.80	10.80	10.00	0	505071	483609
SFWW Tank - WWTP	Proposed	Circular	7.80	7.80	12.00	0	505058	483608
DAF/WAS Tank - WWTP	Proposed	Circular	6.50	6.50	12.00	0	505060	483617
CHP engine housing 1	Proposed	Rectangular	12.20	2.94	2.59	101	505061	483627
MBR Tank	Proposed	Rectangular	10.20	12.60	8.40	101	505075	483656
Waste Management building	Proposed	Rectangular	12.10	22.90	7.20	101	505098	483656
Building 011	Existing	Rectangular	54.80	23.40	10.00	101	505060	483685
Building 012	Existing	Rectangular	80.10	39.60	7.80	101	505067	483653

Note 1: For the Existing Scenario, Building 007 was modelled as the main building for emission point T03. For emission points BH5 and BH6, Building 004 was modelled as the main building.

Note 2: For the Proposed Scenario, Building 007 was modelled as the main building for emission point T03. For emission point A147, the main building was Building 005. For the emission point A151a and A151b, Building 004 was modelled as the main building.

A.2.2 Other Model Inputs

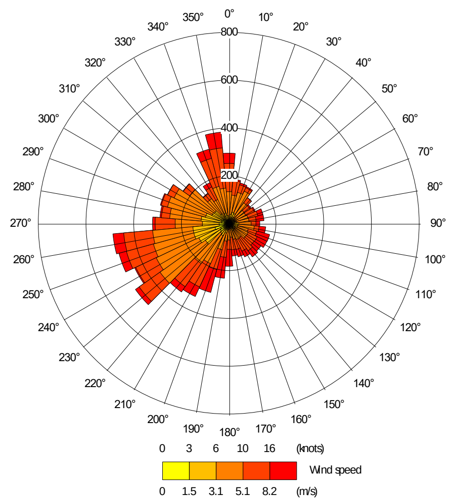
Table A.3: Other model inputs applied

Parameter	Value used	Comments
Surface roughness length for dispersion site	0.5 m	This is appropriate for the dispersion site where the local land-use range is typically suburban. A sensitivity study has been carried out with fixed surface roughness values of 0.1 m and 1.0 m.
Surface roughness length at meteorological station site	0.1 m	This is appropriate for an area where the local land is relatively built-up but adjacent to the coastline.
Minimum Monin-Obukhov Length	1 m	Typical values for the dispersion site
Surface Albedo	0.23 m	Typical values for the dispersion site
Priestley-Taylor Parameter	1 m	Typical values for the dispersion site
Terrain	Not included	Guidance for the use of the ADMS model suggests that terrain is normally incorporated within a modelling study when the gradient exceeds 1:10. As the gradient in the vicinity of the site does not exceed 1:10, a terrain file was not included in the modelling.
Meteorological data	Bridlington meteorological station, 2016 - 2020	Bridlington meteorological station is located approximately 21.2 km southwest of the site and is considered the closest most representative meteorological monitoring station to the site.
Combined flue option	Yes	For the Existing Scenario, as waste exhaust gases from the Maxicon and Beel boilers will exit into the atmosphere via a shared stack, an aai file was used in the model to represent the effects of a single plume.. For the Proposed Scenario, as waste exhaust gases from the proposed steam boilers will exit into the atmosphere via a shared stack, an aai file was used in the model to represent the effects of a single plume.

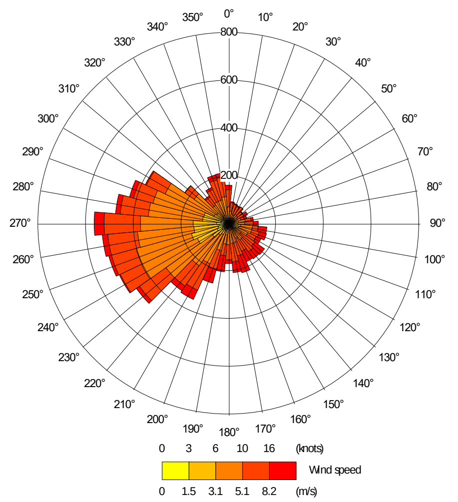
A.2.3 Meteorological Data – Wind Roses

The wind roses for each year of meteorological data utilised in the assessment are shown below.

