North Lincolnshire Green Energy Park

Planning Act 2008

Infrastructure Planning (Applications Prescribed Forms and Procedure) Regulations 2009

APFP Regulation 5(2)(a)

Infrastructure (Environmental Impact Assessment) Regulations 2017

Volume 6

Environmental Statement

6.2.17 Chapter 17 - Health

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Acronyms and Abbreviations

Name	Description
ALARP	As low as reasonably practicable
AQIA	Air Quality Impact Assessment
BRES	Business Register and Employment Survey
BEIS	(Department for) Business, Energy & Industrial Strategy
CEMP	Construction Environmental Management Plan
COMEAP	Committee on the Medical Effects of Air Pollutants
DHPWN	District Heat and Private Wire Network
EIA	Environmental Impact Assessment
EMF	Electric and Magnetic Fields
ERF	Energy Recovery Facility
ES	Environmental Statement
EU	European Union
HGV	Heavy Goods Vehicle
HHRA	Human Health Risk Assessment
HIA	Health Impact Assessment
IRAP	Industrial Risk Assessment Program
NPPF	National Planning Policy Framework
NSIP	Nationally Significant Infrastructure Planning
ONS	Office for National Statistics
PEIR	Preliminary Environmental Information Report
PHE	Public Health England
PM	Particulate Matter
TDI	Total Daily Intake
WHO	World Health Organization

1. INTRODUCTION

1.1.1.1 This chapter provides the assessment of potential effects related to health and wellbeing for the Project, and forms part of the Environmental Statement (ES). Cross-reference is made to wider related topic assessments which inform this assessment, these include:

- Chapter 5 - Air Quality (**Document Reference 6.2.5**);
- Chapter 7 - Noise (**Document Reference 6.2.7**);
- Chapter 11 - Landscape and Visual Impact (**Document Reference 6.2.11**);
- Chapter 13 - Traffic and Transport (**Document Reference 6.2.13**);
- Chapter 14 - Economic, Community and Land Use Impacts (**Document Reference 6.2.14**);
- Chapter 15 - Waste (**Document Reference 6.2.15**); and
- Chapter 16 - Major Accidents and Hazards (**Document Reference 6.2.16**).

1.2 Aims and Objectives

1.2.1.1 There is no statutory requirement to carry out a Health Impact Assessment (HIA) for the Project. The amended Environmental Impact Assessment (EIA) Directive (2014/52/EU) does, however, include the requirement to consider the likely significant effects of projects on 'population and human health' and evolving practice has seen the integration of the HIA into EIA reporting, consistent with the Directive.

1.2.1.2 This assessment of health and wellbeing has, therefore, been undertaken pursuant to the EIA Directive and the continued application of EIA in the UK, post-Brexit, as set out in The Environmental Assessments and Miscellaneous Planning (Amendment) (EU Exit) Regulations 2018.

1.2.1.3 The assessment of health and wellbeing draws upon information from wider topic assessments undertaken as part of the EIA, but also feeds into the overarching assessment of cumulative effects of the Project. In this manner, due consideration is given to the inter-relationship of local populations and the physical environment with which they inhabit and interact with, to ensure that all determinants of health and wellbeing are considered.

1.2.1.4 The aim in undertaking this work is to provide all interested parties with a comprehensive evaluation of the Project's implications for health and wellbeing, and specifically to:

- Determine the potential health and wellbeing impacts of the Project on the local population;
- Assess the nature and extent of these health and wellbeing impacts, including potential benefits;
- Identify ways to maximise positive and minimise negative health and wellbeing impacts; and

- Inform the planning process and respond to health and wellbeing issues raised through this process.

2. LEGISLATION AND POLICY CONTEXT

2.1 Introduction

2.1.1.1 A review has been undertaken of the general planning and strategic policy context for the Project, as set out in Chapter 2 of the ES (**Document Reference 6.2.2**). This section builds upon this, to summarise specific expectations around the consideration of health and wellbeing in the planning context.

2.2 National Energy Policy

2.2.1.1 National Policy Statement EN-1 sets out key policy relating to health and well-being, noting in paragraph 4.13.1 that while access to energy has benefits to society and to people’s health and well-being in general, the “production, distribution and use of energy may have negative impacts on some people’s health”.

2.2.1.2 Paragraph 4.13.2 requires the ES to assess the effects of each element of a project, and for any adverse health impacts, to identify measures to avoid, reduce or compensate for such impacts, including cumulative impacts with other developments, as appropriate. Paragraph 4.13.3 notes that direct impacts on health may arise from exposure to increased levels of “traffic, air or water pollution, dust, odour, hazardous waste and substances, noise, exposure to radiation, and increases in pests”. EN-1 policy relating to specifically to these topics (air pollution, noise etc) is addressed in the respective chapters of the ES.

2.2.1.3 Paragraph 4.13.4 notes that new energy infrastructure may also affect the demographic characteristics of the local population, leading to potential indirect health impacts, such as access to key public services (especially health), transport or the use of open space.

2.2.1.4 Paragraph 4.13.5 goes on to acknowledge that some of the aspects of energy infrastructure which could have a significantly adverse effect on people’s health are strictly regulated (for example certain air pollutants), such that their required mitigation means it is unlikely that health concerns will either constitute a reason to refused consents or require further specific mitigation. However, paragraph 4.13.5 does go on to note that the Planning Inspectorate “will want to take account of health concerns when setting requirements relating to a range of impacts such as noise”.

2.2.1.5 NPS EN-3 notes in paragraph 2.5.43:

> *“Where a proposed waste combustion generating station meets the requirements of WID and will not exceed the local air quality standards, the [Planning Inspectorate] should not regard the proposed waste generating station as having adverse impacts on health.”*

2.2.1.6 On 6 September 2021, BEIS published for consultation a suite of five draft National Policy Statements to guide energy development proposals. The new NPSs were subject to consultation until the end of November. The House of Commons BEIS Committee reported on the Revised (Draft)

National Policy Statement for Energy on 22nd February 2022, providing recommendations in relation to the suite of revised draft NPSs. The expectation is that the suite of revised NPSs will be designated by Summer 2022.

2.2.1.7 The draft NPS EN-1 mainly reiterates the considerations contained in NPS EN-1 but also introduces an additional policy consideration of relevance to assessing effects on health and well-being. Paragraph 4.3.5 points out that:

> *“Opportunities should also be taken to mitigate indirect impacts, by promoting local improvements to encourage health and wellbeing, this includes potential impacts on vulnerable groups within society i.e. those groups within society which may be differentially impacted by a development compared to wider society as a whole.”*

2.2.1.8 Draft NPS EN-3 points out that in relation to the need for a project to have an Environmental Permit to operate:

> *“All large installations are regulated by the Environment Agency (EA) or Natural Resources Wales (NRW) and must comply with strict emission limits set by the Environmental Permitting (England and Wales) Regulations 2016. Permits are not issued if the proposed installation will have unacceptable impacts on human health or the environment.”*

2.2.1.9 Section 2.10 of the NPS for Electricity Networks Infrastructure (EN-5) (and Section 2.13 of the draft NPS EN-5) focuses on the potential health effects of Electric and Magnetic Fields (EMFs), with an emphasis on the effects of overhead higher voltage (400 and 275 kV) lines. NPS EN-5 goes on to state in paragraph 2.10.12:

> *“Undergrounding of a line would reduce the level of EMFs experienced, but high magnetic field levels may still occur immediately above the cable. It is not the Government’s policy that power lines should be undergrounded solely for the purpose of reducing exposure to EMFs.”*

2.3 National Policy on Health and Wellbeing

2.3.1.1 The National Planning Policy Framework (NPPF) specifies the requirement to “ensure that permitted and proposed operations do not have unacceptable adverse impacts on the natural and historic environment or human health, taking into account the cumulative effects of multiple impacts from individual sites and/or a number of sites in a locality”.

2.3.1.2 Health, social and cultural wellbeing is one of the twelve core planning principles of the NPPF and is represented through the following themes:

- **Social objective of planning** (Paragraph 8) – To support strong, vibrant and healthy communities;
- **Health and wellbeing needs** (Paragraph 92c) – Healthy lifestyles to address local wellbeing needs; green infrastructure, local shops,

access to healthier food, allotments and layouts that encourage walking and cycling;

- **Local health and wellbeing strategy** (Paragraph 93b) – Support delivery of local strategies to improve health and wellbeing;
- **Well-designed places** (Paragraph 130f) – Design places that are safe, inclusive, accessible and which promote health and wellbeing;
- **Effects of pollution on health** (Paragraph 185) – Likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, and
- **Health infrastructure** (Paragraph 20c) – Local planning authorities, health and care commissioners and providers are required to co-operate to make provision of health infrastructure.

2.3.1.3 Providing further detail on how health and wellbeing can be integrated into planning, Public Health England (PHE) published its “Advice on the content of Environmental Statements accompanying an application under the Nationally Significant Infrastructure Planning Regime”. The document is intended to help an applicant understand the issues that Public Health England expects to see addressed by an applicant preparing an Environmental Statement as part of its Nationally Significant Infrastructure Planning (NSIP) submission[1].

2.3.1.4 In October 2020, PHE also published the “Health Impact Assessment in spatial planning: A guide for local authority public health and planning teams”, which provides guidance on using HIA in the planning system. The guide forms part of PHE’s strategic commitment to local systems to support preventative action on the wider determinants of health and helps clarify the process of establishing HIA policies and requirements to users of the planning system[2].

2.4 Local Planning Policy

2.4.1.1 The North Lincolnshire Local Plan was adopted in May 2003 and is used to make planning decisions. This plan has since been partially substituted by the Local Development Framework (Core Strategy), which was adopted in June 2011. The Core Strategy sets out the long-term vision for North Lincolnshire and provides a plan for managing growth and development in the area up to 2026. It is part of the development plan for North Lincolnshire and is used to make decisions on planning applications. North Lincolnshire Council is currently preparing a new Local Plan for North Lincolnshire, which will eventually replace both the 2003 Local Plan and the Local Development Framework plans.

2.4.1.2 North Lincolnshire also prepared a ‘Planning for Health and Wellbeing: Supplementary Planning Document’ which forms part of North Lincolnshire’s Local Development Framework. The document provides

[1] Public Health England (2020) Advice on the content of Environmental Statements accompanying an application under the Nationally Significant Infrastructure Planning Regime.

[2] Public Health England (2020) Health Impact Assessment in spatial planning: a guide for local authority public health and planning teams.

information on how health and health inequalities can be positively influenced by good planning. The document also provides guidance on ensuring that the health implications of any new development are considered[3].

2.4.1.3 At the local level, many councils emphasise the need for healthy environments within their Local Plans and policies. They will also often recommend that an HIA is undertaken for major plans, policies and development proposals. HIAs can help local authorities to take appropriate action to improve the health of their communities under the Health and Social Care Act 2012[4]. The Act requires local authorities to use all the resources at their disposal to improve health and wellbeing. The promotion and protection of health and wellbeing are embedded in the duties of the councils, including spatial planning and development management.

2.5 Defining Health and Wellbeing Impact Assessment

2.5.1 *What is 'Health'?*

2.5.1.1 Health, or more importantly, what constitutes good health, is difficult to define and measure in all its aspects for a population, not least because perceptions regarding health and expectations of good health vary. Any definition of health applied in a HIA will influence the overall content and focus of the assessment. Following best practice, this HIA applies the World Health Organization's (WHO) definition, which states that health is;

> *"a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity"*[5]

2.5.2 *Health Determinants*

2.5.2.1 As a consequence of adopting the WHO definition, the basis of this HIA is a broad socio-economic model of health. For any individual, health is determined by a multitude of factors. There are individual factors that relate to age and genetics, which cannot be changed. Next, there are lifestyle factors, such as levels of physical activity, alcohol consumption, tobacco smoking, etc. Beyond these matters, a multitude of external factors play a significant part in determining health. These reflect the wider environment and encompass many aspects of the socio-economic context in which members of a community live and work.

2.5.2.2 A common way of summarising these factors is illustrated as a model of the so-called 'determinants of health'. The core determinants are specific to an individual, whilst the outer determinants are a function of the socio-economic status of an individual. For example, social and community networks are also considered to be important for a person's health and wellbeing. If these networks are strong, evidence suggests that health is

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[3] Planning for Health and Wel being: Supplementary Planning Document, North Lincolnshire Council (November 2016)

[4] UK Government (2012). Health and Social Care Act.

[5] World Health Organization, (1948), Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19-22 June, 1946.

improved. Isolated individuals, on the other hand, typically experience poorer health.

2.5.2.3 Determinants of health are generally well understood and can be defined with some confidence, although no list can be completely comprehensive, especially where the definition of health includes wellbeing, as in this HIA.

2.5.2.4 A health determinant can be any factor which has the potential to influence the health of an individual. Health determinants are categorised in Section 3.9. For the sake of this assessment, the following categories of determinants have been used as follows:

- Physical Environment – the physical characteristics and conditions of an area.
- Living Environment – conditions of the area where people live as well as the relation and sense of character they associate with the area.
- Social Capital – represents the degree of social cohesion which exists in communities. It refers to the processes between people which establish networks, norms, and social trust, and facilitate coordination and co-operation for mutual benefit[6].
- Economics – the status and conditions of an area in terms of economic status and opportunities available.

2.5.2.5 The physical environment (e.g. air quality) is one determinant that has some part to play in the health of populations, but is only one influence. Good housing, access to medical services, transport and being employed in a low stress job are also important.

2.5.2.6 In conducting a HIA, the effect of the Project under consideration on these determinants has to be considered. This is done by defining health 'pathways'. A health pathway can be described as any activity that influences a known determinant of health. These pathways are discussed further in Section 6.

[6] World Health Organisation 1998. Health Promotion Glossary.

3. CONSULTATION RESPONSES

3.1.1.1 An EIA Scoping Report was submitted to the Planning Inspectorate on October 30th 2020, and the scoping opinion was received on December 9th 2020. Responses received from the Planning Inspectorate of relevance to the health and wellbeing assessment, are summarised in Table 1 below.

Table 1: Planning Inspectorates Comments

PINS ID	Applicant's proposed matters to scope out	Inspectorate's comments	Response / Action	Reference within this document
4.10.1	Operational impacts on property prices	The ES should include evidence that demonstrates the re-opening and use of the railway line and other development elements would not impact property prices and/or result in consequential effects on other matters such as health care provision.	Scope has not been changed to include a house price market assessment as this is not a material planning consideration as described in government guidance on 'Determining a planning application' '*A material planning consideration is one which is relevant to making the planning decision in question (e.g. whether to grant or refuse an application for planning permission). The scope of what can constitute a material consideration is very wide and so the courts often do not indicate what cannot be a material consideration. However, in general, they have taken the view that planning is concerned with land use in the public interest, so that the protection of purely private interests such as the impact of a development on the value of a neighbouring property or loss of private rights to light could not be material considerations'.* Paragraph: 008 Reference ID: 21b-008-20140306 Revision date: 06 03 2014	N/A

3.2 Comments Received on Health and Wellbeing

3.2.1.1 Specifically, in relation to the assessment of health and wellbeing, responses were received from Public Health England, and also from Burringham Parish Council and Burton Upon Stather Parish Council. Responses received are summarised in Table 2 below.

Table 2: Comments Received in Response to the Scoping Report

PINS ID	Topic Raised	Comments	Response / Action	Reference within this document
Burton Upon Stather Parish Council	Air Quality	The prevailing winds across most of England are South Westerly and with the Parish of Burton upon Stather together with Normanby and Thealby being located to the northeast of the applicant's proposed Site, they are therefore in the area most likely to be affected by changes in Air Quality from the proposed Waste Incinerator.	An AQIA has been undertaken, refer to Chapter 5 (**Document Reference 6.2.5**).	Chapter 5 (**Document Reference 6.2.5**)and consideration of these findings in this Chapter
Public Health England	Odour	The ES should have a robust and fully justified odour assessment that quantifies the odour impact from the operation of the Proposed Development.	As above	Chapter 5 (**Document Reference 6.2.5**)and consideration of these findings in this Chapter
Public Health England	Air Quality	Insufficient evidence has been provided within the Scoping Report to support the assumption that no air quality cumulative effects on human receptors will arise due to the Proposed Development. Therefore, the Inspectorate does not agree that this matter can be scoped out of the Environmental Statement (ES).	The air quality assessment integrates a Human Health Risk Assessment (HHRA) to understand potential effects on health and wellbeing from emissions to air. The findings are presented in the ES and incorporated into this assessment.	Consideration of HHRA findings in this Chapter. HHRA provided as Appendix B

PINS ID	Topic Raised	Comments	Response / Action	Reference within this document
Public Health England	Combined Emissions	The ES should consider the cumulative effect of all emissions sources at sensitive human and ecological receptors.	As above	Chapter 18 (**Document Reference 6.2.18**) and consideration of these findings in this chapter
Public Health England	Noise	The ES should provide a detailed description of the assessment methodology which should include: ■ the criteria used to determine the sensitivity of receptor and the locations of all sensitive receptors (human and ecological); and ■ the criteria used to determine the magnitude of impact The ES should provide a description of any mitigation measures required to minimise noise impacts on human and ecological receptors.	A detailed noise impact assessment is included within Chapter 7 (**Document Reference 6.2.7**) and summarised in this chapter.	Section 6.2.10
Public Health England	Operational impacts on Demographic effects and impacts on community infrastructure, housing, education, and other community facilities.	The Inspectorate notes that the scale and characteristics of the development are such that significant effects on such facilities may arise during operation and does not agree that this matter can be scoped out of consideration in the ES.	A detailed socio-economic assessment is included within Chapter 14 (**Document Reference 6.2.14**).	See Sections 6.3, 6.4 and 6.5 of this chapter

PINS ID	Topic Raised	Comments	Response / Action	Reference within this document
Public Health England	Electric and Magnetic Fields (EMF)	It is noted that the current proposals do not appear to consider possible health impacts of EMF. We request that the ES clarifies this and if necessary, the proposals should confirm either that the proposed development does not impact any receptors from potential sources of EMF; or ensure that an adequate assessment of the possible impacts is undertaken and included in the ES.	Potential EMF impacts will be considered within the ES.	See Section 6.2.6
Public Health England	Population and Human Health	It should be acknowledged that local communities will experience a number of environmental impacts, which in combination may be deemed significant. As such, we expect population and human health impacts to be considered within the cumulative effects assessment as a specific section. The EIA must define the assessment of sensitivity, magnitude and significance specific to population and human health. This will require the separate assessment of significance specific to population and human health within each relevant chapter. Population and human health impacts should be considered within the cumulative effects assessment in order to identify any in combination effects.	In discussion with PHE, a standalone chapter on human health has been provided which presents a summary of the effects on human health. This assessment has informed the assessment of cumulative effects.	Chapter 18 Cumulative and Infirect Effects Assessment **(Document Reference 6.2.18)**
Public Health England	Vulnerable Populations	An approach to the identification of vulnerable populations, other than deprivation, has not been provided. The impacts on health and wellbeing and health inequalities of the scheme may have a particular effect on vulnerable or disadvantaged	The impacts on health and wellbeing and health inequalities of the Project are considered. This assessment has informed the assessment of cumulative effects.	Chapter 18 **(Document Reference 6.2.18)**

PINS ID	Topic Raised	Comments	Response / Action	Reference within this document
		populations (including those that fall within the list of protected characteristics). The ES should clearly identify the range of vulnerable populations that have been considered within the assessment.		
Public Health England	Mental Health	There should be parity between mental and physical health, and any assessment of health impact should include the appreciation of both. An estimation of community anxiety and stress should be included as part of the assessment of the proposed plans.	The impacts on health and wellbeing and the distinction between mental and physical impacts of the Project are considered. A qualitative judgement is made on the consideration of anxiety and stress as there is inadequate data to provide a quantitative assessment of effect.	See Section 6
Burringham Parish Council	Odour	Concerns were raised that when the prevailing westerly winds occur the communities such as Flixborough will be concerned about possible bad smells from store materials.	Included in the Air Quality Assessment within Chapter 5 (**Document Reference 6.2.5**). Odour is principally controlled through best practice design for the ERF which draws potentially odorous air from the tipping hall through the process thus destroying odours. This along with other measures are detailed in the Air Quality Impact Assessment (AQIA).	Chapter 5 (**Document Reference 6.2.5**)and consideration of these findings in this Chapter

3.2.1.2 Table 3 below sets out the key stakeholder comments from the pre-application statutory consultation specific to Health. The table describes how each response has been or will be addressed by the Project. Responses have been included when they are directly relevant to the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (the Infrastructure EIA Regulations 2017), have required a technical clarification and / or further impact assessment. The full set of responses is contained in the Consultation Report (**Document Reference: 7.1 Appendix I-1**).

3.2.1.3 The consultee types for the purposes of statutory consultation under the 2008 Act are as follows:

- s42(a) is with prescribed consultees;
- s42(b) is with local authorities;

- s44 is with consultees with an interest in land; and
- s47 is with the local community.