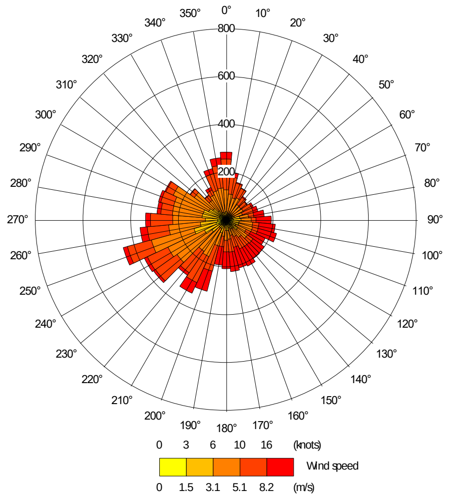
Bridlington meteorological station, 2016



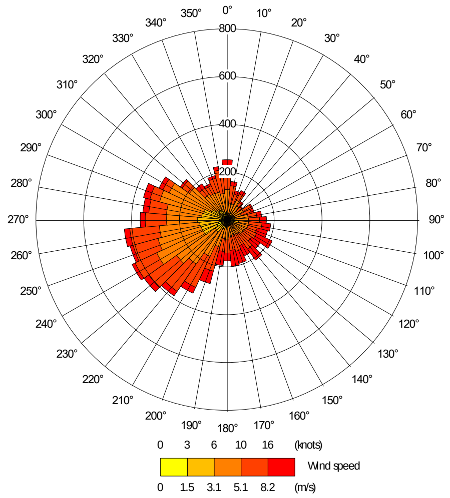
Bridlington meteorological station, 2017



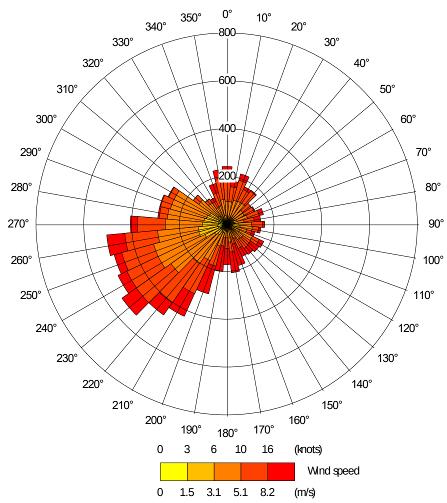
Bridlington meteorological station, 2018



Bridlington meteorological station, 2019



Bridlington meteorological station, 2020



A.2.4 Model Domain/Study Area

The ADMS model calculates the predicted concentrations based on a user defined grid system. Generally, the larger the study area, the greater the distance between the grid calculation points and the lower the resolution of the dispersion model predictions. This is to be offset against the need to encompass an appropriately wide area within the dispersion modelling study to capture the dispersion of the stack emissions.

The modelled grid was specified as a 1.5 km x 1.5 km grid with calculation points every 10 m (i.e. 151 points along each grid axis) with a grid height of 1.5 m. This size of grid was selected to provide a good grid resolution and also encompass a sufficient area so that the maximum predicted concentrations would be determined. The area within the site boundary was excluded from the modelled grid as it is not accessible to the general public. The modelled grid parameters are presented in Table A.4.

Table A.4: Modelled grid parameters

	Start	Finish	Number of grid points	Grid spacing (m)
Easting	504325	505825	151	10
Northing	483047	484547	151	10
Grid height	1.5	1.5	1	-

As well as the modelled grid, the potential impact at 26 sensitive human receptors (e.g. exposure locations such as residential properties, George Pindar School and a football pitch) and 6 protected conservation areas within the required study area were assessed. The receptor locations are shown in Figure 3 and Figure 4 and further details of the receptor locations are provided in Table A.5 and Table A.6.

Table A.5: Assessed sensitive human receptor locations

Receptor	Description	Grid reference		Distance from Thermal Oxidiser stack (km)	Direction from Thermal Oxidiser stack
		Easting	Northing		
R1	Residential property on Shire Croft	505138	483967	0.18	NNE
R2	Residential property on Shire Fold	505172	483947	0.18	NNE
R3	Residential property on Osgodby Lane	505479	484353	0.69	NE
R4	Residential property on Osgodby Lane	505516	483986	0.48	ENE
R5	Static caravan	505637	483781	0.56	E
R6	Residential property on Jackson Close	505293	483706	0.24	ESE
R7	Residential property on Shelley Close	505224	483641	0.22	SE
R8	Residential property on Shelley Close	505228	483622	0.23	SE
R9	Residential property on Shelley Close	505227	483599	0.25	SE
R10	Residential property on Shelley Close	505222	483583	0.26	SE
R11	Residential property on Shelley Close	505228	483558	0.28	SSE
R12	Residential property on West End View	505166	483546	0.27	SSE
R13	Residential property on Mount View Road	505141	483510	0.29	SSE
R14	Residential property on Mount View Road	505132	483472	0.33	S
R15	Residential property on Main Street	505076	483459	0.34	S
R16	Residential property on Main Street	505037	483421	0.38	S
R17	Residential property on Carr House Lane	504970	483280	0.53	SSW
R18	Residential property on Moor Lane	504664	483618	0.448	WSW
R19	Residential property on Moor Lane	504671	483692	0.417	WSW
R20	George Pindar School	504897	483720	0.19	WSW
R21	Residential property on Pindar Road	504912	483824	0.17	W
R22	Residential property on Pindar Road	504955	483828	0.12	WNW
R23	George Pindar School tennis courts	504891	483675	0.22	WSW
R24	George Pindar School football pitch	504875	483643	0.25	SW
R25	George Pindar School football pitch	504865	483598	0.29	SW
R26	Sports field	505255	483826	0.18	E

Table A.6: Assessed protected conservation area locations

Receptor	Description	Grid reference		Distance from Thermal Oxidiser stack (km)	Direction from Thermal Oxidiser stack
		Easting	Northing		
H1	Flamborough and Filey Coast SPA	507945	484424	2.94	ENE
H2	Cayton, Cornelian and South Bays SSSI	506156	484706	1.41	NE
H3	The Dell LNR	504503	483946	0.59	WNW
H4	Cayton Meadow LWS	504006	482823	1.45	SW
H5	Burton Riggs Gravel Pits LWS	503192	483226	1.97	WSW
H6	High Deepdale LWS	504345	485320	1.69	NNW

A.2.5 Treatment of oxides of nitrogen

It was assumed that 70% of NOx emitted from the assessed combustion plant will be converted to NO_2 at ground level in the vicinity of the site, for determination of the annual mean NO_2 concentrations, and 35% of emitted NOx will be converted to NO_2 for determination of the hourly mean NO_2 concentrations, in line with guidance provided by the Environment Agency (Environment Agency, 2021). This approach is likely to overestimate the annual mean NO_2 concentrations considerably at the most relevant assessment locations close to the site.

A.2.6 Calculation of PECs

In the case of long-term mean concentrations, it is relatively straightforward to combine modelled process contributions with baseline air quality levels, as long-term mean concentrations due to plant emissions could be added directly to long-term mean baseline concentrations.

It is not possible to add short-period peak baseline and process concentrations directly. This is because the conditions which give rise to peak ground-level concentrations of substances emitted from an elevated source at a particular location and time are likely to be different to the conditions which give rise to peak concentrations due to emissions from other sources.

As described in the Environment Agency guidance (Environment Agency, 2022), for most substances the short-term peak PC values are added to twice the long-term mean baseline concentration to provide a reasonable estimate of peak concentrations due to emissions from all sources.

A.2.7 Modelling Uncertainty

There are always uncertainties in dispersion models, in common with any environmental modelling study, because a dispersion model is an approximation of the complex processes which take place in the atmosphere. Some of the key factors which lead to uncertainty in atmospheric dispersion modelling are as follows:

- The quality of the model output depends on the accuracy of the input data enter the model. Where model input data are a less reliable representation of the true situation, the results are likely to be less accurate;
- The meteorological data sets used in the model are not likely to be completely representative of the meteorological conditions at the site. However, the most suitable available meteorological data was chosen for the assessment;
- Models are generally designed on the basis of data obtained for large scale point sources and may be less well validated for modelling emissions from smaller scale sources;
- The dispersion of pollutants around buildings is a complex scenario to replicate. Dispersion models can take account of the effects of buildings on dispersion; however, there will be greater uncertainty in the model results when buildings are included in the model;
- Modelling does not specifically take into account individual small-scale features such as vegetation, local terrain variations and off-site buildings. The roughness length (zo) selected is suitable to take general account of the typical size of these local features within the model domain; and
- To take account of these uncertainties and to ensure the predictions are more likely to be over-estimates than under-estimates, the conservative assumptions described below have been used for this assessment.