Table 3: Section 42 and Section 47 Consultation Responses on the PEIR

Consultee type	Consultee	Comments	Response / Action	Reference within this document
S42(a)	Public Health England	The health baseline data should include local data in relation to mental health and wellbeing. There should be an estimation of community anxiety and stress included as part of the assessment of the proposed plans. This may be a mix of qualitative and quantitative data. For example, insights could be gathered during the analysis of public consultation responses from the local community and social media. Population and human health impacts should be considered within the cumulative effects assessment in order to identify any in combination effects.	Chapter 17: Health of the Environmental Statement (**Document Reference 6.2.17)** provides further assessment of potential impacts relating to the Energy Recovery Facility, during both construction and operation, on mental health. Section 5 includes a review of current literature and baseline conditions with regard to mental health in the vicinity of the Project.	This Chapter and Chapter 18 **(Document Reference 6.2.18)**
S47	Local Community	I don't see the point in a visitor centre, you wouldnt [sic] want children anywhere near with the toxin levels that will be leaked out in the environment and hazards. It's not a safe environment for children.	As set out in Chapter 17: Health of the Environmental Statement (**Document Reference 6.2.17**), our assessment acknowledges that there is evidence of public anxiety over perceived impacts of ERFs, particularly during operation. Our assessment concludes that the implementation of on-site health and safety procedures will reduce the chance of any such accident occurring, and the likelihood of accidents occurring is low. The Project will continue to liaise with the local community during construction and operation, to understand and mitigate concerns.	This chapter

Consultee type	Consultee	Comments	Response / Action	Reference within this document
S47	Local Community	Build an education centre to educate future generations on renewable energy. But that education centre should begin with not building such sites near to rural residential housing that can impact on health and well being of it`s residents AND CHILDREN. Education about learning from the past mistakes. And past mistakes taught us this site is not suitable for such a vast plant and the hazards it will bring.	The Project is designed with the benefit of all of the proven safety measures deployed on similar sites globally that have demonstrated a good safety track record to minimise the risk of accidents. These design safety features and operational processes have been informed and reinforced by an assessment of historical data, which we report on in Chapter 17: Health of the Environmental Statement (**Document Reference 6.2.17**),. Facilities of this type are strictly regulated, and we are consulting with relevant regulatory bodies, including the Health and Safety Executive and the Environment Agency, on our design and operational processes. It is not envisaged that there will be a significant impact upon human health. The Project will also be subject to strict regulatory controls and the requirement for ongoing monitoring of various activities at the site.	This chapter
S47	Local Community	This seems a good idea but not at the cost of the communitys [sic] health. Surely the local council could provide these without the incinerator.	The Project meets the R1 energy efficiency criteria set out in the Waste Framework Directive 2008/98/C (WFD) to qualify as an energy recovery operation, and is therefore an Energy Recovery Facility rather than an incinerator. The assessment of effects on health and wellbeing in Chapter 17: Health of the Environmental Statement (**Document Reference 6.2.17**) seeks to understand if there could be potential effects on health. It is not envisaged that there will be a significant impact upon human	This chapter

Consultee type	Consultee	Comments	Response / Action	Reference within this document
			health. The Project will also be subject to strict regulatory controls and the requirement for ongoing monitoring of various activities at the site.	
S47	Local Community	Furthermore, there are too many unanswered questions about the emissions of ultra-fine particulate matter from incinerators and how these could potentially affect local residents. There is a growing body of evidence which suggests these emissions could pose a dangerous risk to people's health and I am concerned to learn that there is yet to be a cumulative health impact assessment for those residents who would be affected by the incinerator. This potential risk must be viewed within the context of what we already know i.e. that people living in areas with high levels of air pollution suffer from poorer health and wellbeing. The steelworks already present a problem with regard to air quality in the area and this can only be made worse by the proposed development. If there is the slightest risk the incinerator will add to the health problems caused by poor air quality there must be an urgent review of the health implications, their impact and how they will be controlled.	The Project meets the R1 energy efficiency criteria set out in the Waste Framework Directive 2008/98/C (WFD) to qualify as an energy recovery operation and is therefore an Energy Recovery Facility rather than an incinerator. Chapter 17: Health of the Environmental Statement **(Document Reference 6.2.17)** includes detailed consideration of the cumulative impact on the health and wellbeing of the local community. It is not envisaged that there will be a significant impact upon human health. The Project will also be subject to strict regulatory controls and the requirement for ongoing monitoring of various activities at the site. Our assessment also included consideration of the baseline conditions in the vicinity of the Project, which informed an understanding of how those communities may be susceptible to potential health and wellbeing impacts.	This chapter and Chapter 18 **(Document Reference 6.2.18)**
S47	Local Community	It's bad enough with the landfill site at Roxby, I have a lung condition if the plans are given	We take seriously the concerns of local residents with regards to their health. The assessment of effects on health and wellbeing in Chapter 17:	Chapter 5 **(Document Reference**

Consultee type	Consultee	Comments	Response / Action	Reference within this document
		the go ahead people like myself are going to suffer with there [sic] breathing.	Health of the Environmental Statement **(Document Reference 6.2.17)** seeks to understand if there could be potential effects on health and wellbeing from emissions to air, including emissions associated with construction traffic and the proposed carbon capture system aspect of the ERF plant (particularly amines, nitramines and nitrosamines) during operation. It is not envisaged that there will be a significant impact upon human health. The Project will also be subject to strict regulatory controls and the requirement for ongoing monitoring of various activities at the site.	**6.2.5)** and consideration in this chapter
S47	Local Community	Who knows what long term effects those chemicals used will have. We have farmland around here, will it affect the crops or get into them, and that alongside the affected air/dust levels could cause illness and possibly cancer clusters in this area. I suspect that I will need to keep my windows shut and hanging washing outside will become affected.	We take seriously the concerns of local residents with regards to their health. The Human Health Risk Assessment in Chapter 17: Health of the Environmental Statement (**Document Reference 6.2.17**), seeks to understand if there could be potential effects on health and wellbeing from emissions to air. It is not envisaged that there will be a significant impact upon human health. The Project will also be subject to strict regulatory controls and the requirement for ongoing monitoring of various activities at the site.	Appendix B-HHRA
S47	Local Community	Do the people of this area so close to where the Flixborough disaster occurred deserve the ongoing stress and impact on their mental health of such a plant ?	We take seriously the concerns of local residents with regards to their health. We have assessed impacts on health as part of Chapter 17: Health of the Environmental Statement **(Document Reference** 6.2.17). Section 6.5 of our assessment	Consideration in this chapter

Consultee type	Consultee	Comments	Response / Action	Reference within this document
			acknowledges that the Flixborough chemical plant explosion of 1974 may have left a residual memory in the local population. Furthermore, we acknowledge that there is public concern regarding waste management facilities. Chapter 17: Health of the Environmental Statement **(Document Reference 6.2.17)** provides further assessment of potential impacts relating to the Energy Recovery Facility during both construction and operation, on mental health. This assessment includes a review of current literature and baseline conditions with regard to mental health in the vicinity of the Project. It is not envisaged that there will be a significant impact upon human health. The Project will also be subject to strict regulatory controls and the requirement for ongoing monitoring of various activities at the site.	
S47	Local Community	I have concerns for the health of my grandchildren who live in Flixborough , one of whom has to use an inhaler.	We take seriously the concerns of local residents with regards to their health. The Human Health Risk Assessment in Chapter 17: Health of the Environmental Statement **(Document Reference 6.2.17)** seeks to understand if there could be potential effects on health and wellbeing from emissions to air, including emissions associated with construction traffic and the proposed carbon capture system aspect of the ERF plant (particularly amines, nitramines and nitrosamines) during operation.	Chapter 5 **(Document Reference 6.2.5)** and this chapter

Consultee type	Consultee	Comments	Response / Action	Reference within this document
			It is not envisaged that there will be a significant impact upon human health. The Project will also be subject to strict regulatory controls and the requirement for ongoing monitoring of various activities at the site.	
S47	Local Community	The environmental impact on air quality is also of concern , having family members with lung problems . COPD caused by working in industry in the past when things were different and concern was not voiced . [sic]	We take seriously the concerns of local residents with regards to their health. The Human Health Risk Assessment in Chapter 17: Health of the Environmental Statement **(Document Reference 6.2.17)** seeks to understand if there could be potential effects on health and wellbeing from emissions to air, including emissions associated with construction traffic and the proposed carbon capture system aspect of the ERF plant (particularly amines, nitramines and nitrosamines) during operation. It is not envisaged that there will be a significant impact upon human health. The Project will also be subject to strict regulatory controls and the requirement for ongoing monitoring of various activities at the site.	Chapter 5 **(Document Reference 6.2.5)** and this chapter
S47	Local Community	In the assessment on health the report says the impact on health is minimal - it should be zero!	The National Planning Policy Framework specifies the requirement to "ensure that permitted and proposed operations do not have unacceptable adverse impacts on the natural and historic environment or human health, taking into account the cumulative effects of multiple impacts from individual sites and/or a number of sites in a locality".	chapter 18 **(Document Reference 6.2.18)**

Consultee type	Consultee	Comments	Response / Action	Reference within this document
			The World Health Organisation states that a Health Impact Assessment is a practical approach used to judge the potential health effects of a project, on a population. Recommendations are produced, with the aim of maximising the proposal's positive health effects and minimising its negative health effects. The intention of a such an assessment is therefore not to prove a proposal has zero impact on health. We have assessed impacts on health in Chapter 17: Health of the Environmental Statement **(Document Reference 6.2.17)**. The purpose of the assessment of effects on health and wellbeing is to provide all interested parties with a comprehensive evaluation of the Project's implications for health and wellbeing. Specifically, the assessment determines the potential health and wellbeing impacts of the Project on local receptors, and ways to minimise negative health and wellbeing impacts. It also aims to identify ways to maximise positive health and wellbeing impacts. It is not envisaged that there will be a significant impact upon human health, as a result of the Project. The Project will also be subject to strict regulatory controls and the requirement for ongoing monitoring of various activities at the site.	
S47	Local Community	Oh I cannot wait to breathe in polluted air when the wind is in the direction of Burton upon Stather. What about our health? Has anyone considered what it will do to our	We take seriously the concerns of local residents with regards to their health. The Human Health Risk Assessment in Chapter 17: Health of the Environmental Statement **(Document Reference**	Chapter 5 **(Document Reference**

Consultee type	Consultee	Comments	Response / Action	Reference within this document
		lungs. Please think about the effects on health in many years to come. Scunthorpe is already listed as a polluted area. Why would you add to that? Why can this not be built so close to villages? But I suppose my comments will go unnoticed as will countless others...	**6.2.17)** seeks to understand if there could be potential effects on health and wellbeing from emissions to air. It is not envisaged that there will be a significant impact upon human health. The project will continue to communicate with stakeholders to address any issues or concerns which may arise. It is not envisaged that there will be a significant impact upon human health, as a result of the Project. The Project will also be subject to strict regulatory controls and the requirement for ongoing monitoring of various activities at the site.	**6.2.5)** and this chapter

3.2.1.4 Points raised by stakeholders have been addressed through this chapter, including an updated baseline and assessment.

4. METHOD FOR UNDERTAKING THE HIA

4.1 Models for Undertaking the HIA

4.1.1.1 There is an extensive and growing body of knowledge and guidance on HIA. However, no statutory guidance exists and different HIAs employ slightly different methods to meet individual project requirements.

4.1.1.2 According to the Gothenburg consensus (a consensus paper developed by amongst others, the WHO, the Nordic School of Public Health and the European Commission, which is designed to provide a common understanding and approach to undertaking HIA), HIA is:

> *"a combination of procedures, methods and tools by which a policy, programme or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population"*[7]

4.1.1.3 This HIA also takes into consideration the following guidance:

- A Short Guide to Health Impact Assessment: Informing Healthy Decisions, commissioned by National Health Service Executive London, August 2000;
- An Easy Guide to Health Impact Assessments for Local Authorities, Chimeme Egbutah and Keith Churchill, October 2002;
- Introducing health impact assessment (HIA): Informing the decision-making process, Health Development Agency, 2002; and
- Guidance on HIA: WHO, 2006.

4.2 Reporting on the HIA

4.2.1.1 In response to the Scoping Report, PHE stated its preference for a specific section of the ES to detail the relevant issues, rather than embedded within the individual topic chapters. The Planning Inspectorate also stated that the "assessment of the project should specifically assess significant effects resulting from the risks to human health. Any measures that will be employed to prevent and control significant effects should be presented in the ES."

4.2.1.2 Therefore, it was determined that a standalone section on health and wellbeing would be integrated into the ES, in accordance with the advice of PHE and the Planning Inspectorate.

4.3 Assessment Approach and Methodology

4.3.1.1 The method applied in this Health and Wellbeing assessment follows established best practice, drawing upon available data to inform the assessment of potential impacts on health and wellbeing. It comprises the following key steps:

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[7] World Health Organization (1999) Health impact assessment: Main concepts and suggested approach. Copenhagen: World Health Organization.

- the compilation of an evidence base, comprising a literature review, a community profile and a limited stakeholder engagement;
- analysis of potential health impacts; and
- the conclusions on effects resulting from this process.

4.4 Community Profile

4.4.1.1 The community profile has been informed by a number of data sets, including national statistics such as the National Census 2011, the Indices of Multiple Deprivation 2019, and the UK business register and employment survey (BRES).

4.4.1.2 The combination of statistics and available survey information develops a picture of the existing community profile, including specific areas of sensitivities, susceptibilities and inequalities. This is used to identify sections of the community who may experience potential impacts of the Project in a different or disproportionate manner, in addition to generalised impacts which may be experienced by the community as a whole.

4.5 Literature Review

4.5.1.1 A literature review has been undertaken to collect evidence on the potential health and wellbeing impacts associated with the Project. This was based on literature regarding health effects associated with the various elements of the Project and included a review of completed HIAs on waste management facilities, waste management policies and position papers prepared by relevant groups and authorities. The effects on health of the following topics were considered:

- air quality;
- incineration and public health;
- transport;
- noise;
- visual environment;
- socio-economic characteristics; and
- social capital.

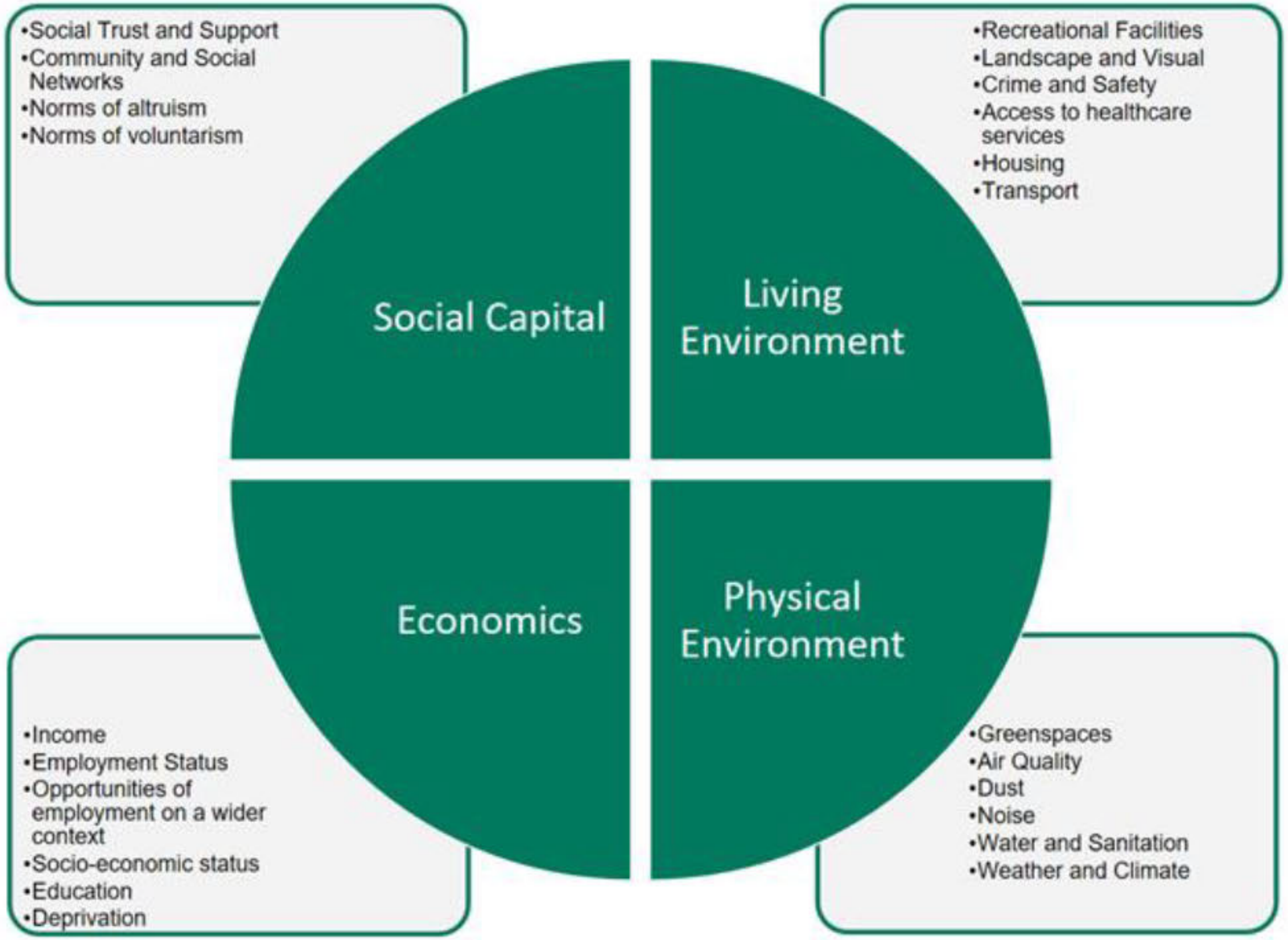
4.5.1.2 The literature review is not a systematic review of all the available literature on these topics but is based on literature that is nationally or internationally recognised, peer reviewed and which reflects the consensus view. All the literature included in the review is publicly available. The literature review has also considered other published HIAs (except those undertaken previously by ERM to ensure independence) on similar or related projects or policies.

4.6 Health Determinants

4.6.1.1 A health determinant can be any factor which has the potential to influence the health of an individual. Health determinants have been categorised into

Social Capital, Living Environment, Physical Environment and Socio-economic characteristics and cover the factors shown in Figure 1.

Figure 1: Health Determinants



5. SUMMARY OF COMMUNITY PROFILE AND LITERATURE REVIEW

5.1 Overview

5.1.1.1 The profile of the communities that may be influenced by the Project provides an understanding of how people in these communities may be susceptible to changes in their health determinants and consequently their health and wellbeing.

5.1.1.2 Community characteristics, such as social and demographic structures, provide an indication as to the resilience of the communities to external changes. The profile of a community may reveal vulnerable parts of communities and indicate how the Project may affect these people disproportionately.

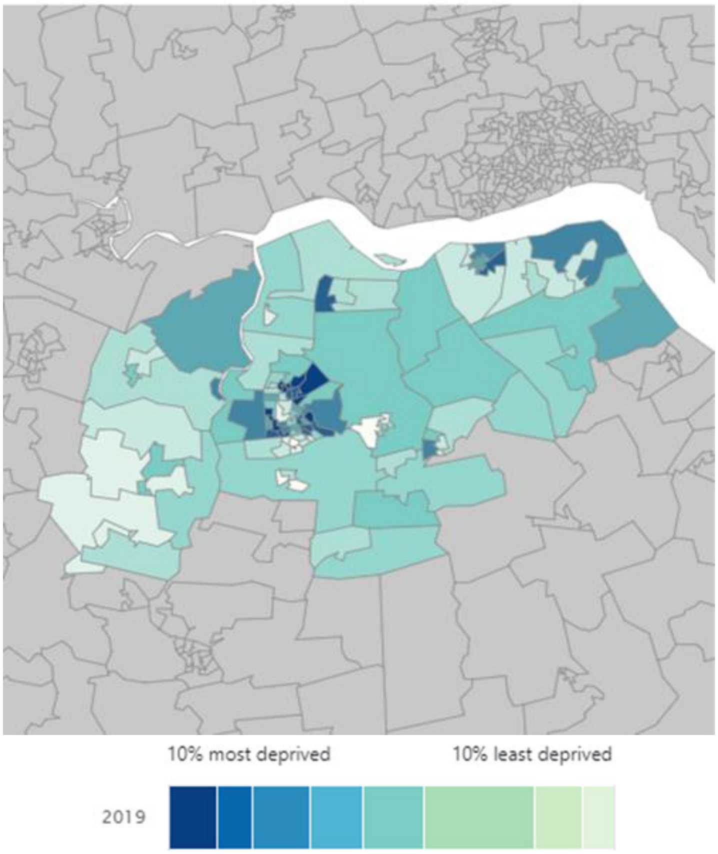
5.1.1.3 The community profile has been assembled using many different data sources, such as the Office for National Statistics and the 2011 census, that provide statistical information on health determinants. Much of the information is numerical in nature and is not set out in detail here. Detailed information on the Community Profile and Literature Review can be found in Appendix A of this chapter. A summary of the salient features is given below.

5.1.1.4 The ’community’ referred to here is not strictly a single entity, but composed of many communities, each with its own characteristics. The wider population considered and for which many statistics are available is North Lincolnshire. This population is approximately 167,000 at present and projected to rise to 176,000 by 2030.

5.1.1.5 The Project itself is located in the Ward of Burton-upon-Stather and Winterton, a rural area with several villages, including Flixborough. The 2011 census recorded 11,326 inhabitants.

5.1.1.6 Burton-upon-Stather and Winterton are neither strongly affluent nor deprived by most socio-economic measures. The very useful Indices of Multiple Deprivation shows that other parts of North Lincolnshire are much more deprived, e.g. parts of Scunthorpe (Figure 2).

Figure 2: Overall Indices of Multiple Deprivation Rank for North Lincolnshire (MHCLG Indices of Deprivation 2019)



5.1.1.7 Taken as a whole, the population of Burton-upon-Stather can be described as being slightly older than the national average, with lower levels of economic activity and unemployment than in the region, suggesting that a larger proportion of the population has retired from work, relative to surrounding areas. Income data are not available at ward level, but for North Lincolnshire, average incomes are lower than the average nationally and have been static or declining in recent years.

5.1.1.8 The health statistics for Burton-upon-Stather ward show that life expectancy is higher than the national average, whereas for North Lincolnshire as a whole it is lower and substantially so in the more deprived areas. Many health statistics of importance are only available for the area of North Lincolnshire and not at ward level. For respiratory and cardiovascular health, for example, it is noteworthy that North Lincolnshire has higher premature mortality rates and hospital admissions than the national average. In addition, a slightly higher proportion of people in North Lincolnshire report anxiety and depression than for England as a whole.

5.2 Summary

5.2.1.1 Looking at the data as a whole, the conclusion is that there are no outstanding aspects of the socio-economic or health status of the population that suggest vulnerabilities to health effects from external changes. As in many cases, however, this does not mean that there are not some parts of the population that would not have some vulnerability, as in the case of the wards with higher levels of multiple deprivation, for example. The population most affected by the Project, i.e. in the villages of Flixborough and others in Burton-upon-Stather and Winterton, does not exhibit any obvious vulnerabilities. As with all assessments of health effects in this context, any changes can only be described at the population level and not for individuals.

5.2.1.2 The literature review identifies and lists vulnerable groups potentially present in a population; the community profile does not indicate that any of these groups are present in the surrounding population. The only possible exception to this is the indication that some health outcomes and conditions are worse than the national average, although some of these are perhaps more applicable to North Lincolnshire as a whole than for the population living closer to the Project.

6. ASSESSMENT OF EFFECTS ON HEALTH AND WELLBEING

6.1.1.1 The assessment of effects on health and wellbeing draws upon the findings of the wider relevant technical assessments, to assess the cumulative effects on health and wellbeing during both construction and operation of the Project. The assessment is framed under the four key categories of health determinants, namely:

- Living environment;
- Physical environment;
- Social capital; and
- Economics.