A.2.8 Conservative Assumptions

The conservative assumptions adopted in this study are summarised below.

- The existing thermal oxidiser, boilers and proposed CHP engine were assumed to operate at maximum load for 8,760 hours each calendar year but in practice, the thermal oxidiser is regularly shut-down (usually for two days once a fortnight for cleaning) and the remaining assessed combustion plant will have periods of shut-down and maintenance and may not always operate at maximum load. Furthermore, the site closes for two weeks over the summer months.
- The study is based on emissions being continuously at the emission limits and calculated emissions specified.
- The maximum predicted concentrations at any residential areas as well as off-site locations were considered for the assessment of short-term concentrations and the maximum predicted concentrations at any residential areas were considered for assessment of annual mean concentrations within the air quality study area. Concentrations at other locations will be less than the maximum values presented.
- The highest predicted concentrations obtained using any of the five different years of meteorological data have been used in this assessment. During a typical year the ground level concentrations are likely to be lower.
- It was assumed that 100% of the particulate matter emitted from the plant is in the PM_{10} size fraction. The actual proportion will be less than 100%.
- It was assumed that 100% of the particulate matter emitted from the plant is in the $PM_{2.5}$ size fraction. The actual proportion will be less than 100%.
- It was assumed the vegetation type selected for each assessed protected conservation area is present at the specific modelled location.

Appendix B. Calculating Acid and Nitrogen Deposition

B.1 Methodology

Nitrogen and acid deposition have been predicted using the methodologies presented in the Air Quality Technical Advisory Group (AQTAG) guidance note: AQTAG 06 "*Technical Guidance on Detailed Modelling Approach for an Appropriate Assessment for Emissions to Air* (AQTAG, 2014).

When assessing the deposition of nitrogen, it is important to consider the different deposition properties of nitric oxide (NO) and NO_2. It is generally accepted that there is no wet or dry deposition arising from NO in the atmosphere. Thus, it is normally necessary to distinguish between NO and NO_2 in a deposition assessment. In this case, the conservative assumption that 70% of the NOx are in the form of NO_2 was adopted.

Information on the existing nitrogen and acid deposition was obtained from the APIS database (Centre for Ecology and Hydrology, 2022). Information on the deposition critical loads for each habitat site was also obtained from the APIS database using the Site Relevant Critical Load function.

The annual dry deposition flux can be obtained from the modelled annual average ground level concentration via use of the formula:

Dry deposition flux (µg/m^2/s) = ground level concentration (µg/m^3) x deposition velocity (m/s)

(where µg refers to µg of the chemical species under consideration).

The deposition velocities for various chemical species recommended for use in the AQTAG guidance note (AQTAG, 2014) are shown below in Table B.1.

Table B.1: Recommended dry deposition velocities

Chemical species	Recommended deposition velocity (m/s)	
NO_2	Grassland (short)	0.0015
	Forest (tall)	0.003
SO_2	Grassland (short)	0.012
	Forest (tall)	0.024

To convert the dry deposition flux from units of µg/m^2/s (where µg refers to µg of the chemical species) to units of kg N/ha/yr (where kg refers to kg of nitrogen), multiply the dry deposition flux by the conversion factors shown in Table B.2. To convert dry deposition flux to acid deposition (keq/ha/yr), multiply the concentrations by the factors shown in Table B.3.

Table B.2: Dry deposition flux conversion factors for nutrient nitrogen deposition

µg/m^2/s of species	Conversion factor to kg N/ha/yr
NO_2	95.9

Table B.3: Dry deposition flux conversion factors for acidification

µg/m^2/s of species	Conversion factor to keq/ha/yr
NO_2	6.84
SO_2	9.84

Appendix C. Results at Sensitive Human Locations

Table C.1: Results of detailed assessment at sensitive human receptor locations for maximum 8-hour mean and 1-hour mean CO predicted concentrations