6.2 The Living Environment

6.2.1.1 The category of living environment encompasses the following health determinants:

- Landscape and visual impacts;
- Transport, including access to healthcare services; and
- Crime and safety.

6.2.2 Landscape and visual

6.2.2.1 The feature that is most directly relevant and which has been assessed in Chapter 11 (**Document Reference 6.2.11**) is landscape and visual impacts. Construction will bring new elements to the landscape that will have an adverse effect on the landscape character of the surrounding areas, specifically for those at Trent Side (Amcotts), Stather Road (Flixborough) and Keadby. As explored in the literature review, the visual presence of industry has been shown to be correlated with emotions of dissatisfaction amongst residents, as well as stress, anxiety and concern. During construction, adverse impacts on landscape character and visual amenity would be caused by construction activity, however, these impacts will be experienced by few people and will be reversible and short term. There is therefore unlikely to be significant impacts to the population's health and wellbeing.

6.2.2.2 In the operation phase, the Project will lead to a change in landscape and land use at the Site, albeit in the context of an already industrial environment due to the presence of Flixborough Industrial Estate. The incremental growth of vegetation and landscape mitigation planting suggests that visual effects would be reduced to minor adverse (i.e. not significant) at year 15 at 9 out of 10 viewpoints. Viewpoint 1 (Trent Side, Amcotts) will experience a major adverse impact at year 15, and Viewpoint 2 (Stather Road, Flixborough) will experience a moderate adverse impact at year 15. The associated change in view at Viewpoint 1 would be experienced by relatively few people and would be limited to the local community on the edge of Amcotts as well as users of the footpath between Church Street and Trent Side. At Viewpoint 2, woodland planting as part of the extension of Burton Wood would provide effective screening by year 15, although the ERF stack may remain visible. Woodland would also screen longer views, though these views will remain available from nearby footpaths. Mitigation outlined in Chapter 11 (**Document Reference 6.2.11**) will further reduce the significance of these predicted impacts.

6.2.2.3 Given the limited impact on this aspect of the living environment, the conclusion is that there will be no effects of significance on health at the population level.

6.2.3 Transport

6.2.3.1 Chapter 13: Traffic and Transport (**Document Reference 6.2.13**) found that there are likely to be negligible impacts on traffic and transport during the construction of the Project, assuming that the Construction Logistics Plan (CLP) is followed (Appendix D to ES Chapter 13, **Document Reference 6.2.13**). Table 15 within the chapter provides the predicted daily and monthly number of construction vehicles that will be required at peak construction traffic during the 6 years of construction. The table suggests that the largest number of delivery vehicles per day is likely to be 55-105 vehicles in year 2 of construction, with the largest number of workforce vehicles per day being 585-800 in Year 4. There is an understanding that the risk to health of the local communities, particularly those of an older demographic or those experiencing health inequalities may rise due to the increased presence of HGVs on the local road network. However, the use of the CLP will ensure that these vehicles are managed in a safe and reliable manner, with the possibility of using river and rail modes of transport to further reduce road traffic. The anticipated increase of vessel movements could be adequately accommodated at Flixborough Wharf within the existing two berths available and its impact upon navigational safety on the River Trent would not be significant. This increase in construction traffic is predicted to have no significance for the health and wellbeing of communities closely situated to the Project.

6.2.3.2 No significant adverse effects have been identified from the operational phase of the Project with regards to the net change in trips over and above the future baseline traffic flows. With regard to motorised road users on the B1216 Ferry Road West (east of the New Access Rd) and Ferry West Road (east of A1077), an adverse effect is predicted of minor significance in relation to driver delay. However, the effect on all other highway links is predicted to be negligible.

6.2.3.3 The use of a Travel Plan for the site is likely to have a positive effect on influencing sustainable travel modes by encouraging a shift from public transport to healthier modes of travel such as walking and cycling. The increased provision of public rights of way should also enhance connectivity for local residents.

6.2.3.4 In light of the proposed mitigation, it is not expected that the impacts from traffic and transport associated with the Project will exacerbate the mental health issues or current health inequalities within the local communities.

6.2.4 Accidents, Crime and safety

6.2.4.1 As noted, the Project will be associated with an increase in traffic, including HGVs, during both the construction and operational phase. This gives rise to a theoretical increased risk of accidents on local roads, but the additional risk is very small and could not be considered significant.

6.2.4.2 Access to the Application Land during construction will be restricted for people not working on the Project and appropriate security measures will be installed on the construction site, meaning the likelihood of an incident occurring involving a member of the public is low. The likelihood of accidents involving workers on-site during construction is low, given the relatively short construction period and the nature of the works being undertaken. While the severity of an accident cannot be predicted, the implementation of on-site health and safety procedures will reduce the chance of any such accident occurring. The health impact of such incidents will be limited to the individual or individuals concerned and will therefore not affect the population health of the local community, with the additional pressure on health services being negligible.

6.2.4.3 The Project is not predicted to influence crime rates in the locality. The potential exists for trespass at the construction site but this is a limited possibility, mitigated by site management and security protocols and does not have any significance for health effects at the population level.

6.2.4.4 It is possible that the local community may have anxiety over potential lack of adherence to Covid restrictions, in particular, during the construction phase of the Project. Adherence to relevant restrictions and guidance in relation to Covid management and prevention will be integrated into the Construction Environmental Management Plan (CEMP) which is secured by requirement 4 of the draft DCO (**Document Reference 2.1**) and will also be communicated to the public to mitigate potential anxiety in relation to this.

6.2.5 Major Accidents and Disasters

6.2.5.1 Chapter 16: Major Accidents and Disasters **(Document Reference 6.2.16)** concluded that with embedded mitigations in place there are no residual risks considered in the ‘extreme risk’ category and all identified hazards can be judged to be ‘Tolerable if as low as reasonably possible (ALARP)’ or ‘Broadly Acceptable’.

6.2.5.2 This assessment is a review based on information available at this stage and has adopted a worst-case approach. As is normal practice, further hazard and risk analysis will be undertaken throughout the lifecycle of the Project in accordance with the requirements of applicable legislation and industry good practice guidance, to ensure risks continue to be managed to a level that is considered ALARP during the detailed design, construction planning and operation of the Project.

6.2.5.3 The likelihood of any accident actually occurring that would have any direct consequences for the local population is extremely low. It is, however, recognised that given the history of the fatal incident at Flixborough, it is reasonable to conclude there will be an underlying anxiety amongst some sections of the local community relating to the risk of an industrial accident. This anxiety may be particularly felt amongst older generations who may have lived through or grown up in the aftermath of the Nypro disaster.

6.2.5.4 To mitigate effects on human health, a proactive and ongoing programme of engagement and information dissemination will be undertaken, including use of scientific and third-party sources to provide objective information into the public domain. It is important that the specific anxiety which the local community may feel in the context of the Nypro disaster is acknowledged and actively mitigated.

6.2.6 The Physical Environment

6.2.6.1 The category of physical environment encompasses the following health determinants:

- Greenspaces;
- Air quality;
- Dust;
- Noise;
- Water and sanitation (scoped out); and
- Weather and climate.

6.2.6.2 All overhead power lines are known to produce Electro Magnetic Fields EMF), which tend to be highest directly beneath a line, and decrease at increasing distance either side of the line. The greater the voltage, the greater the EMF and potential public exposure to electro-magnetic radiation, with the greatest concerns traditionally stemming from overhead 400 kV lines passing over or very close to residential housing, schools etc. Installing electric cables underground eliminates the electric field. A magnetic field is still produced, and this tends to be highest directly above the buried cable. The electric cables for the DHPWNs will be buried throughout their length and will operate at a voltage of 11 or 33 kV. The routes of the DHPWNs involve burial predominantly below roads and in open land. The pathway for public exposure to any health effects will therefore be minimal spatially and in duration. The potential for health effects from the buried and relatively low voltage DHPWN electric cables is therefore negligible and not considered further.

6.2.7 Greenspaces

6.2.7.1 The Project is being primarily developed in a brownfield site and has, therefore, limited impact upon greenspaces. The masterplan for the Project will integrate greenspace and habitat creation into scheme design and landscaping, to enhance the physical environment and engagement will continue with key environmental stakeholders such as the local Wildlife Trust to inform the delivery of this. Enhancements to the local landscape are expected to contribute to increased quality of life and leisure opportunities for local communities, generating a positive effect on health and wellbeing, in particular within the context of known vulnerabilities such as higher than average rates of adverse health outcomes and certain aspects of poor mental health.

6.2.8 Air quality

6.2.8.1 The key component of the Project with respect to emissions to air, is the ERF. In terms of quantifying health effects arising from the Project, any assessment can be confined to a consideration of this part of the Project.

Exposure to Particulate Matter and Nitrogen Dioxide

6.2.8.2 Nitrogen oxides (NOx) and particulate matter will be emitted from the ERF stack on a near continuous basis. The impact of these emissions on local air quality has been assessed in Chapter 5 of the ES **(Document Reference 6.2.5)**, by reference to the applicable air quality standards and appropriate guidance on the assessment of air quality in a planning context. The air quality impact assessment (AQIA) concluded that operational impacts on air quality at sensitive human receptors will be negligible and considering the AQIA criteria there will be no significant effects on human health due to airborne concentrations of pollutants. The assessment of health effects has to take place through a different approach, since there is no threshold of effect; in other words, even the smallest level of impact has a theoretical effect on health that can be quantified.

6.2.8.3 Epidemiological studies have shown convincingly that long term exposure to NO_2 and $PM_{2.5}$ has an effect on mortality rates within an exposed population. Moreover, relationships that define the relative risk for increased mortality with a given increment of the annual average concentration of the pollutant have been defined by reputable advisory groups, e.g. the Committee on the Medical Effects of Air Pollutants (COMEAP). This knowledge can be applied to quantify the health outcomes, which also includes admission to hospital for respiratory or cardiovascular conditions.

6.2.8.4 Air pollution, and especially fine particulate matter, has been associated with many other health outcomes, including many that are not confined to the lungs and cardiovascular system. These associations, however, are not as strong as those described above and do not yet have recognised methods that allow quantification in all cases. This assessment has focused on the effect on mortality of exposure to NO_2 and $PM_{2.5}$ and the effect on hospital admissions of exposure to PM_{10}. There is very good evidence that these pollutants affect health in principle and they are the most severe that could arise. This is not to ignore the possibility of less severe effects, such as impaired health that does not result in medical intervention, but quantification of the effect on mortality and hospital admission provides a proper sense of the scale of the health effects overall.

6.2.8.5 At present, it is not fully understood what the causal mechanisms are that result in premature mortality from exposure to either $PM_{2.5}$ or NO_2. The association is strong, however, and it is generally accepted that a causal mechanism does exist. The effect on mortality is seen on the population as a whole and a shift in the rate of mortality with a change in long term pollutant concentrations. The correct way to interpret this shift is as a 'loss of life years' as an aggregate or average across the exposed population. COMEAP assessment (Appendix C) estimated that the 2008 burden of $PM_{2.5}$ across the whole of the UK was 340,000 life years. This could be thought of as a loss of life expectancy from birth of six months for everyone. Alternatively, this could be expressed as being equivalent to 29,000 premature deaths at typical ages in this year.

6.2.8.6 This context for the effect on mortality is important when considering the results for the ERF. The methodology adopted produces an outcome expressed in 'deaths brought forward'. As explained above, this is technically a loss of life years that is equivalent to a number of premature deaths. Expressing mortality as deaths is easier to understand. These are not actual deaths that occur 'out of the blue' as might be the case for road traffic accidents for example. The effect on life expectancy is similar to that caused by exposure to cigarette smoke or through obesity, i.e. a shortening of life spread across a population. The methodology is only appropriate for quantifying effects in a large population and has no relationship to any individuals.

6.2.8.7 The methodology adopted for quantifying the effect on mortality and hospital admissions is set out in detail within the Human Health Risk Assessment (Appendix B). It is the one proposed by COMEAP for this purpose and conforms to the most recent advice. In summary, it relies on exposure-response coefficients that explain the increase in the relative risk of the health outcome in the exposed population for a given change in the annual average concentration of the pollutant. For example, it is well established that an increase in the concentration of $PM_{2.5}$ of 10 $\mu g/m^3$ is associated with an increase in the mortality rate of 6%. With some simplifying assumptions, this can be used to define the 'Attributable Fraction', which is the proportion of the mortality that is attributable to exposure to a given level of $PM_{2.5}$ concentration. Knowing the baseline rate of mortality means that this value for AF can be used to calculate the increase in mortality for any increase in $PM_{2.5}$ concentration.

6.2.8.8 For mortality, relative risk coefficients have been proposed by COMEAP for both NO_2 and $PM_{2.5}$. There is a recognition by COMEAP, however, that it is likely that the apparent association between mortality and exposure to NO_2 is likely to be caused in part by the coincidental effect of $PM_{2.5}$, which is invariably also present in polluted atmospheres, especially towns and cities. To avoid any double counting, the recommendation is that the mortality calculated for each pollutant should not be additive. Instead, the best estimate is obtained by taking the larger of the two results. In the case of the ERF, the mortality effect attributable to NO_2 is the largest of the two and is taken to represent the total effect. This is despite the fact that the relative risk of exposure to $PM_{2.5}$ is greater, but this factor is outweighed by the fact that much more NO_x is emitted than $PM_{2.5}$.

6.2.8.9 To quantify the health effects, dispersion modelling has been undertaken that generated annual average concentrations within a 20 km radius of the ERF. From these results, a 'population weighted concentration' across this entire area was calculated. This number is then used with the relative risk for each pollutant to calculate the Attributable Fraction, which in turn is multiplied by the baseline rate to quantify the effect. Table 4: Summary of Human Health Effects Assessment: base data provides a summary of the Human Health Risk Assessment data.

Table 4: Summary of Human Health Effects Assessment: base data and results

Base data/ERF attributable health effects	Value
Total population exposed	295,065
Baseline mortality (per annum per 100,000)	1,020
Baseline mortality (per annum total population)	3,009
Respiratory admissions (per 100,000) (England))	2,000
Cardiovascular admissions (per 100,000) (England)	1,731
Population weighted NO_2 concentration	0.061 µg/m^3
Population weighted $PM_{2.5}$ / PM_{10} concentration	0.0036 µg/m^3
Attributable fraction NO_2	0.00014
Attributable fraction $PM_{2.5}$	0.00021
Annual deaths brought forward for the exposed population (NO_2)	0.36
Annual deaths brought forward for the exposed population ($PM_{2.5}$)	0.055
Annual respiratory admissions (per 100,000)	0.0057
Annual cardiovascular admissions (per 100,000)	0.0049
Annual respiratory admissions across the total population	0.015
Annual cardiovascular admissions across the total population	0.013

6.2.8.10 It is a logical consequence of the concept of no threshold of effect for exposure to either $PM_{2.5}$ or NO_2 that there can be no zero effect on health of the ERF's emissions. The outcomes quantified here and presented above are, however, extremely small in relation to baseline mortality rates and hospital admissions. The additional mortality is 0.01% of the existing baseline, for example.

6.2.8.11 There are no recognised criteria for assessing the significance of additional health effects at the population level, so there is no formal context in which to assess this theoretical increase. It can be said with some confidence, however, that the size of these health effects is negligible for public health and orders of magnitude below that which could be detected or measured in the annual statistics.

Exposure to Metals and POPs

6.2.8.12 The ERF will emit a wide range of substances, most of which will be emitted in only very trace quantities. The most important of these in the context of health effects are the metals regulated by the Industrial Emissions Directive and the class of pollutants commonly called 'dioxins', or more correctly polychlorinated dibenzo-para-dioxins and poly chlorinated dibenzo furans. For this ERF, another noteworthy class of pollutant is nitrosamines, associated with the carbon capture utilisation and storage facility. Nitrosamines are not typically assessed as a risk to human health, but their relative novelty requires that they are considered fully in this case.

6.2.8.13 A full assessment of the risk to human health of these substances has been undertaken using the risk assessment protocol developed by the United States Environmental Protection Agency and which has been applied using a commercially available model, the Industrial Risk Assessment Program (IRAP). In contrast to the quantification of health effects through exposure to NO_2 and $PM_{2.5}$, which are calculated at the population level, the assessment of risk posed by metals and dioxins is undertaken by considering hypothetical individuals that represent people within the exposed population. This is because the complete exposure for these pollutants is more complex than simple inhalation at a given location and assumptions need to be made that capture the possible ways in which people may be exposed to these pollutants over a lifetime and beyond the point at which the ERF will cease operation.

6.2.8.14 For most of the substances considered in this assessment, the dominant pathway for exposure is through ingestion, e.g. through the food chain. In this scenario, the pollutant is deposited locally on soils or crop surfaces. From there, it may be ingested directly or absorbed by crops and grazing animals and enter the human food chain. Some pollutants, notably dioxins, ‘bioaccumulate’ in body fats, so that they become more concentrated higher up the food chain in meat and milk.

6.2.8.15 All these possibilities have been accounted for in the modelling. First of all, dispersion modelling has been undertaken in a similar manner to the air quality assessment, so that airborne concentrations and deposition can be quantified at selected receptor points. This information is then used as an input to the IRAP model, which simulates the complex uptake of the substances from soils into the food chain and calculates the dose of each pollutant that a human receptor might ultimately receive over a lifetime. Direct exposure through inhalation is also included.

6.2.8.16 A total of 26 human receptor locations were defined in the modelling, of which 5 were ‘farmers’. This latter category of receptor is more exposed to the pollutants, since farmers are assumed to eat foods grown locally (receptors are shown in Appendix B). The residential receptors are in villages such as Flixborough to the northeast, Amcotts to the southwest, Grange to the south as well as the outskirts of the more urban area of Scunthorpe approximately 2 km to the southeast.

6.2.8.17 For dioxins, the total exposure over a lifetime for these hypothetical individuals was calculated. This additional intake has been compared with the existing likely dietary intake and the Committee on Toxicity’s recommended Total Daily Intake (TDI).

6.2.8.18 The receptor with highest incremental intake of dioxin is a farmer to the north east of the ERF, expressed as 1.7% of the TDI for an adult and 2.4% for a child. (The amount is higher for a child because of the lower body weight). For a resident of Flixborough, the additional intake is ten times lower, at 0.2% for a child and 0.1% for and adult.

6.2.8.19 Dioxins have always been present in the environment in small amounts from natural sources, but their presence became a particular problem in the 20th century as a result of the inadvertent anthropogenic production through burning of polychlorinated biphenyls (PCBs). Environmental contamination reached a peak in the middle part of the century and has been declining ever since. This is reflected in the UK exposure through eating a typical diet. The mean daily intake is now about 30% of the TDI for an adult and falling year by year. The very small additional intakes arising from the ERF's emission will not cause the total intake to exceed the TDI, or even approach it, for people living locally.

6.2.8.20 In considering these results, it should be borne in mind that they have been calculated using a model in which a series of worst-case assumptions have been made about the input data and the receptors. For example, it is assumed that dioxins will be emitted at the limit value over the lifetime of the ERF. In reality, the amount emitted will be lower. For the farmers, it is assumed that they consume meat and dairy products from animals raised on their farms, even if those farms are, in fact, arable.

6.2.8.21 Seven individual metals have been considered in the modelling. The intake of these metals by inhalation and ingestion has been calculated for the residential and farmer receptors. To evaluate the possible effect of these intakes, they have been compared with typical intakes obtained from the UK Total Diet Study. For almost all of the metals and the receptors considered, the additional intake is extremely small (0.1%) or near zero. The only exception is for the nearest farmer in the case of thallium, where the addition intake is calculated to be 33% of the lower range of typical UK intakes. This calculation, however, assumes an emission rate for thallium that is unrealistically high, compared to measurements made at operational energy from waste facilities, as well as a farmer eating entirely home-grown foods.

6.2.8.22 Nitrosamines are potentially carcinogenic and have been assessed using a risk of contracting cancer for the hypothetical receptors. The lifetime risk for the most exposed farmer is calculated to be 1 in 85,000,000 and for a resident of Flixborough is 1 in 264,152,000. These are thousands of times smaller than the benchmark for risk commonly taken for acceptability in the UK.

6.2.8.23 The assessment of pollutants emitted from the ERF that have the potential to be persistent in the environment and cause harm over many years has shown that the likelihood of any health effects in the wider population is negligible. This conclusion is reached on the basis that the additional exposure, through all conceivable pathways, is extremely small in relation to the existing exposure to the pollutants of concern, which are already present in the environment and diet, although not in amounts that are considered to be harmful.

6.2.9 Dust

6.2.9.1 The assessment concluded that construction activity associated with the ERF and new road could potentially generate dust nuisance. However, the residual impact will be minor or negligible and impacts on residents are not considered significant.

6.2.10 Noise and vibration

6.2.10.1 The residual effect of construction noise impacts is predicted to be of overall moderate significance. Impacts are likely to be on a small number of receptors, or over short time periods, as in the case of night works to connect the reopened railway with existing mainline railway. While construction and demolition noise coming from the neighbouring industrial buildings at the Flixborough Industrial Estate have been considered on a worst-case basis, these noise levels will not be at their highest every day. Of major significance is the noise and vibration impact of the installation of the District Heat and Private Wire Network (DHPWN) at Normanby Road and at Concord House on Bessemer Way. While these impacts will be short in duration, mitigation will be considered during the detailed design stage. Potential qualification for additional noise mitigation at the affected receptors will also need to be considered.

6.2.10.2 Road traffic noise off-site may increase due to construction traffic from HGVs and other vehicles accessing the site and during operation from staff, delivery and maintenance vehicles. The predicted changes in traffic indicated that noise levels would not increase significantly, and therefore the assessment concluded that the noise impact from vehicles would be negligible.

6.2.10.3 There are a number of potential activities that will be undertaken onsite during construction of the Project that may cause airborne vibration. Vibration is, however, only likely to have a significant effect within 100m for key activities such as driven piling or use of vibratory compactors. The assessment concluded that in most cases the effects will be below moderate as the main building activities are considerably further than 100m away. The assessment also concluded that the steady state vibration from a vibratory roller used for the DHPWN works was in excess of the criterion and indicated a medium magnitude impact. However, the duration of the impact is expected to be limited to a few nights and therefore was not considered a concern for human health and wellbeing.

6.2.10.4 Engagement and ongoing communication with local communities will be an important mitigation measure to reduce anxiety associated with construction activity. The engagement will include the establishment of a hotline or contact point for residents to report noise disturbance (or any other construction-related issues).

6.2.10.5 During operation of the Project, there are a number of potential activities that will be undertaken onsite that could have an effect on health and wellbeing, in the form of increased stress and annoyance and a decreased sense of wellbeing. These include, among others, the fixed plant, onsite vehicle movements, unloading operations, noise from railway vehicles and road traffic noises.

6.2.10.6 As part of the Project, a new access road will be built between Ferry Road West and Bellwin Drive. The new access road is expected to experience an increase in traffic noise during operation which is above that currently experienced on Stather Road (West). The assessment concluded that the road will be a substantial distance from the nearest Noise Sensitive Receptors (NSRs) which are not expected to experience a significant increase (less than 3 dB). Predicted noise changes from all other roads links are less than 3 dB and therefore not significant.

6.2.10.7 The significance of the residual effects from the operation of the Project will be greater than moderate. However, following the application of a range of mitigation measures detailed in Chapter 7: Noise and Vibration **(Document Reference 6.2.7)** to reduce noise levels, additional mitigation measures are not expected to significantly change the predicted noise levels. A noise monitoring and management programme, which will be developed and agreed with the NLC, will ensure that noise levels are no higher than reported in the ES.

6.2.11 Weather and climate

6.2.11.1 The Project considered potential impacts from extreme weather. Increased extreme weather events are linked to increased hospital admissions (for cardiovascular, kidney and respiratory disease) and death rates (from heatstroke, cardiovascular disease, respiratory disease and cerebrovascular disease). During the construction and operation phases, the Project is not especially vulnerable to extremely high temperatures or drought conditions. The plant will be designed to cope with anticipated weather conditions for this part of the UK. At worse, extremely cold or freezing temperatures may cause delays to the construction process but no risks were associated with human receptors.

6.3 Social Capital

6.3.1.1 Social capital within the communities and local population affected by the Project could be influenced in several ways. In particular, the Project has the capacity to change the way local people perceive the area in which they live and to have an impact on feelings of ‘reciprocity’ and trust in institutions.

6.3.1.2 Feedback from consultation suggests that some respondents are concerned about the impact of the Project on the air quality and by extension their perception of the attractiveness of the area to live in. The predicted effects of emissions on human health have been set out previously in this Chapter and in full within Chapter 5: Air Quality **(Document Reference 6.2.5)**. Acknowledging and proactively addressing public perceptions in this context, will mitigate negative perceptions of the area and impacts on social capital in this context.

6.3.1.3 During the construction phase, there will be a requirement to bring workers to the Application Land for part of, or the entirety of the duration of construction activity. The presence of this workforce has the potential to temporarily alter social capital in the local population, through feelings of mistrust. Interaction is likely to be limited, however, so impacts of this kind on social capital are assumed to be low at this stage and can be further mitigated through measures such as advance communication of proposed construction works, and liaison with local communities during construction activity.

6.3.1.4 The existence of the Project in itself, prior to any planning decision and through its construction to early operational phases, has some potential to erode social capital by undermining trust in authority. The experience of similar projects elsewhere, and the existing industrial nature of the area, tend to suggest that any impact of this kind will be limited in scale and duration. Ongoing liaison with local communities will be key to maintaining trust and mitigating the potential for erosion of social capital in the area.

6.3.1.5 The analysis of impacts on social capital at the population level indicates that any effects on health and wellbeing will be temporary. However, ongoing communication and liaison with the local community will be undertaken to ensure maintenance of trust and alleviate potential concerns, in particular, around construction activity but also at the operational stage of the Project.

6.4 Economics

Potential Impacts during Construction

6.4.1.2 The socio-economic assessment identified that 16 business premises will be directly affected within the Order Limits. There would be a direct loss of around 40 jobs associated with the relocation of the businesses at Wharfside Court unless these businesses can be relocated within the Local Impact Area. Negative impacts on health and wellbeing would arise from the loss of employment and businesses but pre-emptive agreement over suitable relocated premises, would mitigate against such disbenefits and potential anxiety over uncertainty associated with when and how relocation would be undertaken. The re-location of businesses does not qualify under the DCO criteria and discussions are continuing with the local authority to deliver alternative relocation options for these businesses.

6.4.1.3 Net job creation from construction was identified to be 2,940 jobs, taking account of leakage and displacement. The assessment also concluded that construction activity could also lead to supply chain opportunities for local businesses and based on a Gross Value added figure of £47,770, a net economic benefit of £140m spread across the six-year construction period. This scale of economic impact could generate significant health and wellbeing benefits in the area through sustaining/growing local businesses, income generation, enhanced socio-economic status and quality of life for local people working for such businesses or accessing direct employment during construction. These health and wellbeing benefits will accrue for the duration of the employment and would be of most benefit to those currently experiencing socio-economic deprivation, economic inactivity or unemployment within the area. Opportunities to target employment opportunities within these sections of the community will be capitalised upon wherever possible.

6.4.1.4 The assessment found that, whilst highly skilled or specialised construction workers are expected to be drawn in from outside the wider impact area, the impact on the demographic area and the difference to the baseline conditions of demand for local services, such as health and education services or use of communal facilities, is likely to be insignificant.

Potential Impacts during Operation

6.4.1.5 The ERF is expected to create 290 full time jobs as set out in Table 19 of Chapter 14: Economic, Community and Land Use Impacts **(Document Reference 6.2.14)**. It is likely that some of these jobs will be accessed by local residents. After the actions of leakage and displacement are accounted for, this results in a minimum of 136 net additional permanent jobs created in the area. As with the construction phase, further indirect employment opportunities will be generated for local businesses through the supply chain, resulting in an additional 39 jobs as a result of the multiplier effect. This will provide a total operational net employment gain of 175. In addition to income and enhanced socio-economic status, health benefits such as delayed mortality, decreased illness, and improved wellbeing will be experienced by those employed during the operation phase and will be of longer-term benefit.

6.4.1.6 The Project has been assessed to generate significant socio-economic benefits to the local and wider regional economy. The health and wellbeing benefit this accrues to local communities will be maximised through local procurement policies and enhancing access to employment opportunities for those who are economically inactive or those on less favourable employment terms.

6.5 Summary of effects

6.5.1.1 Potential effects on human health and wellbeing arising from dust emissions and noise have been identified as a result of construction activity. Mitigation such as dust suppression measures will be adopted to protect those living in closest proximity to the site and will be integrated into the CEMP (secured by requirement 4 of the draft DCO, **Document Reference 2.1**) and construction management planning to reduce effects on health and wellbeing. Mitigation will also be required to reduce the effect on health and wellbeing from noise arising from the installation of the DHPWN pipework and cables. A residual effect may nonetheless occur. Monitoring of noise levels and the provision of a contact point for local communities will be integrated into the CEMP.

6.5.1.2 There is a recognition that anxiety exists within sections of the community over the operation of the ERF with relation to perceived effects on human health arising from emissions to air. The quantitative assessment of the effects of emissions to air concluded that their magnitude in the wider population will be negligible. It is, however, likely that anxiety may persist if not actively mitigated. Anxiety in the local area is also recognised as emanating from the legacy of the Nypro disaster, in particular amongst older generations for whom the disaster has been a defining influence in their sense of place.

6.5.1.3 These anxieties are assessed in the wider context of pre-existing mental health within the community. North Lincolnshire has a higher percentage of the population reporting high anxiety scores compared to the national figures, and a higher percentage of patients recorded with depression than those recorded on average for England.

6.5.1.4 In this context, mitigation will be implemented to abate public anxiety and potential effects on human health and wellbeing through proactive engagement with the local community and wider stakeholders. This will include the deployment of a Community Liaison Officer, publication of the CEMP, the adoption of a hotline or alternative contact mechanisms for residents and advance notification of proposed construction works, amongst other measures.

6.5.1.5 The assessment concludes that the operation of the facility is not predicted to lead to significant negative health and wellbeing effects if the identified mitigation to address public anxiety is implemented successfully. The Project will be subject to strict regulatory controls and the requirement for ongoing monitoring of various activities at the site. To reduce potential anxiety, environmental monitoring data will be published for local communities, and wider stakeholders, to access via the Project website.

6.5.1.6 The socio-economics assessment identified the potential direct and indirect employment and economic development generated by the Project. This will have a positive effect on health and wellbeing. Opportunities will be taken to enhance such benefits through local procurement of people, goods and services, wherever appropriate. Positive effects are also predicted to arise through enhancement of the physical environment and leisure opportunities this may generate.

6.5.1.7 The health and wellbeing assessment, and specifically the effects identified within this Chapter, has informed the assessment of cumulative effects set out in Chapter 18 **(Document Reference 6.2.18)**.

APPENDIX A COMMUNITY PROFILE AND LITERATURE REVIEW

NORTH LINCOLNSHIRE GREEN ENERGY PARK

Planning Act 2008

Infrastructure Planning (Applications Prescribed Forms and Procedure) Regulations 2009

North Lincolnshire Green Energy Park

Appendix A - Health Annex

Chapter 17 Health Annex

May 2022

Pins No.: EN010116

The business of sustainability

ERM

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Acronyms and Abbreviations

Name	Description
BRES	Business Register and Employment Survey
dB	Decibel
ERF	Energy Recovery Facility
GP	General Practice
HGV	Heavy Goods Vehicle
HIA	Health Impact Assessment
IARC	International Agency on Cancer Research
IMD	Index of Multiple Deprivation
LSOA	Lower Super Output Area
NDEA	N-Nitrosoiethylamine
NDMA	N-Nitrosodimethylamine
NIPH	Norwegian Institute of Public Health
ONS	Office for National Statistics
PEIR	Preliminary Environmental Information Report
PM	Particulate Matter
SAC	Special Area of Conservation
SOC	Standard Occupation Classification
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
UK	United Kingdom
UKHLS	United Kingdom Household Longitudinal Study
WHIASU	Wales Health Impact Assessment Support Unit
WHO	World Health Organisation

1. COMMUNITY PROFILE

1.1 Overview

1.1.1.1 Assessing the profile of the community is a key component of a Health Impact Assessment (HIA), as it helps in developing an understanding of how those communities may be susceptible to potential health and wellbeing impacts and benefits arising from the Project.

1.1.1.2 There is evidence to suggest that community characteristics such as ethnicity, deprivation and social and demographic structures can influence how susceptible a population is to external changes. Analysing the profile of a community can also help identify sensitive people and vulnerable communities that may be present and how the potential impacts from the Project may affect them disproportionately.

1.1.1.3 The community profile is also useful in highlighting 'hot spot' areas of high inequality, which may be more susceptible to health impacts and benefits. Mapping the areas where there is existing poor health is, therefore, a crucial component of the community profile.

1.1.1.4 In order to assess the potential effects of the Project, the environmental conditions, resources and receptors surrounding the Project in a defined study area have been identified.

1.1.2 Extent of Study Area

1.1.2.1 Since submission of the Preliminary Environmental Information Report (PEIR), the area of the Order Limits has been refined to remove the southern extent of the Northern District Heat Private Wire Network (DHPWN). The Application Land includes land within and adjacent to Flixborough Wharf in North Lincolnshire in the Yorkshire and Humber region of England. The nearest village to the Project is the Village of Flixborough, which lies immediately to the east, and the nearest town is Scunthorpe, approximately 2 km southeast, as shown in Figure 2.

1.1.2.2 The village of Flixborough is located within the Burton upon Stather and Winterton ward which corresponds to the United Kingdom (UK) parliamentary constituency of Brigg and Goole in North Lincolnshire, Yorkshire and Humber, as shown in Figure 2 and Figure 3.

1.1.3 Sources of Information and Data

1.1.3.1 The community profile has been informed by a number of different data sources providing available statistical information on health and wellbeing with sources including:

- Population projections from the Office for National Statistics;
- The 2011 Census; and
- Nomis Official Labour Market Statistics.

1.1.3.2 More recently published data were found for the Brigg and Goole constituency, of which Flixborough is part. Where relevant, this information will also be referred to, as part of forming an understanding of the community baseline.

1.2 Population

1.2.1 Population density

1.2.1.1 The 2011 census states that the Burton upon Stather and Winterton ward had a population of 11,326 people[1]. For the wider area of North Lincolnshire, the population was estimated as 167,446[2]. North Lincolnshire has a population density of 204 people/km^2[3], whilst the national average is 275 people/km^2.

1.2.1.2 As an indication of the future trends in population, the office for national statistics predicts that the population of North Lincolnshire would be 175,145 by 2025, 176,052 by 2030 and 177,729 by 2040[4].

1.2.2 Age

1.2.2.1 In Burton upon Stather and Winterton, the highest proportion of the population in 2011 was aged 45-59 years (22.4%), followed by 30-44 years (18.7%) and 65-74 years (11%). In North Lincolnshire, the highest proportion of the population were aged 50-59 years (14%), followed by 60-69 years (13%) and 30-39 years (12%). In 2019, the highest proportion of the population in Brigg and Goole was aged 50-59 years (15.6%), followed by 60-69 years (13.4%) and 40-49 years (12.1%).

1.2.2.2 The proportion of residents within Brigg and Goole in the age groups between 0-39 years (42%) is lower than the average for North Lincolnshire (45%), the Yorkshire and Humber (50%) and England (50%). This value is even lower within the ward of Burton upon Stather and Winterton (40%), indicating an older relative demographic.

1.2.2.3 The mean age of the population of Burton upon Stather and Winterton is 42, which is similar to the mean age of the population of North Lincolnshire (41.4 years) and older than the mean age for the Yorkshire and Humber (39 years) and the national average (39.6 years).

1.2.2.4 Population projections predict that by 2025 19% of the population of North Lincolnshire will be aged 45-54, 18% of the population will be aged between 30-44 and 13% of the population will be aged 65-74. These predictions stay relatively similar through 2030, 2035 and 2040 – with the population of 45-54 year olds growing to 19%, those aged 30-44 decreasing to 17% and those aged 65-74 remaining around 13%.

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[1] NOMIS Official Labour Market Statistics (2011), Burton upon Strather and Winterton Ward (as of 2011) Local Area Report, viewed 16 November 2021

[2] NOMIS Official Labour Market Statistics (2011), Burton upon Strather and Winterton Ward (as of 2011) Local Area Report, viewed 16 November 2021

[3] ONS Population Estimates – UK, England, Wales, Scotland and Northern Ireland.

[4] Nash, A. (2020), Population Projections for Local Authorities, ONS, viewed 24 November 2021

1.2.3 Gender

1.2.3.1 As of 2011, Burton Upon Stather and Winterton ward had a near 50/50 split. The full breakdown, as well as comparators to North Lincolnshire, Yorkshire and Humber and England are shown in Table 1.

Table 1: Gender Balance within Burton upon Stather and Winterton Ward, North Lincolnshire, Yorkshire and Humber and England[5]

	Burton upon Stather and Winterton Ward (%)	North Lincolnshire (%)	Yorkshire and Humber (%)	England (%)
All Males	49.8	49.5	49.5	49.4
All Females	50.2	50.5	50.5	50.6

1.2.4 Ethnicity

1.2.4.1 As of the 2011 Census, the majority of the population of Burton upon Stather and Winterton ward identify as white (97.9%) with only 2.1% of the population identifying as belonging to an ethnic minority group. This is a much smaller proportion than for the population of England as a whole, where ethnic minorities represent around 15% of the population.

1.2.5 Religion

1.2.5.1 As of the 2011 Census, the majority of the population of Burton Upon Stather and Winterton identify as Christian (69.7%), which is in keeping with the population of England as a whole. The proportion of those identifying as having no religion is also in keeping with the national average. The proportion of Brigg and Goole's population that is Buddhist, Hindu, Jewish, Muslim or Sikh is lower than the national average, as shown in Table 2.

Table 2: Proportion of the Populations within Burton Upon Stather and Winterton and England belonging to each of the Major Religions of the UK[6]

Religion	Burton Upon Stather and Winterton (%)	England (%)
Christian	69.7	59.8
Buddhist	0.2	0.5
Hindu	0.1	1.5
Jewish	0.0	0.5
Muslim	0.3	5
Sikkh	0.4	0.8
Other religion	0.3	0.4
No religion	21.5	24.7

[5] ONS Population estimates - local authority based by single year of age, NOMIS Official Labour Market Statistics.
[6] Census (2011), Religion, NOMIS Official Labour Market Statistics, viewed 24 November 2021

1.3 Employment and Economic Activity

1.3.1 Economic Activity and Labour Supply

1.3.1.1 The 2020 Annual Population Survey provides data on Economic Activity Rate, which refers to those people who are economically active, expressed as a percentage of the population aged 16-64. According to the survey, 78.4% of Brigg and Goole constituents aged 16-64 were economically active (Table 3). This rate is higher than that of North Lincolnshire (76.8%) and Yorkshire and Humber (77.8%), but lower than that of England (79.6%). The unemployment rate in Brigg and Goole is 2.3% lower than that of North Lincolnshire, 2.1% lower than that of Yorkshire and Humber and 3.1% lower than the national average.

Table 3: Economic Activity and Unemployment Rates in Burton upon Stather and Winterton, Brigg and Goole, North Lincolnshire, Yorkshire and Humber and England[7]

	Burton upon Stather and Winterton (2011 Census data)	Brigg and Goole	North Lincolnshire	Yorkshire and Humber	England
Economic Activity Rate (%)	69	78.4	76.8	77.8	79.6
Unemployment Rate (%)	3.6	2.0	4.3	4.1	5.1

1.3.2 Employment by Occupation Type

1.3.2.1 The Business Register and Employment Survey (BRES) presents the employment figures by the industrial sector. This data is workplace-based rather than residence-based. They describe the jobs in the area, rather than the jobs being held by residents of the area. Table 4 presents the breakdown of employment by industrial sector for Brigg and Goole and the comparable areas as of 2020.

[7] ONS Annual Population Survey 2020, NOMIS Official Labour Market Statistics.

Table 4: Employment by Industrial Sector in Brigg and Goole, North Lincolnshire, Yorkshire and Humber and England[8]

Industry	Burton upon Stather and Winterton (% - 2011 Census)	Brigg and Goole (%)	North Lincolnshire (%)	Yorkshire and Humber (%)	England (%)
B : Mining and Quarrying	0.6	0.4	0.3	0.1	0.1
C : Manufacturing	18.4	12.9	23	11.4	7.3
D : Electricity, Gas, Steam and Air Conditioning Supply	0.7	0.4	0.3	0.3	0.4
E : Water Supply; Sewerage, Waste Management and Remediation Activities	0.7	0.4	1.2	0.7	0.6
F : Construction	7.9	7.3	8.1	5.4	6.5
G : Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	15.2	16.1	14.9	15.5	14.1
H : Transportation and Storage	5.4	11.3	8.1	5.1	5.2
I : Accommodation and Food Service Activities	4.9	5.6	4.7	6.5	6.4
J : Information and Communication	1.3	1.1	0.8	2.9	4.5
K : Financial and Insurance Activities	2.4	0.4	0.5	2.8	3.4
L : Real Estate Activities	0.9	0.8	0.8	1.3	2
M : Professional, Scientific and Technical Activities	3.4	5.6	3.4	6.9	9.7
N : Administrative and Support Service Activities	3.5	9.7	6.8	8.4	8.4
O : Public Administration and Defence; Compulsory Social Security	5.7	2.6	2.7	4.4	4.3

[8] ONS Business Register and Employment Survey 2020 (Data excludes farm based agriculture).

1.3.2.2 In Brigg and Goole, there is a dependency on the manufacturing, wholesale, retail and repair of vehicles, and Transportation and Storage for 40.3% of employment. This value is lower than in North Lincolnshire, where these sectors account for 46% of employment, but higher than in Yorkshire and Humber (32%) and England (26.6%).

1.3.2.3 The nearest town to the Project, Scunthorpe, is a key manufacturer of basic metals. The town has a high dependence on key employers in the industry, including British Steel, Foxhills Industrial Estate, Southpark Industrial Estate and Skippingdale Retail Park, Gallagher and Lincolnshire Retail Parks. Scunthorpe represents a big proportion of North Lincolnshire's well-established heavy industry base, with metals manufacture being the second highest employer and exporter, enabling 2,854 employment opportunities. There are fewer high value-added professional services in Scunthorpe relative to national and regional averages, which gives rise to a relatively low-wage low-service economy.

1.3.2.4 A person's occupation relates to their main job and is derived from either their job title or details of the activities involved in their job. Employment by occupation type for 2020 in Brigg and Goole and the comparable areas is presented in Table 5. The data are residence-based and therefore show the occupation types held by people who live in the areas in question, not the occupation job types that are physically located in the area.

Table 5: Employment by Occupation in Brigg and Goole, North Lincolnshire, Yorkshire and Humber and England[9]

Occupation	Brigg and Goole (%)	North Lincolnshire (%)	Yorkshire and Humber (%)	England (%)
1. Managers Directors and Senior Officials	13.7	10.8	9.9	11.8
2.Professional Occupations	14.8	17.6	20.3	22.4
3. Associate Prof and Tech Occupations	11.9	12.7	14.7	15.3
4. Administrative and Secretarial Occupations	13.5	11.0	9.5	10
5. Skilled Trades Occupations	12.8	11.6	10.1	9.4
6. Caring, Leisure and Other Service Occupations	10.4	12.9	9.9	8.8
7. Sales and Customer Service Occupations	-	7.4	7.2	6.7
8. Process, Plant and Machine Operatives	8.0	7.9	7.2	5.6

[9] ONS Annual Population Survey 2020, NOMIS Official Labour Market Statistics.

Occupation	Brigg and Goole (%)	North Lincolnshire (%)	Yorkshire and Humber (%)	England (%)
9. Elementary Occupations	10.7	8.1	11.0	9.6

1.3.2.5 As of 2020, Brigg and Goole had a similar proportion of its population in the Standard Occupation Classification (SOC) 8-9 (18.7%) to Yorkshire and Humber (18.2%) and a higher proportion relative to North Lincolnshire (16%) and England (15.2). Brigg and Goole had a lower proportion of its population in SOC 1-3 (40.3%) compared with that of North Lincolnshire (41.2%), Yorkshire and Humber (45.1%) and England (49.8%).