Receptor ID	Baseline air quality level (µg/m³)	Maximum 8-hour running mean			Maximum 1-hour mean		
		EQS (µg/m³)	Existing Scenario PC (µg/m³)	Proposed Scenario PC (µg/m³)	EQS (µg/m³)	Existing Scenario PC (µg/m³)	Proposed Scenario PC (µg/m³)
R1	193	10,000	32.8	54.9	30,000	38.6	64.1
R2	193		32.5	51.7		33.6	69.1
R3	198		9.8	21.4		11.0	30.9
R4	193		12.2	26.8		14.0	42.1
R5	193		9.6	28.8		11.3	50.5
R6	193		19.6	65.8		21.9	93.4
R7	193		22.7	108.5		26.3	146.2
R8	193		20.7	104.4		23.7	129.6
R9	193		19.1	102.7		22.5	142.4
R10	193		19.3	107.9		25.4	132.0
R11	193		19.4	96.2		26.2	117.9
R12	193		19.0	201.7		23.6	527.6
R13	193		20.5	139.3		28.6	190.2
R14	193		21.5	103.2		57.7	130.7
R15	193		23.7	106.9		35.5	122.5
R16	193		19.6	87.6		25.7	108.3
R17	195		14.9	45.1		17.3	66.0
R18	195		13.5	34.5		14.9	59.3
R19	195		14.2	35.7		15.0	58.0
R20	195		20.8	90.4		24.2	109.0
R21	195		24.5	60.6		28.2	77.9
R22	195		29.3	65.8		31.8	88.3
R23	195		18.4	103.0		24.7	113.9
R24	195		17.3	85.9		25.6	119.2
R25	195		17.2	83.1		27.6	105.2
R26	193		22.5	58.8		25.7	83.8

Table C.2: Results of detailed assessment at sensitive human receptor locations for annual mean and 1-hour mean (99.79th percentile) NO_2 predicted concentrations

Receptor ID	Annual mean				99.79th percentile of 1-hour mean			
	Baseline air quality level (µg/m³)	EQS (µg/m³)	Existing Scenario PC (µg/m³)	Proposed Scenario PC (µg/m³)	EQS (µg/m3)	Baseline air quality level (µg/m³)	Existing Scenario PC (µg/m³)	Proposed Scenario PC (µg/m³)
R1	6.7	40	3.4	4.0	200	13.5	21.6	22.8
R2	6.7		3.9	4.7		13.5	21.3	22.2
R3	6.9		1.2	1.4		13.8	6.4	7.0
R4	6.7		1.8	2.3		13.5	8.6	9.1

Receptor ID	Annual mean				99.79th percentile of 1-hour mean			
	Baseline air quality level (μg/m^3)	EQS (μg/m^3)	Existing Scenario PC (μg/m^3)	Proposed Scenario PC (μg/m^3)	EQS (μg/m3)	Baseline air quality level (μg/m^3)	Existing Scenario PC (μg/m^3)	Proposed Scenario PC (μg/m^3)
R5	6.7		1.5	2.0		13.5	6.9	7.5
R6	6.7		2.5	4.6		13.5	14.5	14.6
R7	6.7		1.7	5.5		13.5	16.2	16.5
R8	6.7		1.6	5.3		13.5	15.2	16.0
R9	6.7		1.5	5.0		13.5	14.5	16.1
R10	6.7		1.5	4.9		13.5	14.6	16.6
R11	6.7		1.5	4.2		13.5	15.3	16.3
R12	6.7		2.1	4.6		13.5	15.6	30.4
R13	6.7		2.2	4.5		13.5	15.7	26.1
R14	6.7		2.3	4.4		13.5	23.0	29.9
R15	6.7		2.1	4.4		13.5	19.2	28.9
R16	6.7		1.7	3.0		13.5	14.9	21.8
R17	12.1		1.1	1.4		24.2	9.8	13.0
R18	12.1		1.0	1.2		24.2	8.8	9.7
R19	12.1		1.1	1.3		24.2	9.0	9.9
R20	12.1		1.7	3.2		24.2	14.6	15.4
R21	12.1		2.7	3.6		24.2	18.0	18.1
R22	12.1		2.8	3.9		24.2	20.6	20.7
R23	12.1		1.4	3.1		24.2	13.4	16.4
R24	12.1		1.3	2.7		24.2	12.4	17.7
R25	12.1		1.1	2.3		24.2	12.2	18.1
R26	6.7		3.1	4.8		13.5	16.5	16.7