1.3.3 Earnings/Income

1.3.3.1 The Office of National Statistics surveys annual hours and earnings. Table 6 presents the average gross earnings for full-time employees between 2014 and 2020. The data set indicates that whilst there has been an increase in average annual gross earnings in England and the Yorkshire and Humber region from 2014 to 2020 (from £29,054 to £34,121 and £34,238 and £39,420 respectively), however average earnings in Brigg and Goole have remained relatively stagnant between £30,173 and £31,861. In North Lincolnshire, average earnings spiked from £31,089 in 2014 to £33,772 in 2017, before decreasing down to below 2014 levels in 2020.

1.3.3.2 Average earnings are lower in Brigg and Goole, North Lincolnshire, Yorkshire and Humber than the average annual gross earnings in England. Evidence suggests that low incomes are associated with negative health impacts (Public Health England 2014[10]). Adequate wages are vital for providing people with sufficient income to live a healthy life, which should include costs relating to nutrition, physical activity, housing, psychosocial interaction, clothing, transport, heating and hygiene. Those living on a low income have a greater risk of poor health.

Table 6: Breakdown of Average Annual Gross Earnings between 2014 and 2020 in Brigg and Goole, North Lincolnshire, Yorkshire and Humber and England[11]

Area	Mean Annual Gross Earnings (£)						
	2014	2015	2016	2017	2018	2019	2020
Brigg and Goole	31,376	31,861	30,173		31,563	31,563	30,693
North Lincolnshire	31,089	31,303	29,864	33,772	31,279	32,611	31,315
Yorkshire and Humber	29,054	29,345	29,932	30,839	31,987	33,030	34,121
England	34,238	34,217	35,045	36,084	37,306	38,250	39,420

[10] Public Health England (2014) Local Action on Health Inequalities: Health Inequalities and the living wage

[11] ONS (2012), Employee earning in the UK Statistical bulletins, viewed 6 December 2021

1.3.4 Local Businesses

1.3.4.1 In 2021, the Office for National Statistics (ONS) published UK business statistics including activity, size and location for 2020. There were a total of 3,260 businesses in Brigg and Goole. The breakdown per sector is shown in Table 7 and the business size bands are given in Table 8.

Table 7: Businesses in Brigg and Goole by Sector[12]

Sector	Number of Businesses	Percentage (%)
1 : Agriculture, forestry & fishing	400	12.3
2 : Mining, quarrying & utilities	30	0.9
3 : Manufacturing	210	6.4
4 : Construction	460	14.1
5 : Motor trades	150	4.6
6 : Wholesale	115	3.5
7 : Retail	195	6.0
8 : Transport & storage (inc. postal)	300	9.2
9 : Accommodation & food services	200	6.1
10 : Information & communication	90	2.8
11 : Financial & insurance	55	1.7
12 : Property	95	2.9
13 : Professional, scientific & technical	385	11.8
14 : Business administration & support services	220	6.7
15 : Public administration & defence	40	1.2
16 : Education	50	1.5
17 : Health	95	2.9
18 : Arts, entertainment, recreation & other services	175	5.4
Total	3260	

Table 8: Business Size Bands in Brigg and Goole[13]

Size Band	Total	Percentage (%)
Micro (0-9 employees)	2920	89.6
Small (10-49 employees)	280	8.6
Medium (50-249 employees)	55	1.7
Large (250+ employees)	5	0.2
Total Businesses	3260	

[12] Shaw, B. (2020), UK Business, Activity, Size and Location: 2020, ONS, viewed 6 December 2021.
[13] Shaw, B. (2020), UK Business, Activity, Size and Location: 2020, ONS, viewed 6 December 2021.

1.4 Education Skills and Training

1.4.1.1 Brigg and Goole have a generally higher skills base among the labour supply compared with North Lincolnshire. As of 2019, the proportion of the population with Level 4 qualifications and above was 25.1%, which is higher than that of North Lincolnshire (21.5%) but significantly lower than national levels (40%) and regional levels (34.2%). The proportion of constituents within Brigg and Goole and residents in the Yorkshire and Humber with no qualifications for both was 8.5%. This is lower than the average for North Lincolnshire (11.3%), but higher than the national average (7.5%).

1.4.1.2 As of 2019, the proportion of the population that were employed in highly skilled occupations (SOC levels 1-3) in Brigg and Goole and North Lincolnshire was 40.3% and 37.8% respectively. These values are far lower than the national average of 47.4% in 2019. The 2017 Employer Skills Survey highlighted that employers in North Lincolnshire had recruitment difficulties due to a ‘low number of applicants with the required skills’. The survey identified that this factor was the main cause for 38% of ‘hard to fill’ vacancies. These skills gap also exists in lower skill-based occupation levels including customer services and sales roles; 42% of North Lincolnshire employers highlighted this issue compared with the national rate of 18%.

1.5 Transport

1.5.1 *Public Transport Access and Connectivity*

1.5.1.1 A major strength of North Lincolnshire is the transport network and international connections. North Lincolnshire is home to the UK’s largest port, Immingham, which is located on the south bank of the Humber Estuary, west of Grimsby and near the town of Immingham. There are significant freight movements through North Lincolnshire, with 20% of all UK rail freight passing through the area. However, the high levels of freight traffic and insufficient associated infrastructure mean that routes to and from the South Humber Gateway are often congested.

1.5.1.2 The North Lincolnshire area has 11 railway stations, with regular services to Doncaster, Cleethorpes, Grimsby, Sheffield, and Manchester. There are four main rail lines servicing North Lincolnshire, including Trans-Pennine, Barton Line, Lincoln Line, and Brigg Line. Despite these strong rail links, rail is not viewed as the primary means of travel, particularly for commuting purposes. North Lincolnshire has the highest percentage of private transport usage in the Humber area. The North Lincolnshire Council Local Transport Plan 2011-2026 recognised that North Lincolnshire’s residents have limited access to major employment areas (e.g., Scunthorpe and the market towns of Barton upon Humber, Brigg, Crowle, Epworth, Winterton and Kirton in Lindsey) by public transport.

1.5.1.3 The majority of North Lincolnshire’s bus services are operated from Scunthorpe Bus Station by Stagecoach and Hornsby Travel. The network is split into urban services and rural or inter-urban services. Due to relatively low population density in some of North Lincolnshire’s rural towns and villages, there are often low levels of passenger demand, which causes a reliance on subsidies for continued services. The provision of free bus travel for older and disabled people has played a significant role in increasing accessibility to key services in North Lincolnshire.

1.5.1.4 Two National Cycle Network routes run through North Lincolnshire: The Sustrans Route 1 and 169. Sustrans Route 1 runs from Dover to Shetland through North Lincolnshire, and Route 169 ('The Ridgeway') runs east to west along the edge of Scunthorpe towards Normanby.

1.5.1.5 The Application Land is located at and around Flixborough Wharf, adjacent to Flixborough Industrial Estate. Road access to Flixborough Wharf is currently via B roads that link to the A1077 and A18 and on to the motorway network via the M181, located approximately 5 km to the south (Figure 5). A 9 km long single-track rail line connects the Flixborough Wharf with the steel works at Scunthorpe. This line was in use until 2012, carrying steel and iron ore to service British Steel (Tata) before being bought by the current owners, RMS Ports. The area is also accessible through river access via the Flixborough Warf, an operational port located on the tidal River Trent.

1.5.2 Car Ownership

1.5.2.1 As of the 2011 Census, the level of car or van ownership in Burton upon Stather and Winterton was 87.3%[14]. 43.2% of residents in Burton upon Stather and Winterton had access to one car or van whilst 12.8% of residents had no car or van access in the household. This value is lower than the averages for the wider North Lincolnshire area (20.7%), Yorkshire and Humber (27.6%) and England (26%).

1.6 Housing

1.6.1 Housing Tenure and Type

1.6.1.1 The 2011 Census indicated that out of the 36,884 households in the Brigg and Goole Constituency, 69.2% own a house, 11.3% socially rent (e.g. from the local authority), 12.9% privately rented and 1.4% live rent free. The proportion of housing by type in Burton Upon Stather and Winterton ward as of 2011 is shown in Table 9.

Table 9: Proportion of Housing by Type in Burton Upon Stather and Winterton ward[15]

Housing Type	Percentage (%)
Detached	47.9
Semi-Detached	38.9
Terraced	10.0

[14] NOMIS Official Labour Market Statistics (2011), Burton upon Strather and Winterton Ward (as of 2011) Local Area Report, viewed 16 November 2021

[15] NOMIS Official Labour Market Statistics (2011), Burton upon Strather and Winterton Ward (as of 2011) Local Area Report, viewed 16 November 2021

Housing Type	Percentage (%)
Flats/Maisonettes	2.4
Mobile Homes/Caravans	1.7

1.6.2 *Crime*

1.6.2.1 Humberside Police is the force responsible for policing The East Riding of Yorkshire which includes northern parts of Lincolnshire, such as Burton Upon Stather and Winterton. For the year ending September 2020, the total recorded crime rate in Humberside (98.8) is similar to that of Yorkshire and The Humber (98.9) and significantly higher than the national rate (82.8)[16]. Table 10 shows the 2020 crime rate (per 1000 population) for England, Yorkshire and The Humber and Humberside categorised by offence group. The most common form of crime in Humberside is violence against a person (36.7), theft (28.0) and public order offences (11.4).

Table 10: Types of Crime per 1000 population for Humberside, Yorkshire and The Humber and England[17]

Crime Group	Humberside	Yorkshire and The Humber	England
Violence against a person	36.7	37.6	29.9
Sexual offences	3.1	3.0	2.6
Robbery	0.9	1.0	1.3
Theft offences	28.0	28.3	26.8
Criminal damage and arson	12.5	11.1	8.6
Drug offences	2.0	3.0	3.3
Possession of weapons offences	0.6	0.9	0.8
Public order offences	12.4	11.4	7.8
Miscellaneous crimes against society	2.7	2.8	1.8

1.6.2.2 Within Burton upon Stather and Winterton, the rate of all police recorded crime (per 1000 population) as of 2017 (40.6%) is lower than both the rate for North Lincolnshire (80.7%) and England (88.3). The rate of violent crime in Burton Upon Stather and Winterton reported by police (per 1000 population) as of 2017 (11.8%) is also lower than the rate for North Lincolnshire (14.1%) and England (21.4%).

1.6.2.3 The primary crime hotspot in North Lincolnshire is the Scunthorpe town centre and Crosby area, neighbouring Burton Upon Stather and

[16] Office for National Statistics - Crime in England and Wales: Police Force Area Data Tables Year ending September 2020.
[17] ONS – Crime in England and Wales: Police Force Area Tables.

Winterton[18]. While crime levels are falling, there are still disproportionately higher levels of crime in some Scunthorpe wards, namely Ashby, Brumby, Crosby and Park and Town.

1.7 Health

1.7.1 *Overall Health Indicators*

1.7.1.1 As of the 2011 Census, the majority of residents in Burton Upon Stather and Winterton self-rated their health as either 'very good' (43.6%) or 'good' (36.5%). A full breakdown and comparison to other areas are provided in Table 11. While the level of self-identification of very good health is discernibly lower than the national average, the aggregate of those with good and very good self-rated health in the area is broadly consistent with the national average, mirroring a broad consistency at the sub-optimal levels of 'fair', 'bad' and 'very bad' rating of health.

Table 11: Self-rated Quality of Health for Individuals in Burton upon Stather and Winterton, North Lincolnshire, Yorkshire and Humber and England[19]

Quality of Health	Burton Upon Stather and Winterton (%)	North Lincolnshire (%)	Yorkshire and Humber (%)	England (%)
Very good	43.6	43.7	45.6	47.2
Good	36.5	35.8	34.4	34.2
Fair	15.0	14.7	14.0	13.1
Bad	3.9	4.5	4.7	4.2
Very bad	1.1	1.2	1.3	1.2

1.7.2 *Life Expectancy*

1.7.2.1 Within the ward of Burton Upon Stather and Winterton, the average life expectancy at birth is 81.0 for men and 85.1 for women. This is higher than the national average of 79.8 for men and 83.4 for women. It is also 2.0 and 2.5 years higher than the average of men and women respectively in North Lincolnshire. Within North Lincolnshire, life expectancy is 9.7 years lower for men and 9.1 years lower for women in the most deprived areas than in the least deprived areas. Infant mortality in North Lincolnshire (3.72 per 1000 live births) is lower than both the regional average (4.3) and the national average (3.93).

1.7.3 *Deprivation*

1.7.3.1 The 2019 indices of multiple deprivation provide an indication of the quality of life experienced by a population. Lower Super Output Areas (LSOA) are geographic areas with an average population of 1,500 or 650 households. They are standard statistical geography used to divide up the country into

[18] North Lincolnshire Strategic Assessment 2016 – Safer Neighbourhoods.

[19] White, E. (2013), General Health in England and Wales: 2011 and comparison with 2011, ONS, viewed 6 December 2021

even areas, each with a similar total population. There are 32,844 LSOAs in England. The indices measure deprivation against several criteria in LSOA and Local Authorities across the country, with 1 being the most deprived and 32,844 being the least deprived.

North Lincolnshire

1.7.3.2 Local authority districts include lower-tier non-metropolitan districts, London boroughs, unitary authorities and metropolitan districts. At the time of publication, there were 317 local authority districts in England. Using the Index of Multiple Deprivation (IMD) rank of average summary measure, North Lincolnshire local authority ranked as the 127th most deprived local area in England in 2020, compared to a ranking of 120 most deprived in 2010. This demonstrates a decrease in deprivation relative to the other local authorities over that period. Figure 4**Error! Reference source not found.** shows the overall IMD rank for North Lincolnshire.

Burton Upon Stather and Winterton

1.7.3.3 The Application Land falls fall within the North Lincolnshire LSOA 005C in Burton Upon Stather and Winterton. Table 12 shows the ranking of the LSOA 005C within the Application Land and the 14 neighbouring LSOAs in the 2020 Indices of Multiple Deprivation. This LSOA is one of 101 LSOAs in North Lincolnshire. The LSOA is ranked 21,590 out of 32,844 LSOAs in England; whereby 1 is the most deprived LSOA. The neighbourhood is therefore among the 50% least deprived neighbourhoods in the country.

Table 12: Ranking of LSOA 005C and surrounding LSOAs in the 2019 Indices of Multiple Deprivation[20].

LSOA Name	Sum of IMD Rank (where 1 is most deprived)	Sum of Income Rank (where 1 is most deprived)	Sum of Employment Rank (where 1 is most deprived)	Sum of Education, Skills and Training Rank (where 1 is most deprived)	Sum of Health Deprivation and Disability Rank (where 1 is most deprived)	Sum of Crime Rank (where 1 is most deprived)	Sum of Barriers to Housing and Services Rank (where 1 is most deprived)	Sum of Living Environment Rank (where 1 is most deprived)
North Lincolnshire 005A	8962	9467	7508	6059	6769	9445	14565	28415
North Lincolnshire 005B	15807	17169	14111	14209	14811	18359	12994	9173
North Lincolnshire 005C	21590	22502	16231	17366	17967	27377	9248	29844
North Lincolnshire 005D	18848	21015	14531	16958	14637	21839	9663	22686
North Lincolnshire 006A	7422	7043	6067	5718	7033	9153	29907	10816
North Lincolnshire 006B	11592	15382	13794	12123	18823	25588	693	8070

20 National Statistics (2019), English indices of deprivation 2019, Ministry of Housing, Communities & Local Government. *Ranked in the most deprived 10% of LSOAs in the country

LSOA Name	Sum of IMD Rank (where 1 is most deprived)	Sum of Income Rank (where 1 is most deprived)	Sum of Employment Rank (where 1 is most deprived)	Sum of Education, Skills and Training Rank (where 1 is most deprived)	Sum of Health Deprivation and Disability Rank (where 1 is most deprived)	Sum of Crime Rank (where 1 is most deprived)	Sum of Barriers to Housing and Services Rank (where 1 is most deprived)	Sum of Living Environment Rank (where 1 is most deprived)
North Lincolnshire 007A	13886	13219	13604	9270	8982	21784	11907	23071
North Lincolnshire 007B	2703*	3890	4121	882*	4383	1278*	28393	7115
North Lincolnshire 007C	17814	18361	16116	16872	6753	17019	20696	26887
North Lincolnshire 007D	2851*	3428	2362*	1236*	2308*	5863	24854	22254
North Lincolnshire 008B	2606*	2845*	4522	429*	4778	835*	28730	19940
North Lincolnshire 008C	2189*	1722*	2192*	1153*	3096*	2688*	25249	25018
North Lincolnshire 009A	20868	19605	17909	14036	15135	14479	32527	22697
North Lincolnshire 009B	19877	16752	19173	11895	17470	13058	32102	21087

LSOA Name	Sum of IMD Rank (where 1 is most deprived)	Sum of Income Rank (where 1 is most deprived)	Sum of Employment Rank (where 1 is most deprived)	Sum of Education, Skills and Training Rank (where 1 is most deprived)	Sum of Health Deprivation and Disability Rank (where 1 is most deprived)	Sum of Crime Rank (where 1 is most deprived)	Sum of Barriers to Housing and Services Rank (where 1 is most deprived)	Sum of Living Environment Rank (where 1 is most deprived)
North Lincolnshire 013A	13468	17502	14897	17319	16109	12638	2539*	9339

1.7.3.4 The National Health Service Health Profile for Burton Upon Stather and Winterton shows that between 2014 and 2016 there were approximately 104 deaths a year, of which 37 were premature deaths (under the age of 75 years). The highest proportion of premature deaths were due to cancers (46%), the most common of which being those occurring in the lung and digestive organs. Other causes of premature death included heart and circulatory diseases (23%), respiratory diseases (8%) and "other causes", including intentional and unintentional harm and diseases of the digestive system. Within Burton upon Stather and Winterton, the incidence of breast cancer and prostate cancer is below the national average while incidences of colorectal and lung cancer are above the national average.

1.7.4 *Global Burden of Disease*

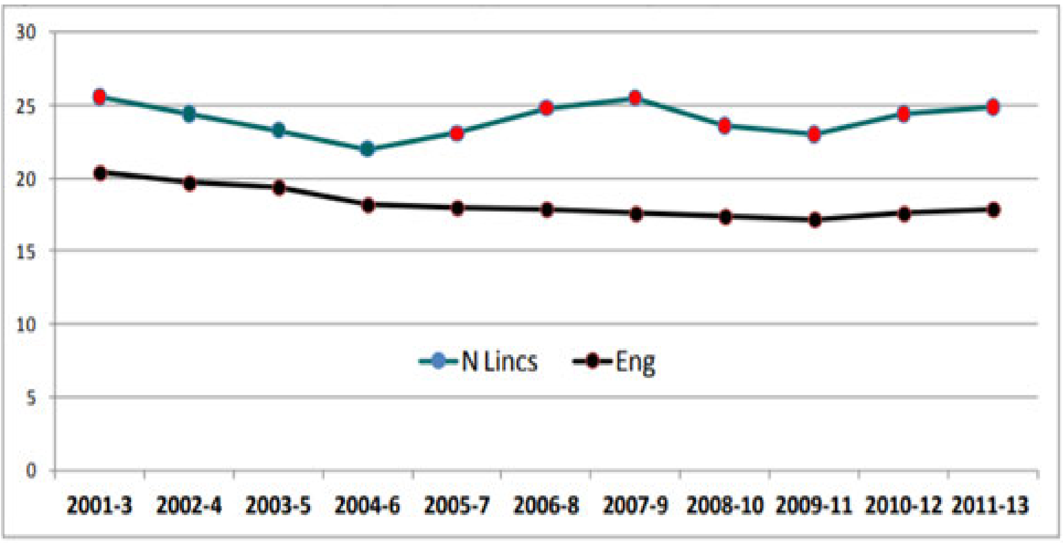
1.7.4.1 The global burden of disease is an indicator of the impact of a health problem on a given population, which helps to predict future health needs. The top causes of total disability adjusted life years in North Lincolnshire include:

- Ischaemic heart disease (7.7%);
- low back pain (6.3%);
- chronic obstructive pulmonary disease (5.3%);
- tracheal, bronchus and lung cancer (4.3%);
- atroke (4.1%);
- Alzheimer's disease and other dementias (3.3%);
- headache disorders (3.0%); and
- Diabetes Mellitus (2.5%).

1.7.4.2 The 2011 Census shows that of the population of Burton Upon Stather and Winterton with long term health problems or disabilities, 80.6% stated that their day-to-day activities were not limited, 11.1% stated that their day-to-day activities were limited a little and 8.2% stated that their day-to-day activities were limited a lot. The proportion of the population of Burton Upon Stather and Winterton whose daily activities were limited a lot was lower than the proportion for North Lincolnshire (9.15%), the Yorkshire and Humber (9.1%) and England (8.3%).

1.7.5 *Respiratory Health*

1.7.5.1 In Yorkshire and Humber, approximately 2.5 years of life are lost as a result of asthma mortality. This is 25% higher than the national average. Within the Yorkshire and Humber, seven local authorities had statistically lower rates of admissions in under 19s due to asthma than the national average. Four local authorities had statistically significant higher rates of asthma admissions (per 100,000 people) than the national average (186), including North Lincolnshire (251). In North Lincolnshire, the rate of premature death from preventable respiratory diseases was consistently higher than the national average from 2001 to 2013 (Figure 1).



Source: Public Health Outcomes Framework, 2014

Figure 1: Premature Death Rates from Potentially Preventable Respiratory Disease (2001-2013)

1.7.6 Road Traffic

1.7.6.1 From 2016-2018, the number of people per 100,000 population killed and seriously injured on roads in North Lincolnshire (64) is higher than both the regional average for Yorkshire and Humber (49.1) and the national average (41.6).

1.7.7 Healthcare Facilities

1.7.7.1 Healthcare facilities comprise hospitals, clinics, General Practice (GP) surgeries, outpatient care centres, and provisions for physical and mental health and wellbeing. The range of facilities which serve a local area can and do vary significantly, but accessibility to healthcare is recognised as an imperative.

1.7.7.2 There are 19 medical centres in North Lincolnshire spread across the north, east, south and west Care Networks within North Lincolnshire. Within Burton Upon Stather and Winterton, there is one medical centre called Winterton Medical Practice.

1.7.8 Physical Environment

1.7.8.1 There are no national or international environmental designations within the Application Land, but several in close proximity (Figure 5).

1.7.8.2 The south and west area of the Application Land is brownfield mixed-use land that abuts the River Trent corridor on the westernmost edge. The Humber Estuary Special Protection Area (SPA) is approximately 6.8 km north and the Humber Estuary Special Area of Conservation (SAC), Ramsar Site and Site of Special Scientific Interest (SSSI) adjoin the Site along the River Trent corridor. There are two Local Wildlife Sites (Slag Banks and Phoenix Parkway) in the area which are situated approximately 1 km and 1.4 km southeast of the Application Land.

1.8 Mental Health and Wellbeing

National Level

1.8.1.2 Mental ill health is widespread and can impact individuals of all ages and backgrounds. The United Kingdom Household Longitudinal Study (UKHLS) has tracked changes in the levels of psychological distress at the national level from 2019 onwards. The data suggests that the proportion of adults aged 18 and over that reported a significant level of psychological distress increased from 20.8% in 2019 to 29.5% in April 2020, then fell down to 21.3% in September 2020[21]. The increase in those affected by psychological distress is correlated with the onset of the Covid-19 pandemic and associated restrictions around daily activities. During the pandemic, approximately 26.1% of respondents aged 18 and over reported self-harm thoughts and 7.9% self-harm behaviours at least once between March 2020 and May 2021.

1.8.1.3 Variation was found within the UK population with some groups being more likely to experience poor or deteriorating mental health during the approximately 2-year-long study[28]. In particular, women, young adults (18-34 years of age), adults with pre-existing mental or physical health conditions, adults experiencing loss of income or employment, adults in deprived neighbourhoods, some ethnic minority populations and those who experienced local lockdowns during the pandemic were more at risk.

1.8.1.4 Between June and November 2020, young adults aged 18 to 25 with long standing mental or physical health conditions, lower household incomes or who were unemployed or not in school reported higher levels of loneliness than their peers[28]. Similarly, the prevalence of clinically significant depressive symptoms in adults aged 52 and over increased from 12.5% pre-pandemic to 28.5% in November to December of 2020, with an associated increase in loneliness and deterioration in quality of life.

1.8.1.5 The impact of neighbourhood stressors on psychological distress was shown to be stronger during lockdown compared to pre-pandemic[28]. The difference in the level of psychological distress associated with living in a neighbourhood with many social stressors (e.g., lack of green space, industrial buildings, litter, graffiti and vandalism) compared with living in a neighbourhood with few stressors increased by 20% between the lockdown period and pre-pandemic levels. An awareness of the compounding impact of potential lockdowns during the pandemic period is therefore essential to affectively assess potential impacts on mental health.

Local Level

1.8.1.6 Public Health England publishes data on the percentage of patients/ residents who have long-term mental health problems. Table 13 presents this data for Winterton Medical Practice and includes the comparative figures for North Lincolnshire and England. The percentage of those reporting long-term mental health problems in the area are around a third

[21] Office for Health Improvement and Disparities (2021), Research and analysis 2. Important findings, Gov.UK, viewed 12 December 2021

lower (7.2%) than the value in North Lincolnshire (12.3%) and England (11%).

Table 13: Prevalence of long-term mental health problems (all ages)[22]

GP/ Area	% of Patients Reporting Long-term Mental Health Problems (all ages) (2021)
Winterton Medical Practice	7.2
North Lincolnshire	12.3
England	11.0

1.8.1.7 Public Health England also publishes data on the percentage of patients/ residents (aged 18 and over) who have been diagnosed with depression. Table 14 presents this data from 2019/2020 for Winterton Medical Practice and includes the comparative averages for North Lincolnshire and England. The percentage of those patients recorded with depression in the region and the local area to the Project are higher (13.6% and 13.7% respectively) than those recorded on average for England (11.6%).

Table 14: Prevalence of Depression (18+)[23]

GP/ Area	% of Patients Recorded with Depression (ages 18+) (2019/2020)
Winterton Medical Practice	13.6
North Lincolnshire	13.7
England	11.6

1.8.1.8 Data is also readily available for patients that reported high anxiety scores in 2019/2020. This information can provide an insight into self-reported wellbeing. Data is only available at a county, regional and national level. Table 15 shows that North Lincolnshire and the wider Yorkshire and Humber region have a higher percentage of the population reporting high anxiety scores (23.0% and 22.1% respectively) compared to the national figures (21.9%). The data suggests higher relative levels of anxiety and depression, but lower long-term mental health illnesses than the national average.

Table 15: Self-Reported Wellbeing - Anxiety Score[24]

Area	% Reporting High Anxiety Scores (2019/2020)
North Lincolnshire	23.0
Yorkshire and Humber	22.1
England	21.9

[22] Office for Health Improvement and Disparities (2021), Public Health Profiles, Fingertips, viewed 14 December 2021

[23] Office for Health Improvement and Disparities (2021), Public Health Profiles, Fingertips, viewed 14 December 2021

[24] Office for Health Improvement and Disparities (2021), Public Health Profiles, Fingertips, viewed 14 December 2021

1.8.1.9 Research has shown that there can be lasting impacts on the mental health of populations directly and indirectly affected by a disaster, with knock-on implications for subsequent generations.[25] In the case of Burton Upon Stather and Winterton, the Flixborough chemical plant explosion in 1974, which killed 28 people and severely injured 36 people, might have left a residual memory in the local population such that there may be underlying anxiety for some local people. A literature review has been undertaken to further understand how industrial disasters affect communities. This can be found in section 2.

1.9 Summary

1.9.1.1 The community profile provides the baseline data against which the analysis of potential impacts from the Project will be undertaken. It demonstrates that the local population is better than the national average for many factors that influence health, including self-rated health, life-expectancy and unemployment rate.

1.9.1.2 The overall price of properties in Burton Upon Stather and Winterton is also broadly in line with the national average. However, the area has a lower economic activity rate and income, as well as higher levels of deprivation and crime than the national average. The proportions of the population in standard occupation classification 8-9 and with no qualifications were also found to be higher than the national average.

1.9.1.3 There are a number of specific health indicators for which the Burton Upon Stather and Winterton area performs notably worse than the national average, including the incidence of colorectal and lung cancer. Incidences of breast cancer and prostate cancer are however below the national average.

1.9.1.4 Disparities exist within the Burton Upon Stather and Winterton locality, which includes some of the most deprived areas in the UK. Therefore, significant variations in health outcomes between these areas occur that might not be evident in available figures for the area as a whole.

1.9.1.5 Whilst in many respects the profile of the community is broadly characteristic of the regional and national picture, the area specific attributes of heightened socio-economic deprivation and below national average performance for certain key health indicators may give rise to enhanced vulnerability and differential health impacts within and across the local population. These factors have, and will continue, to inform the determination of potential impacts and proposed mitigation, which are identified in the Environmental Statement.

[25] Makwana, N. (2019), Disaster and its impact on mental health: A narrative review, J Family Med Prim Care, 8(10): 3090-3095.

2. LITERATURE REVIEW

2.1 Introduction

2.1.1.1 This section summarises the information contained within the literature review, which forms the evidence base for research relating to changes in health determinants and consequent health effects. A literature review was conducted using peer-reviewed and grey literature (i.e., information not produced by commercial publishers) to inform the methodology of the assessment and the key determinants of mental health impacts, specifically in the context of the UK and potential Project-specific impacts. The review was conducted using key databases such as ScienceDirect, Web of Science and JSTOR. The literature review will continue to evolve and be updated accordingly.

2.1.1.2 Evidence of how health and wellbeing can be affected by different determinants and pathways is described below under the following headings:

- air quality;
- employment and socio-economic characteristics;
- noise;
- social capital;
- traffic and transport;
- visual environment;
- waste disposal facilities and public health;
- carbon capture and public health;
- perceived risk of Energy Recovery Facilities (ERF); and
- industrial disasters and mental health.

2.2 Air Quality

2.2.1.1 Exposure to outdoor air pollution is associated with both acute (short-term) and chronic (long-term) health effects. The short-term effects of poor air quality include an exacerbation of asthma symptoms, coughing, wheezing and shortness of breath[26]. Long-term effects include stroke, lung cancer, respiratory conditions, and cardiovascular disease. Air pollution can adversely affect human health across the entire lifespan of an individual, including the foetus, and there is emerging evidence associating air pollution with affecting early childhood development. A strong body of epidemiological evidence provides a case for the association between long-term exposure to man-made air pollution with cardiovascular morbidity and a reduction in life expectancy – an annual effect equivalent to 28,000 to 36,000 deaths.

[26] Public Health England (2018). Health Matters: Air pollution – sources, impacts and actions.

2.2.1.2 Air pollution is a mix of both natural and man-made particles and gases; major components are particulate matter (PM) and nitrogen dioxide (NO_2).

2.2.1.3 The risk of adverse health effects is higher for more vulnerable demographics, which includes the elderly, children, pregnant women, and those with existing cardiovascular or respiratory disease. The risk of adverse health effects is also higher for those more socio-economically disadvantaged groups, who are more likely to live, work or learn near busy roads.

2.2.1.4 Sources of PM are primarily combustion and construction activities, including traffic. Dust emissions and subsequent deposition arising from construction activities can cause annoyance. Dust can also irritate the eyes and aggravate pre-existing respiratory problems, such as asthma.

2.3 Employment and Socio-economic Characteristics

2.3.1.1 There is a direct link between being in 'good' work and positive health outcomes. Good work is defined as 'having a safe and secure job with good working hours and conditions, supportive management and opportunities for training and development'[27]. There is evidence that those in good work have a better quality of life and health outcomes and are protected against social exclusion. Employment and income are regarded as key determinants of health through influencing where an individual lives, the education they receive, their access to healthcare and their lifestyle and behaviour patterns.

2.3.1.2 Increased employment opportunities can have a positive influence on health through increasing social contact, involvement in a collective effort or activity and by forming social relationships. All of these contribute to wellbeing. In addition, those in insecure employment are likely to suffer from poorer mental health than those in secure employment.

2.3.1.3 Ethnic minorities, young people and the disabled generally face the highest levels of unemployment. These groups are likely to be found in more insecure employment and be poorly paid. Unemployment is consistently related to negative health outcomes, primarily through increased likelihood of poverty, stress, unhealthy behaviours and implication for future employment. Thus, these lead to increased risk of mortality and morbidity, including poor mental health and health-harming behaviours.

2.3.1.4 Employment and income together contribute to a person's socio-economic status. There is a broad summary of evidence showing inequalities in socio-economic status reflecting health inequalities, a higher level of deprivation correlates to poorer health outcomes. In broad terms, the greater the income, the better the health of a person. However, this relationship is not strictly linear. Above a certain threshold, higher income is less strongly related to improved health across a population.

[27] Public Health England (2019), Health Matters: health and work, GOV.UK, viewed 4 January 2022

2.4 Noise

2.4.1.1 Noise has the potential to affect health in a variety of ways. This includes direct damage to the ear (auditory) as a result of excessive noise levels, but also non-auditory effects including cognitive responses such as distraction and disturbance. These in turn can contribute to sleep disturbance, changes in social behaviour, interference with daily activities and loss of productivity, annoyance and mental health impacts. Non-cognitive responses beyond auditory damage include hypertension and other health impacts related to loss of sleep and increased stress. There is also an association with quality of life, with evidence suggesting that those living in quiet locations have a better quality of life[28]. It has been shown that noise levels that are sufficiently high can induce cardiovascular effects at the population level, including acute myocardial infarction.

2.4.1.2 Noise is defined as 'any unwanted sound' and can arise from multiple sources, including traffic, construction and industry activities. The presence of some noise is inevitable and unavoidable, but adverse health impacts occur when this is excessive in volume and duration. World Health Organisation (WHO) guiding principles recommends road traffic levels are kept below 53 decibels Lden and night noise exposure is kept below 43 dB Lnight[29].

2.4.1.3 Guidelines for specific environments recognise the risk that industrial environments can have in contributing to hearing impairment for those exposed for prolonged periods. Therefore, guideline recommendations for industrial, commercial shopping and traffic areas, both indoor and outdoor are 70 dB, recommended exposure maximum of 24 hours.

2.5 Odour

2.5.1.1 Historically, unpleasant odours have been considered warning signs or indicators of potential risks to human health[30].

2.5.1.2 The potential impact of odour on health is largely psychological, where the perception of odour may result in increased annoyance, anxiety and changes in social behaviour. Odour is not, however, associated with physical health effects.

2.5.1.3 If residents' perceptions, concerns and attitudes towards waste management facilities are either not well understood or underestimated, people can produce strong opposition[31].

2.6 Social Capital

2.6.1.1 Social capital is understood as 'social connections and the benefits they generate'[32]. These benefits can operate at an individual, community or

[28] European Commission (2015), Thematic Issue: Noise Impacts on Health, Science for Environment Policy, Issue 47.

[29] World Health Organisation. Environment and health: Noise.

[30] Schiffman and Williams (2005) Science of odor as a potential health issue

[31] De Fea, De Gisi and Williams (2013) Public perception of odour and environmental pollution attributed to MSW treatment and disposal facilities: A case study

[32] Siegler, V. and Office for National Statistics (2014), Measuring Social Capital, Office for National Statistics

regional level, and include support networks, civic engagement and trust, co-operative norms, lower crime levels and higher levels of life satisfaction and mental health. Social capital is often considered to be an indicator of general wellbeing, with these factors associated with an increase in overall wellbeing of an individual. Social capital is also understood to have an influence on mental health and behaviour. There is an identified association between social capital and health behaviours; those with less social capital are more likely to adopt unhealthy behaviours such as smoking, drinking, physical inactivity, poor diet. Healthier behaviours are identified in individuals with higher levels of social capital.

2.6.1.2 The body of research linking social capital and health is more tentative than other health determinants and pathways, and there is no consensus that particular social capital indicators are linked to particular health outcomes. Nonetheless, it is considered that social capital is an important community level 'asset' and will be considered as such within the assessment.

2.6.1.3 It has been suggested that social capital affects health through several mechanisms: norms and attitude that influence health behaviours, psychosocial networks that increase access to health care and psychosocial mechanisms that enhance self-esteem. Health behaviours such as smoking, alcohol consumption, physical activity, dietary choices and duration of sleep are major determinants of health and mortality. Furthermore, they are important determinants of disparities in health between subgroups of the population. There is also evidence for an association between social capital and health behaviour and social capital and health. However, the literature analysing social capital and various health behaviours simultaneously as determinants of health is scarce and findings concerning the potential role of health behaviours as a mediating factor in the association between social capital and health have been inconsistent[33].

2.6.2 Vulnerable Populations

2.6.2.1 Certain parts of the population may experience disproportionate negative health effects as a result of a development. The Wales Health Impact Assessment Support Unit (WHIASU) provides a suggested list of vulnerable groups[34] which can be found in Table 16 below.

2.6.2.2 Research suggests that these groups are susceptible to poor health, chronic disease, disability, and early mortality[35]. In literature, the experience of disproportionate negative health effects is referred to as "Health Disparities." Healthy People 2020 defined a health disparity as: "… a particular type of health difference that is closely linked with economic, social, or environmental disadvantage. Health disparities adversely affect groups of people who have systematically experienced greater social or

[33] Nieminen, T., Prättälä, R., Martelin, T. et al. (2013) Social capital, health behaviours and health: a population-based associational study. BMC Public Health 13, 613.

[34] Wales Health Impact Assessment Support Unit. Health Impact Assessment: A practical guide.

[35] School of Nursing and Health Studies (n.d.), Vulnerable Populations and Health Disparities, University of Miami, viewed 27 February 2022

economic obstacles to health based on their racial or ethnic group, religion, socio-economic status, gender, age, or mental health; cognitive, sensory, or physical disability; sexual orientation or gender identity; geographic location; or other characteristics historically linked to discrimination or exclusion"[36].

Table 16: Suggested List of Vulnerable Groups

Age-related groups	Income-related groups	Groups who suffer Discrimination or Other Social Disadvantage	Geographical Groups
Children and young people	People on low income	People with physical or learning disabilities/difficulties	People living in areas known to exhibit poor economic and/or health indicators
Older people	Economically inactive	Refugee groups	People living in isolated/over-populated areas
	Unemployed/workless	People seeking asylum	People unable to access services and facilities
	People who are unable to work due to ill health	Travellers	
		Single parent families	
		Lesbian and gay and transgender people	
		Black and minority ethnic groups	
		Religious groups	

2.7 Traffic and Transport

2.7.1.1 Transport plays a vital role in promoting health and wellbeing. It does this directly by providing communities with access to a range of services and amenities required to treat ill-health and to manage and promote healthy living. It also does so indirectly through allowing individuals to maintain social and familial networks and through providing access to employment[37].

2.7.1.2 Transport can have negative health impacts, due to the risk of accidents-causing injury or death. Transport emissions can lead to air pollution, resulting in respiratory and cardiovascular problems. Traffic movements can also result in noise pollution. Traffic, in particular congestion and excess traffic, can lead to increased stress, frustration or aggression. It can in turn lead to increased likelihood of a crash or accident. The presence of excessive traffic can affect perceptions of neighbourhood quality. In particular, the presence of Heavy Goods Vehicles (HGV), which can cause anxiety regarding road safety.

[36] Office of Disease Prevention and Health Promotion (n.d.), Disparities, health.gov, viewed 27 February 2022.
[37] World Health Organization. (2000) Transport, environment and health. WHO Regional Publications, European Series. No.89

2.8 Visual Environment

2.8.1.1 People attach considerable importance to the quality of their surroundings. Quality of place is linked to positive health outcomes and there is extensive evidence linking a positive visual environment, including presence of green space, and better physical and mental wellbeing. There are a number of pathways linking landscape and health outcomes. Greenspace has been shown to have a beneficial impact in reducing stress and anxiety levels. The beneficial impacts of green space have been found to decline as proximity decreases[38].

2.8.1.2 The prosperity of an area can be influenced by the visual image of the place, the quality of landscape, and any presence of industry. The visual presence of industry can also lead to feelings of dissatisfaction amongst residents, as well as stress, anxiety and concern.

2.8.1.3 There is evidence linking quality of places with health and wellbeing across a range of environmental, social and lifestyle determinants. Health and wellbeing are influenced positively by factors such as attractiveness of the place[39].

2.9 Waste Disposal Facilities and Public Health

2.9.1.1 Public concern regarding health impacts of waste disposal facilities has mainly focused on concerns around the impact of incineration on air quality and the risk this may pose to nearby residents. Campaign groups have previously challenged the development of ERF on the basis of their perceptions of how emissions adversely affect public health[40]. The literature indicates that modern, well-regulated and well-managed waste recovery facilities only make a very small contribution to local concentrations of air pollutants[41]. There is also currently no peer-reviewed evidence directly linking waste disposal facilities to negative health effects[42]. A study undertaken by Air Quality Consultants concluded well managed modern energy from waste facilities are unlikely to pose a significant health risk in the UK, and the studies published in the last 5 years in the UK and internationally have not found consistent epidemiological evidence of health effects associated with modern ERF facilities[43].

2.9.1.2 The majority of published studies concentrate on health effects from the older generation of incinerators. Whilst pre-1990 incinerators may have been responsible for some long-term contamination of the surrounding area, with possible consequent long-term health effects, the current evidence suggests that the new generation of ERF plants are not responsible for any significant or detectable health effects. Their

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[38] O'Brien, L., Williams, K. and Stewart, A. (2010), Urban health and health inequalities and the role of urban forestry in Britain: A review, The Research Agency of the Forest Commission

[39] Public Health and Landscape (2013), Creating healthy places, Landscape Institute Position Statement.

[40] South London Waste Partnership (n.d.), Public concerns around ERFs, viewed 26 February 2022

[41] Public Health England 2019. Municipal waste incinerators emissions: impact on health.

[42] Public Health England 2019. PHE statement on modern municipal waste incinerators (MWIs) study.

[43] Air Quality Consultants 2020. Health Effects due to Emissions from Energy from Waste Plant in London

contribution to local air quality impacts is very minor and they are not major sources of any particular pollutant, be it dioxins or fine particles. As a combustion source, they contribute to NO_x concentrations, but not in a substantial manner compared to many industries or indeed the many small-scale combustion sources that are unregulated and unabated.

2.9.1.3 To date, no project of this kind has been refused planning consent on the grounds of its stack emissions and effects on human health, and nor has any application for an environmental permit been refused by the Environment Agency on these grounds.

2.9.1.4 There is nonetheless evidence of public anxiety over perceived impacts, in particular, within areas where such developments are new (see Section 2.10.2). Such anxiety appears to abate once the ERF plant is built and has been operating but the maintenance of ongoing dialogue is critical to addressing concerns and reducing anxiety. There is, therefore, a need to be aware of, and responsive to, concerns and anxiety which may exist amongst the public and communicate with regard to this issue.

2.10 Carbon Capture Facilities and Public Health

2.10.1.1 The major concern with carbon capture and public health is a group of chemicals called amines. These compounds react to create new compounds both within the process itself and once emitted to the environment. The most significant emissions are likely to be to air in the flue gas or to wastewater from pollution abatement processes.

2.10.1.2 Nitrosamines and nitramines are possible carcinogens. Whilst there are toxicity data available for a few of the more generally researched substances (e.g. the nitrosamine drinking water contaminant N-Nitrosodimethylamine (NDMA)), the environmental toxicity of many of the other individual compounds is not well understood.

2.10.1.3 Nitrosamines pose a potential environmental and health threat because they have a demonstrated environmental toxicity (US EPA, 2011; Brooks, 2008). NDMA and N-Nitrosoiethylamine (NDEA) are potential chemical mutagenic carcinogens and are listed by the International Agency on Cancer Research (IARC) as a group 2A carcinogen classified as “probably carcinogenic to humans” (IARC, 2012). A commonly quoted value (NIPH, 2011) for total (grouped) nitrosamines and nitramines, initially proposed by the Norwegian Institute of Public Health (NIPH), is $0.3 ng/m^3$.

2.10.1.4 The UK approach for deriving health guidelines for non-threshold mutagenic carcinogens is based on categorical risk level (as opposed to the NIPH quantitative risk assessment). There is, therefore, continuing effort in research for dose-response inhalation toxicity data from which to derive more realistic levels that are protective of human health[44].

2.10.1.5 There is broad interest in understanding the degradation of amines to nitramines and nitrosamines. Nitrosamines are known to be potent

44 Natural Scotland Scottish Government (2015), Review of amine emissions from carbon capture systems, SEPA, viewed 18 January 2022

carcinogens. Also, nitramines are expected to be carcinogenic, but detailed studies on the health impacts of nitramines are still insufficiently available.