Table C.3: Results of detailed assessment at sensitive human receptor locations for 24-mean (99.18th percentile) and 1-hour mean (99.73rd percentile) SO_2 predicted concentrations

Receptor ID	99.18th percentile of 24-hour mean				99.73rd percentile of 1-hour mean			
	Baseline air quality level (μg/m^3)	EQS (μg/m^3)	Existing Scenario PC (μg/m^3)	Proposed Scenario PC (μg/m^3)	EQS (μg/m^3)	Baseline air quality level (μg/m^3)	Existing Scenario PC (μg/m^3)	Proposed Scenario PC (μg/m^3)
R1	7.2	125	-	1.5	350	7.2	-	3.2
R2	7.2			1.7		7.2		3.5
R3	7.2			0.5		7.2		1.5
R4	7.2			1.0		7.2		2.7
R5	7.2			1.0		7.2		3.0
R6	7.2			3.0		7.2		5.7
R7	7.2			5.0		7.2		8.8
R8	7.2			4.7		7.2		8.6
R9	7.2			4.9		7.2		8.5
R10	7.2			5.4		7.2		8.6
R11	7.2			4.9		7.2		7.9

Receptor ID	99.18th percentile of 24-hour mean				99.73rd percentile of 1-hour mean			
	Baseline air quality level (µg/m³)	EQS (µg/m³)	Existing Scenario PC (µg/m³)	Proposed Scenario PC (µg/m³)	EQS (µg/m³)	Baseline air quality level (µg/m³)	Existing Scenario PC (µg/m³)	Proposed Scenario PC (µg/m³)
R12	7.2			7.0		7.2		14.6
R13	7.2			5.3		7.2		11.3
R14	7.2			4.9		7.2		7.1
R15	7.2			5.1		7.2		7.2
R16	7.2			3.4		7.2		5.9
R17	8.8			1.4		8.8		3.1
R18	8.8			1.0		8.8		2.5
R19	8.8			1.0		8.8		2.4
R20	8.8			4.0		8.8		6.6
R21	8.8			2.2		8.8		4.5
R22	8.8			2.5		8.8		4.9
R23	8.8			4.0		8.8		7.0
R24	8.8			3.4		8.8		6.6
R25	8.8			3.4		8.8		6.5
R26	7.2			2.8		7.2		4.8

Table C.4: Results of detailed assessment at sensitive human receptor locations for 15-minute mean (99.9th percentile) SO_2 predicted concentrations

Receptor ID	99.9th percentile of 15-minute mean			
	Baseline air quality level (µg/m³)	EQS (µg/m³)	Existing Scenario PC (µg/m³)	Proposed Scenario PC (µg/m³)
R1	7.2	266	-	4.4
R2	7.2			5.2
R3	7.2			2.7
R4	7.2			4.3
R5	7.2			6.0
R6	7.2			7.5
R7	7.2			10.7
R8	7.2			10.5
R9	7.2			10.2
R10	7.2			10.3
R11	7.2			9.6
R12	7.2			22.5
R13	7.2			14.1
R14	7.2			8.1
R15	7.2			8.2
R16	7.2			6.9
R17	8.8			4.5
R18	8.8			3.8
R19	8.8			3.7
R20	8.8			8.0

Receptor ID	99.9th percentile of 15-minute mean			
	Baseline air quality level (µg/m³)	EQS (µg/m³)	Existing Scenario PC (µg/m³)	Proposed Scenario PC (µg/m³)
R21	8.8			5.3
R22	8.8			6.0
R23	8.8			8.6
R24	8.8			8.7
R25	8.8			7.9
R26	7.2			6.2

Table C.5: Results of detailed assessment at sensitive human receptor locations for annual mean and 24-hour mean (90.41st) percentile) PM_{10} predicted concentrations