2.10.1.6 At the moment a very conservative safety limit for nitrosamine concentration (e.g. in Norway) lies at 0.1 ppt. This safety level, however, is too low to be measured. Therefore, detailed modelling calculations are highly relevant. For nitramines, the safety limits are unclear due to the insufficient studies on their health impacts. Despite their carcinogenicity nitrosamines are expected to have limited impact because they photolyse efficiently which limits their atmospheric lifetime significantly. Nitramines, in contrast, do not photolyse nor hydrolyse and will therefore end up in soil and groundwater where they could potentially represent risks to human health and the environment[45].

2.10.2 Perceived Risk of ERF

2.10.2.1 Protests against waste incinerators have occurred across England and Wales throughout the last two decades, highlighting the perceived controversial nature of incineration projects within the UK. Such projects are associated with concerns around health problems, environmental impacts (e.g. pollution, dust and noise), technological accidents, and the decrease in value of surrounding properties. These concerns can contribute to heightened stress levels of local residents.

2.10.2.2 A body of research suggests that the perceived risk associated with different technologies is not correlated with the number of deaths they cause, but with the degree of knowledge (e.g. the novelty of the risk or visibility of the consequences) about the technology. Research by Gregory, Flynn and Slovic (1995) describes the characteristics that associate waste incinerators with high perceptions of risk include that they are associated with involuntary exposure, the impacts are inequitably distributed and the magnitude and persistence of their effects over time is not well known46.

2.10.2.3 Studies show that risks are considered to be greater for hazards which are seen as involuntary, uncontrollable, potentially catastrophic. These are usually grouped as “dread risk” (Lima 2004)[47].

2.10.2.4 The level of risk perception, the amount of knowledge and the degree of involvement are important aspects that define the attitude of local communities towards a plant. A study in Modena found that where an incineration plant had been operational for many years, no relationship was

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[45] Dr Dautzenberg, G. and Dr Bruhn, T. (2013), Environmental Impacts of Carbon Capture Technologies: An Overview of the state of development, potential side effects and current challenges for science and society, Institute for Advanced Sustainability Studies

[46] Gregory R, Flynn J and Slovic P (1995) Technological Stigma, Am. Sci 83 (3) 220-223.

[47] Lima ML (2004) *On the influence of risk perception on mental health: living near an incinerator*, Journal of Environmental Psychology, 24 (1) 71-84

found between residence near the plant and citizen's attitude toward it (Bena et al 2019)[48].

2.10.3 Industrial Disasters and Mental Health

2.10.3.1 The Flixborough Disaster of June 1974 was an explosion of a chemical plant that occurred close to the village of Flixborough, North Lincolnshire. The explosion was the largest ever peacetime explosion within the UK, killing 28 people and severely injuring a further 36 others. The disaster led to nation-wide public outcry over process safety and is likely to have left a lasting memory and possibly underlying anxiety in the local population surrounding Flixborough.

2.10.3.2 In addition to social and economic losses, stress, trauma and emotional instability are common impacts on communities affected by industrial disasters. While many of these mental health impacts recover over time, some individuals experience persistent and severe psychotic symptoms such as Post Traumatic Stress Disorder (PTSD), anxiety and depression. The excess morbidity rate of psychiatric disorders in the first year following a disaster was determined to be in the order of 20% (Bromet et al., 2012). The risk of suicide attempts is reported to be higher among those living with inadequate mental health support (Kar, 2010). Studies have also found evidence of increased domestic violence and substance abuse following disasters (Goldstein, Osofsky & Lichtveld, 2011).

2.10.3.3 The psychological impacts of disasters have been found to be more prominent in children, women and the elderly, who often become the part of the most vulnerable population following an event. Peek (2008) determined that there are behavioural, psychological and emotional issues that are observed in older children and adolescents following a disaster. It is therefore possible that children present in and around Flixborough during the disaster may still feel the impact of the disaster as adults today and may have emotional concerns over the Project. It is likely to have left a lasting memory and possibly underlying anxiety in the local population surrounding Flixborough.

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[48] Bena A, Gandini M, Cadum E, Procopio E, Salamina G, Orengia M & Farina E (2019) *Risk perception in the population living near the Turin municipal solid waste incineration plant: survey results before start-up and communication strategies*, BMC Public Health, 19 (483)

APPENDIX A FIGURES

Figure 2: North Lincolnshire Map

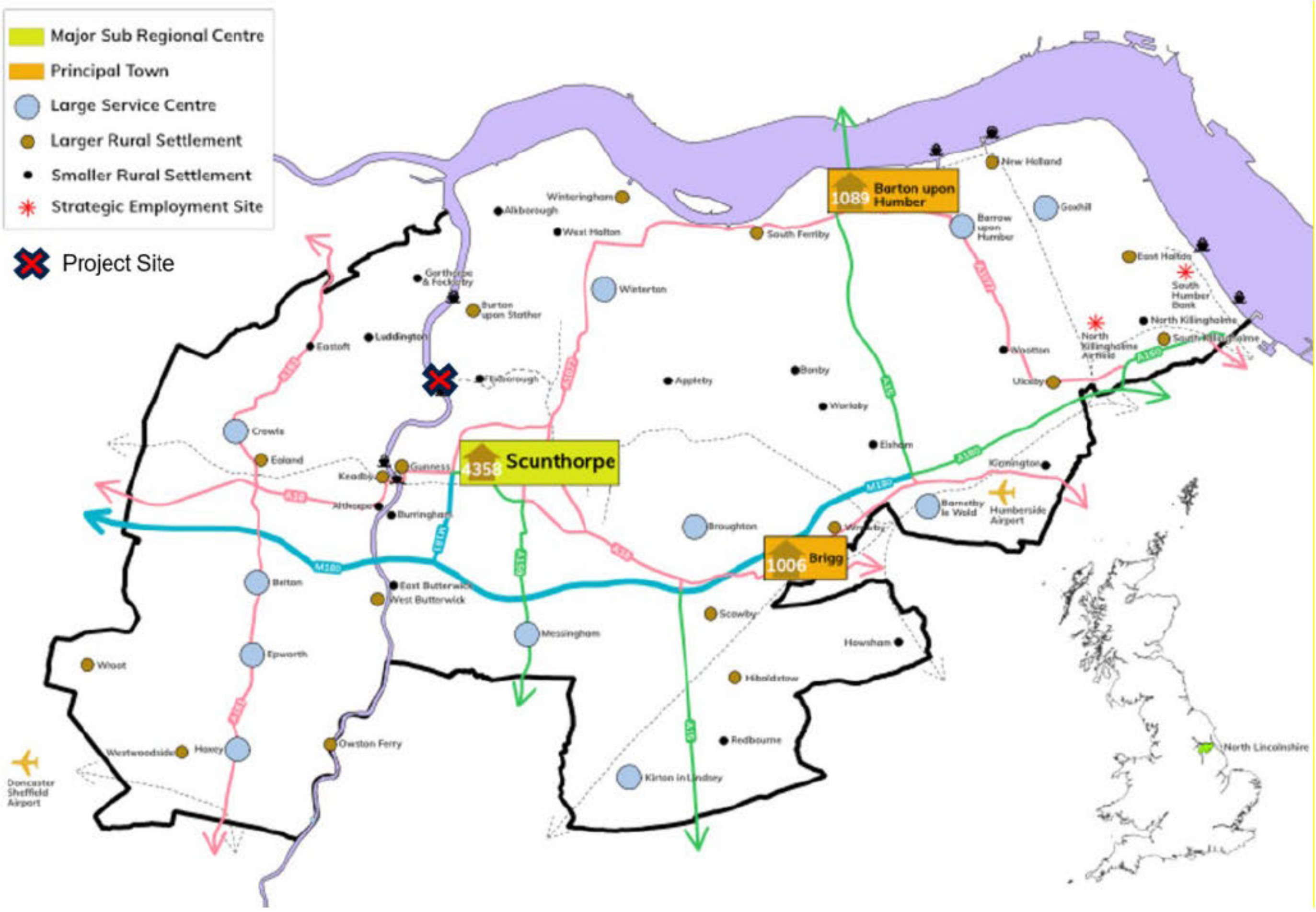
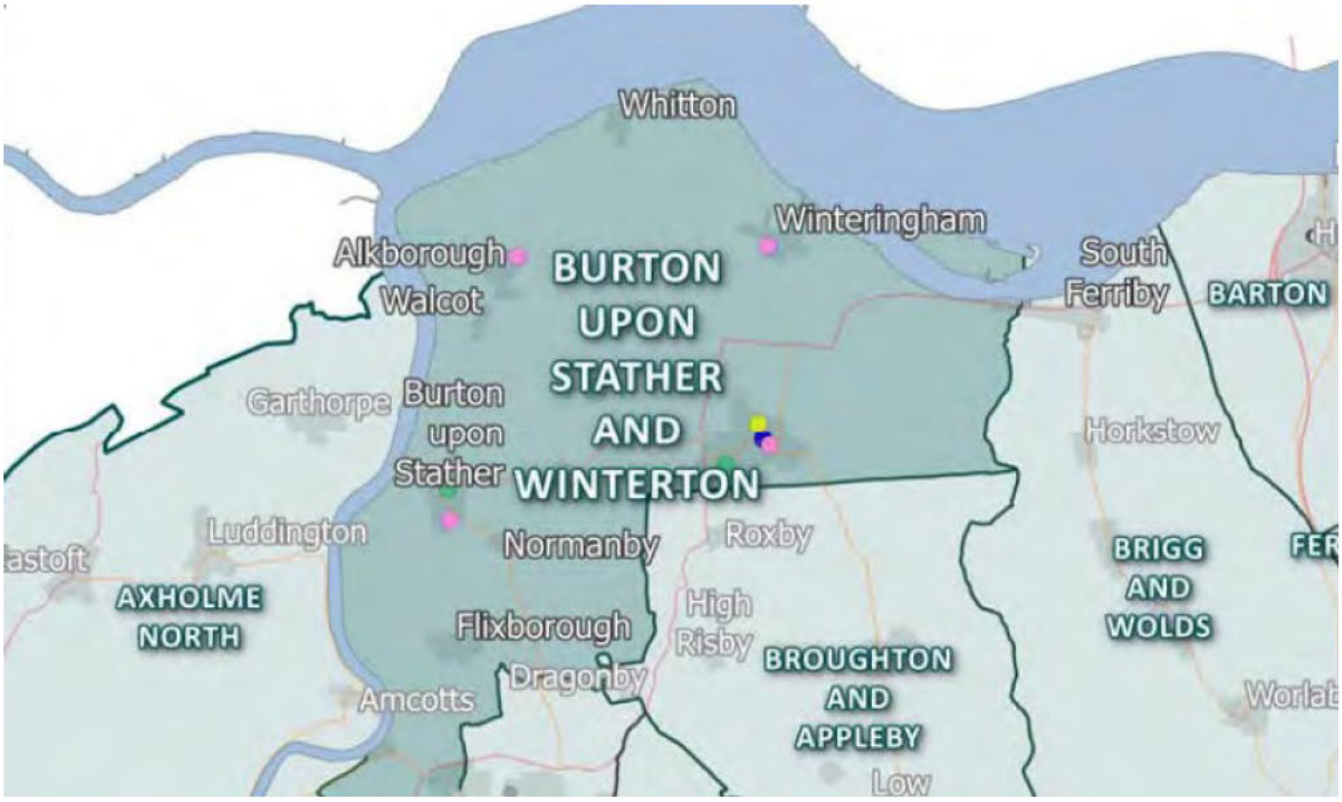
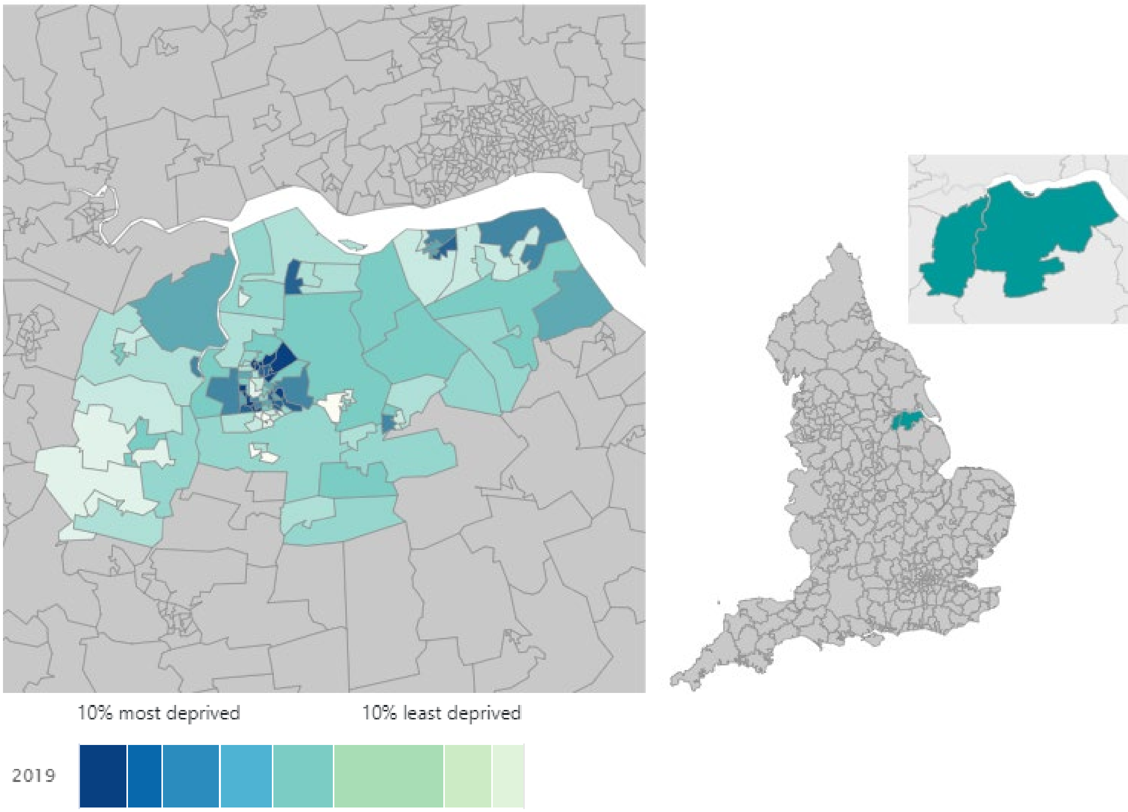


Figure 3: Burton Upon Stather and Winterton Ward Map (North Lincolnshire Clinical Commissioning Group 2018)[49]



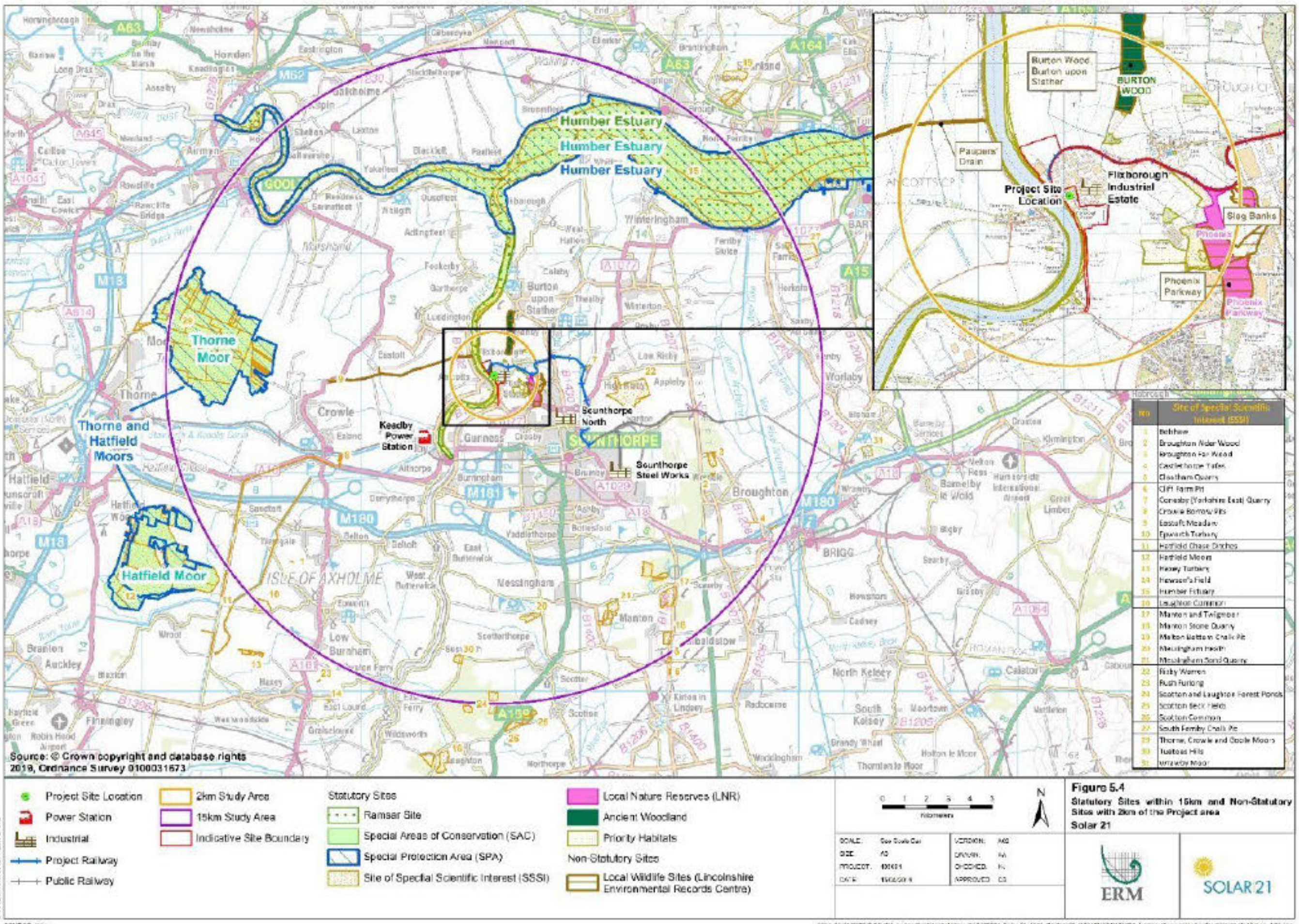
[49] NORTHLINCS.GOV.UK (n.d.), Public Health in North Lincolnshire, visited 18 January 2022

Figure 4: Overall Indices of Multiple Deprivation Rank for North Lincolnshire. Source: MHCLG Indices of Deprivation 2019 explorer[50].



[50] Ministry of Housing, Communities & Local Government (2019), The English Indices of Deprivation 2019, National Statistics.

Figure 5: Environmental Designations within 2 km and 15 km from the Application Land



APPENDIX B HUMAN HEALTH RISK ASSESSMENT

North Lincolnshire Green Energy Park

Appendix B – Human Health Risk Assessment

March 2022

Project No.: EN010116

The business of sustainability

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Acronyms and Abbreviations

Name	Description
ADD	Average Daily Dose
ADMS	Atmospheric Dispersion Modelling System
AELs	Associated Emission Levels
AERMOD	American Meteorological Society/Environmental Protection Agency Regulatory Model
AT	Average Time
BAT	Best Available Techniques
CCS	Carbon Capture Systems
CO_2	Carbon Dioxide
cm	centimetres
COPC	Compounds of Potential Concern
COT	Committee on Toxicity
CSF	Cancer Slope Factor
DCO	Development Consent Order
EA	Environment Agency
ED	Exposure Duration
ELVs	Emission Limit Values
EPA	Environmental Protection Agency
ERF	Energy Recovery Facility
HHRAP	Human Health Risk Assessment Protocol
HMIP	Her Majesty's Inspectorate of Pollution
IED	Industrial Emissions Directive
IRAP	Industrial Risk Assessment Programme
Kg	kilogram
M	metres
MDI	Mean Daily Intake
MWe	Megawatts
NDNS	National Diet and Nutrition Survey
NSIP	Nationally Significant Infrastructure Project
PCBs	Polychlorinated Biphenyl
PCDD/Fs	Polychlorinated Dibenxofurans
Pg	Picogram

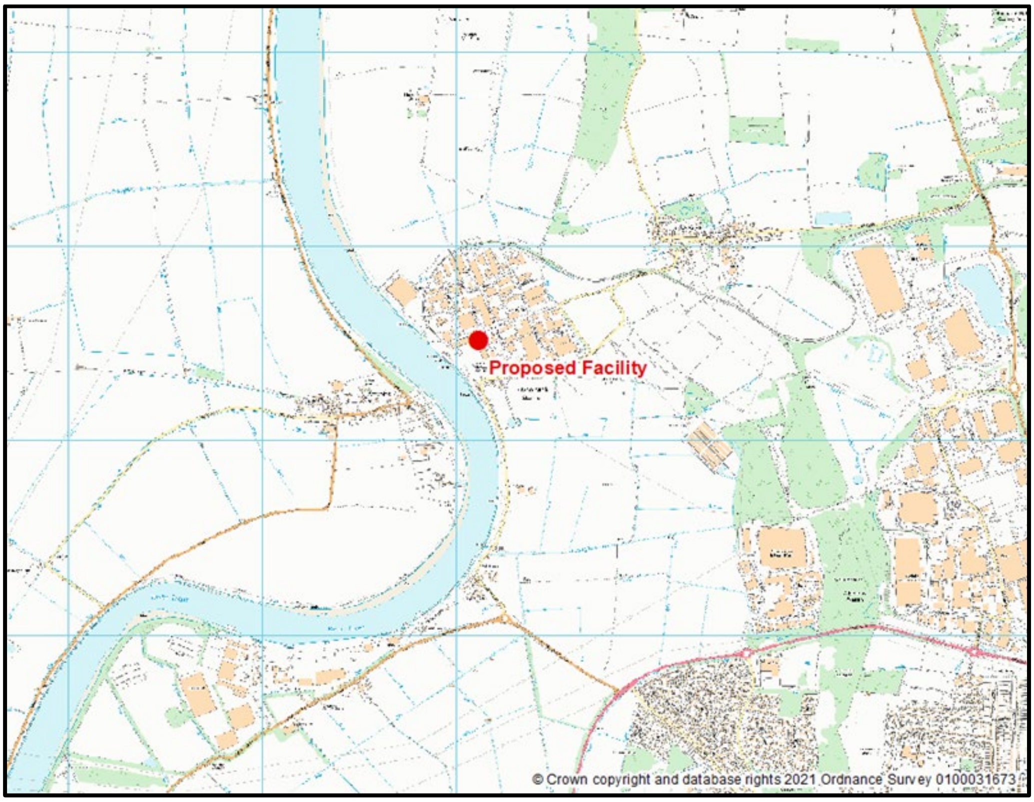
RDF	Refuse Derived Fuel
S	seconds
SoS	Secretary of State
I-TEQ	International Toxic Equivalent Emission
TDI	Tolerable Daily Intake
TDS	Total Diet Study
URF	Unit Risk Factor
UK	United Kingdom
US	United States

1. INTRODUCTION

1.1 Background

1.1.1.1 The Applicant has commissioned an assessment to consider the effects on human exposure from emissions to air from the Project. The focus of the assessment are the emissions to air from the energy recovery facility (ERF). The location of the ERF is presented in Figure 1. The site is located within an area dominated by industrial use but with agricultural land and residential areas beyond these industrial areas.