Receptor ID	Annual mean				90.41st percentile of 24-hour mean			
	Baseline air quality level (µg/m³)	EQS (µg/m³)	Existing Scenario PC (µg/m³)	Proposed Scenario PC (µg/m³)	EQS (µg/m³)	Baseline air quality level (µg/m³)	Existing Scenario PC (µg/m³)	Proposed Scenario PC (µg/m³)
R1	12.1	40	-	0.01	50	24.3	-	0.04
R2	12.1			0.02		24.3		0.05
R3	13.0			0.00		26.0		0.01
R4	12.1			0.01		24.3		0.03
R5	12.1			0.01		24.3		0.03
R6	12.1			0.04		24.3		0.12
R7	12.1			0.07		24.3		0.21
R8	12.1			0.07		24.3		0.20
R9	12.1			0.06		24.3		0.19
R10	12.1			0.06		24.3		0.19
R11	12.1			0.05		24.3		0.15
R12	12.1			0.06		24.3		0.18
R13	12.1			0.04		24.3		0.15
R14	12.1			0.04		24.3		0.15
R15	12.1			0.04		24.3		0.16
R16	12.1			0.03		24.3		0.10
R17	13.0			0.01		26.0		0.04
R18	13.0			0.01		26.0		0.02
R19	13.0			0.01		26.0		0.03
R20	13.0			0.03		26.0		0.10
R21	13.0			0.02		26.0		0.06
R22	13.0			0.02		26.0		0.07
R23	13.0			0.03		26.0		0.11
R24	13.0			0.02		26.0		0.10
R25	13.0			0.02		26.0		0.08
R26	12.1			0.04		24.3		0.11

Table C.6: Results of detailed assessment at sensitive human receptor locations for annual mean $PM_{2.5}$ predicted concentrations

Receptor ID	Annual mean			
	Baseline air quality level (µg/m³)	EQS (µg/m³)	Existing Scenario PC (µg/m³)	Proposed Scenario PC (µg/m³)
R1	7.0	20	-	0.01
R2	7.0			0.02
R3	7.3			0.00
R4	7.0			0.01
R5	7.0			0.01
R6	7.0			0.04
R7	7.0			0.07
R8	7.0			0.07
R9	7.0			0.06
R10	7.0			0.06
R11	7.0			0.05
R12	7.0			0.06
R13	7.0			0.04
R14	7.0			0.04
R15	7.0			0.04
R16	7.0			0.03
R17	7.5			0.01
R18	7.5			0.01
R19	7.5			0.01
R20	7.5			0.03
R21	7.5			0.02
R22	7.5			0.02
R23	7.5			0.03
R24	7.5			0.02
R25	7.5			0.02
R26	7.0			0.04

Table C.7: Results of detailed assessment at sensitive human receptor locations for annual mean and maximum 24-hour mean TVOC predicted concentrations

Receptor ID	Annual mean				100th percentile of 24-hour mean			
	Baseline air quality level	EQS (µg/m³)	Existing Scenario PC (µg/m³)	Proposed Scenario PC (µg/m³)	EQS (µg/m³)	Baseline air quality level	Existing Scenario PC (µg/m³)	Proposed Scenario PC (µg/m³)
R1	0.2	5 (Benzene)	-	1.9	30 (Benzene)	0.3	-	16.7
R2	0.2			2.4		0.3		20.2
R3	0.2			0.7		0.3		5.8
R4	0.2			1.6		0.3		9.9
R5	0.2			1.7		0.3		11.7
R6	0.2			6.0		0.3		30.4
R7	0.2			10.3		0.3		59.7
R8	0.2			9.8		0.3		51.9

Receptor ID	Annual mean				100th percentile of 24-hour mean			
	Baseline air quality level	EQS ($\mu g/m^3$)	Existing Scenario PC ($\mu g/m^3$)	Proposed Scenario PC ($\mu g/m^3$)	EQS ($\mu g/m^3$)	Baseline air quality level	Existing Scenario PC ($\mu g/m^3$)	Proposed Scenario PC ($\mu g/m^3$)
R9	0.2			9.4		0.3		56.4
R10	0.2			9.0		0.3		52.9
R11	0.2			7.4		0.3		50.0
R12	0.2			8.0		0.3		75.9
R13	0.2			5.8		0.3		61.5
R14	0.2			5.4		0.3		53.0
R15	0.2			5.8		0.3		51.6
R16	0.2			3.7		0.3		37.4
R17	0.2			1.3		0.3		16.6
R18	0.2			0.9		0.3		11.8
R19	0.2			1.0		0.3		13.1
R20	0.2			3.7		0.3		46.6
R21	0.2			2.3		0.3		24.3
R22	0.2			2.6		0.3		24.7
R23	0.2			4.1		0.3		50.1
R24	0.2			3.5		0.3		42.5
R25	0.2			3.0		0.3		37.8
R26	0.2			5.1		0.3		29.4