Figure 1: Location of the North Lincolnshire Green Energy Park



1.1.1.2 The ERF will be capable of efficiently recovering energy stored within waste products. The ERF will have a capacity to convert up to 760,000 tonnes of waste per year, into electricity, with a maximum output of up to 95 megawatts (MWe). Energy is released through combustion of the waste and the heat released by the combustion process is utilised within a boiler to generate steam, used to drive a steam turbine and electricity generator.

1.1.1.3 The waste used to fuel the ERF is known as refuse derived fuel (RDF), made up of municipal solid waste, or commercial or industrial waste of a similar composition, that has undergone treatment and sorting to remove a proportion of any biogenic content and any waste that could be recycled.

1.1.1.4 The main ERF building will house the following key components:

- tipping hall;

- bunker hall;
- boiler hall;
- turbine hall (with ACC/air blast coolers on the roof);
- flue gas treatment system;
- district heating equipment;
- switchyard;
- water treatment facility;
- bottom ash hall;
- administration and control room and offices;
- exterior storage tanks for ammonia, diesel and fire water; and
- CO_2 capture utilisation and storage facility.

1.1.1.5 The Project is a Nationally Significant Infrastructure Project (NSIP) under the Planning Act 2008 being a land-based power generation facility generating more than 50 MWe. The Application has been submitted to the Planning Inspectorate, with the decision whether to grant a Development Consent Order (DCO) being made by the Secretary of State for Business, Energy and Industrial Strategy (BEIS) pursuant to the Planning Act 2008 (2008 Act). The operation of the ERF would be regulated by the Environment Agency (EA) under the Environmental Permitting Regulations.

1.1.1.6 Emissions to air from the ERF will be via three 120 m high flues likely to be contained within a common wind shield. Emissions to air from the ERF will be governed by the Industrial Emissions Directive[1] (IED). In the absence of site-specific emissions monitoring data, the relevant Best Available Techniques (BAT)-Associated Emission Levels (AELs) were used for the assessment. These were obtained from the most recent BAT-conclusions document for waste incineration (European Parliament, 2019).

1.1.1.7 This human health risk assessment supplements the air quality assessment (**Document Reference 6.2.5**). This assessment only considers emissions to air as human exposure to airborne emissions is by far the most common type of exposure experienced by members of the public[2].

1.1.1.8 The air quality assessment of emissions has been provided by the Applicant (**Document Reference 6.2.5**). The air quality assessment provides a comparison of predicted concentrations for pollutant emissions at off-site locations with background air quality and air quality standards and guidelines for the protection of human health. The air quality assessment assumes the theoretical position that the maximum permissible emission limit values (ELVs) based on the December 2019 BAT-AELs are emitted during all times

1 The Industrial Emissions Directive (2010/75/EU)

2 Risk Assessment of Dioxin Releases from Municipal Waste Incineration Processes, Her Majesty's Inspectorate of Pollution (March 1996)

of operation. This position is considered unlikely to be a realistic operating scenario.

1.1.1.9 Given the above operating scenario, the emissions from the ERF would contain a number of substances that cannot be evaluated in terms of their effects on human health simply by reference to ambient air quality standards. Health effects could occur through exposure routes other than purely inhalation. As such, an assessment needs to be made of the overall human exposure to the substances by the local population and then the risk that this exposure causes.

1.2 Purpose of the Assessment

1.2.1.1 This assessment has been undertaken to support the DCO application and has been prepared in accordance with the assessor's extensive experience of the requirements of the Regulator for these types of development. In particular, this is a human health risk assessment of dioxin/furan emissions from the ERF based on the United States (US) Environmental Protection Agency (EPA) Human Health Risk Assessment Protocol (HHRAP)[3] methodology. In addition, the impact of trace metal emissions is provided for those metals included in the HHRAP methodology (arsenic, antimony, cadmium, chromium, mercury, nickel, lead and thallium).

1.2.1.2 The ERF will be equipped with an amine solvent-based post combustion carbon capture system. This may give rise to emissions of amine solvents but also nitrosamines which have the potential to effect human health. Therefore, these are considered also.

1.2.1.3 Human exposure to dioxins and furans has been compared against the Committee on Toxicity (COT) Tolerable Daily Intake (TDI) of 2 pg/kg per day. An assessment of exposure to dioxin-like Polychlorinated Biphenyls (PCBs) has also been included. For the metals, the predicted exposure is compared to background exposure levels for the trace metals considered. For nitrosamines, there are no background intakes with which to compare predicted exposures. However, nitrosamines are known carcinogens and the assessment has considered the carcinogen risk of exposure based on the carcinogenic risk factors included within the HHRAP methodology.

1.2.1.4 The HHRAP method does not contain physical properties or exposure parameters for individual dioxin-like PCBs but does provide information for two dioxin-like PCB mixtures (Aroclor 1016 and Aroclor 1254). Therefore, for these two substances typical emissions for dioxin-like PCBs have been included in the Industrial Risk Assessment Programme (IRAP) model and these have been assumed to comprise entirely of Aroclor 1016 or Aroclor 1254 depending on which substance gives rise to the highest exposure.

[3] US EPA Office of Solid Waste (September 2005) Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities

1.3 Scope of the Assessment

1.3.1.1 The assessment presented here considers the potential impact of substances released by the ERF on the health of the local population at the point of maximum exposure. These include substances that are 'persistent' in the environment and have several pathways from the point of release to the human receptor. Essentially, they can be described as dioxins/furans and dioxin-like PCBs and are present in extremely small quantities and are typically measured in mass units of nanograms (ng = 10^{-9} g), picograms (pg = 10^{-12} g) and femtograms (fg = 10^{-15} g).

1.3.1.2 Unlike substances such as nitrogen dioxide, which have short term, acute effects on the respiratory system, dioxins/furans and dioxin-like PCBs have the potential to cause effects through long term, cumulative exposure. A lifetime is the conventional period over which such effects are evaluated. A lifetime is taken to be 70 years, as is the default assumption of the HHRAP methodology.

1.3.1.3 The exposure scenarios used here represent highly unrealistic situations in which exposure assumptions are chosen to represent a worst case and should be treated as an extreme view of the risks to health. While individual high-end exposure estimates may represent actual exposure possibilities (albeit at very low frequency), the possibility of all high-end exposure assumptions accumulating in one individual is, for practical purposes, never realised. Therefore, intakes presented here should be regarded as an extreme upper estimate of the actual exposure that would be experienced by the real population in the locality.

1.4 Approach to the Assessment

1.4.1.1 The risk assessment process is based on the application of the US EPA HHRAP. This protocol has been assembled into a commercially available model, Industrial Risk Assessment Program (IRAP, Version 5.1.0) and marketed by Lakes Environmental of Ontario.

1.4.1.2 The approach seeks to quantify the hazard faced by the receptor, the exposure of the receptor to the substances identified as being a potential hazard and then to assess the risk of the exposure, as follows:

- Quantification of the exposure: an exposure evaluation determines the dose and intake of key indicator chemicals for an exposed person. The dose is defined as the amount of a substance contacting body boundaries (in the case of inhalation, the lungs) and intake is the amount of the substance absorbed into the body. The evaluation is based upon worst-case, scenarios, with respect to the following:
  - location of the exposed individual and duration of exposure;
  - exposure rate;
  - emission rate from the source.

- Risk characterisation: following the above steps, the risk is characterised by examining the toxicity of the chemicals to which the individual has been exposed and evaluating the significance of the calculated dose by a comparison of intakes with the tolerable daily intake (TDI) for dioxins/furans and dioxin-like PCBs and background intakes for the trace metals.

2. METHODOLOGY FOR ESTIMATING EXPOSURE TO EMISSIONS

2.1 Introduction

2.1.1.1 An exposure assessment for the purposes of characterising the health impact of the ERF emissions requires the following steps:

1. Measurement or estimation of emissions from the source.
2. Modelling the fate and transport of the emitted substances through the atmosphere and through soil, water and biota following deposition onto land. Concentrations of the emitted chemicals in the environmental media are estimated at the point of exposure, which may be through inhalation or ingestion.
3. Calculation of the uptake of the emitted chemicals into humans coming into contact with the affected media and the subsequent distribution in the body.

2.1.1.2 With regard to step three, the exposure assessment considers the uptake of polychlorinated dibenzo-para-dioxins and polychlorinated dibenzofurans (PCDD/Fs), often abbreviated to 'dioxins/furans' and dioxin-like PCBs and trace metals from the combustion sources and nitrosamines from the carbon capture system (CCS).

2.2 Potential Exposure Pathways

2.2.1.1 There are two primary exposure 'routes' where humans may come into contact with chemicals that may be of concern:

- direct, via inhalation; or
- indirect, via ingestion of water, soil, vegetation and animals and animal products that become contaminated through the food chain.

2.2.1.2 There are four other potential exposure pathways of concern following the introduction of substances into the atmosphere:

- ingestion of drinking water;
- dermal (skin) contact with soil;
- incidental ingestion of soil; and
- dermal (skin) contact with water.

2.3 Exposure Pathways Considered in the Assessment

2.3.1.1 The possible exposure pathways included in the IRA) model are shown in Figure 2. Dermal contact with soil is an insignificant exposure pathway on the basis of the infrequent and sporadic nature of the events and the very low dermal absorption factors for this exposure route, coupled with the low plausible total dose that may be experienced (when considered over the lifetime of an individual). Health risk assessments of similar emissions[4] have

[4] Pasternach (1989) The Risk Assessment of Environmental and Human Health Hazards, John Wiley, New York

concluded that dermal absorption of soil is at least one order of magnitude less efficient than lung absorption.

2.3.1.2 Similar arguments are relevant with respect to the elimination of aquatic pathways from consideration; swimming, fishing and other recreational activities are also sporadic and unlikely to lead to significant exposures or uptake of any contamination into the human body via dermal contact with water.

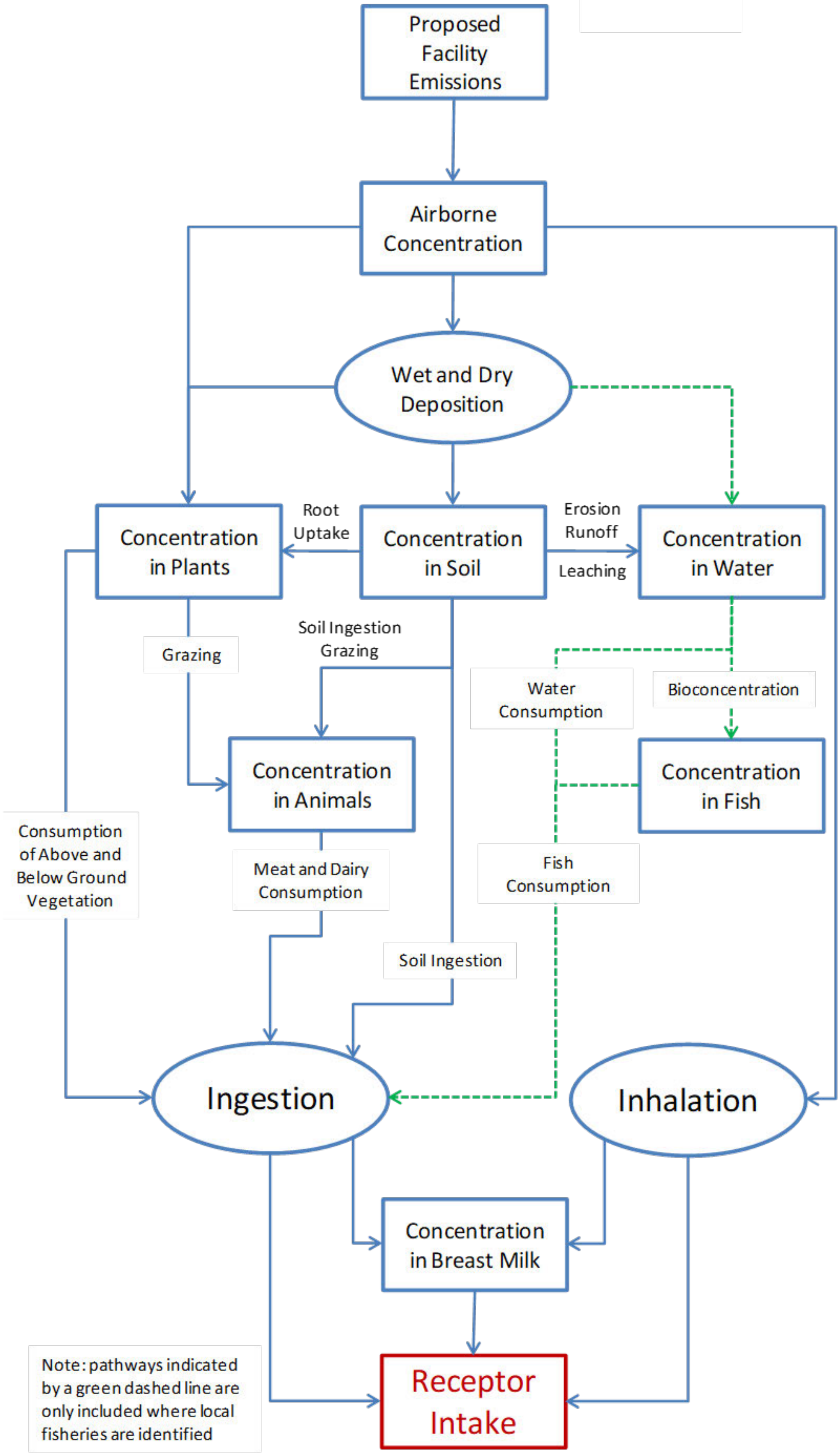
2.3.1.3 Exposure via drinking water requires contamination of surface drinking water sources local to the point of consumption. The likelihood of contamination reaching a level of concern in the local water sources and ground water supplies is extremely low, particularly where there is no large-scale storage (e.g. reservoirs) or catchment areas for local water supplies within 5 km from the ERF. However, the US EPA's HHRAP does include the ingestion of drinking water from surface water sources as a potential exposure pathway where water bodies and water sheds have been defined within the exposure scenario. The ingestion of groundwater as a source of local drinking water is not considered by the HHRAP as it is considered to be an insignificant exposure pathway for combustion emissions.

2.3.1.4 The ingestion of drinking water from surface water sources is only considered a potential exposure pathway where there is a local surface water body which provides local drinking water. However, it is our experience that drinking water from a reservoir located close to an ERF makes a very small contribution to the total exposure. Therefore, exposure via drinking water is generally only considered where there is the potential for exposure via the ingestion of fish and the presence of edible fish farms (e.g., trout or salmon farms).

2.3.1.5 Based on the assessment of the potential significance of the exposure pathways the key exposure pathways which are relevant to the assessment and, hence, subject to examination in detail are as follows:

- inhalation;
- ingestion of food; and
- ingestion of soil.

Figure 2: Exposure Pathways for Receptors



2.3.1.6 Therefore, the exposures arising from ingestion are assessed with reference to the following:

- milk from home-reared cows;
- eggs from home-reared chickens;
- home-reared beef;
- home-reared pork;
- home-reared chicken;
- home-grown vegetable and fruit produce;
- breastmilk; and
- soil (incidental).

2.3.1.7 The inclusion of all food groups in the assessment conservatively assumes that both arable and pastureland are present in the vicinity of the predicted maximum annual average ground level concentration. This is a highly unlikely scenario, but it has been included as a means of building a high degree of conservatism into the assessment and, hence, reducing the risk of exposures being underestimated. However, it should be noted that not all exposure scenarios will result in the ingestion of home-reared meat and animal products and these food products are only considered by the HHRAP for farmers and the families of farmers.

2.3.1.8 Similarly, the ingestion of fish is only considered where there is a local water body that is used for fishing and where the diet of the fisher (and family) may be regularly supplemented by fish caught from these local water sources. There are no edible fish farms identified within 5 km of the ERF. The nearest fishery (Trentside Fishery) is located 3 km north of the ERF but is a coarse fishery and fish are not taken for consumption. Therefore, the ingestion of locally caught fish has not been considered, as consumption rates are likely to be very small.

2.4 Emissions and Dispersion Modelling Input Data

2.4.1 Compounds of Potential Concern (COPCs)

2.4.1.1 The substances which have been considered in the assessment are referred to as COPCs and include the seventeen PCDD/F congeners that are known to be toxic (refer *Section 2.4.4*). In addition, the IRAP model includes two dioxin-like PCBs (Aroclor 1016 and Aroclor 1254). These comprise a mixture of congeners with one to four chlorine atoms for Aroclor 1016 with a chlorine content of 41% by mass (average of three chlorine atoms). Similarly, Aroclor 1254 has between four and seven chlorine atoms and a chlorine content of 54% by mass (average of five chlorine atoms).

2.4.1.2 Emissions of arsenic, antimony, cadmium, chromium, mercury, nickel, lead and thallium have also been included in the model in order to determine the impact of metal emissions at each receptor location. Other trace metals that have regulated emissions are not included in the IRAP model and cannot be assessed.

2.4.1.3 Nitrosamines and nitramines will be released from the carbon capture system. The IRAP model includes three COPCs related to these emissions. These are n-nitrosodibutylamine, n-nitrosdipropylamine and n-nitrosodiphenylamine. Initial modelling is used to determine which COPC gives rise to the highest impact and all nitrosamine and nitramine emissions are then assumed to comprise entirely of this COPC.

2.4.2 Emission Parameters

2.4.2.1 Emissions from the ERF are assumed to be emitted via three separate flues within a multi-flue stack. However, as a worst-case each flue is assumed to emit individually rather than as a combined emission source. Emission parameters assumed for the assessment are consistent with those used for the air quality assessment as summarised in Table 1.

Table 1: Summary of the Emission Parameters for Dispersion Modelling

Parameter	Individual Flue Emissions
Number of sources	3
Stack location grid reference	486116, 414518 486118, 414516 486119, 414519
Stack height (m)	120
Temperature of emission (ºC)	130
Actual flow rate (m^3 s^{-1})	76.6
Emission velocity at stack exit (m s^{-1})	16.0
Normalised flow rate (Nm^3 s^{-1}) (a)	56.5
Flue/effective stack diameter (m)	2.47
(a) Reference conditions of 273K, 1 atmosphere, dry and 11% oxygen	

2.4.3 Emission Concentrations

2.4.3.1 Within the IED and for the BAT-AELs, emissions of metals are divided into three groups. The total emissions of metals within each group is not permitted to exceed the prescribed emission limit set for the group. For the purposes of the modelling, it would be unreasonable to assume that each metal emits at the group limit. Therefore, EA guidance[5] has been used to define trace metal emissions. The guidance provides fewer conservative assumptions, whereby Group 3 metals are assessed based on emissions of these metals derived from data from other operational facilities. Information is provided as a proportion of the IED emission limits and are presented in

[5] Environment Agency (June 2016) Guidance on Assessing Group 3 Metal Stack Emissions from Incinerators (Version 4)

Table 2. For the Group 3 metals, the average emission for the operational facilities is presented.

2.4.3.2 The EA does not provide comparable emission concentrations for the Group 1 and Group 2 metals or for PCDD/Fs. However, annual reports on UK Energy from Waste Statistics are provided by Tolvik Consulting with the most recent report published for 2020[6]. This report includes information on compliance with ELVs for 54 operational EfW facilities in the UK. Typical emission concentrations for cadmium, thallium and PCDD/fs have been obtained from this report and are also provided in Table 2.

Table 2: Summary of Typical PCDD/F and Metal Emissions from Waste Combustion Facilities

Metal Species	IED Limit (mg Nm^{-3})	Average Emission as %age of the IED Limit
PCDD/Fs	0.1 ng Nm^3	11.4%(a)
Antimony	0.5	0.3%(b)
Arsenic	0.5	0.2%(b)
Cadmium	0.05	4.0%(c)
Chromium	0.5	1.7%(b)
Lead	0.5	2.2%(b)
Mercury	0.05	5.9%(a)
Nickel	0.5	3.0%(b)
Thallium	0.05	4.0%(c)

(a) Tolvik Consulting UK Energy from Waste Statistics (2020)
(b) EA guidance for Group 3 metals
(c) Tolvik Consulting UK Energy from Waste Statistics (2020) gives cadmium and thallium combined emissions at 4.0%

2.4.3.3 The following emission concentrations are assumed for the assessment.

- PCDD/Fs – BAT-AEL of 0.06 ng Nm^{-3};
- cadmium and thallium – 50% of the BAT-AEL at 0.01 mg Nm^{-3};
- mercury – 0.000007 mg Nm^{-3} at BAT AEL); and
- antimony, arsenic, chromium, lead and nickel as provided by the EA guidance (Table 2).

2.4.3.4 A summary of the emission concentrations and emission rates assumed for the assessment is provided in Table 3.

[6] UK Energy from Waste Statistics – 2020, Tolvik Consulting (May 2021)

Table 3: Summary of the Emission Concentrations and Emission Rates for Dispersion Modelling

Pollutant	Daily Emission Concentration (mg Nm^{-3}) (a)(b)	Total Emission Rate (g s^{-1}) Each Flue
PCDD/Fs	0.06	3.4×10^{-9}
Cadmium	0.01 (c)	0.00057
Thallium	0.01 (c)	0.00057
Mercury	0.000007 (d)	0.0000004
Antimony	0.0015 (e)	0.000085
Arsenic	0.00090 (e)	0.000051
Chromium	0.0084 (e)	0.00047
Lead	0.011 (e)	0.00063
Nickel	0.015 (e)	0.00085

(a) Reference conditions of 273K, 1 atmosphere, dry and 11% oxygen

(b) Emission concentrations expressed as mg Nm^3 (at reference conditions) except for PCDD/Fs which are in ng Nm^3 (at reference conditions)

(c) Assumed to be 50% of the Group 1 limit of 0.02 mg Nm^3

(d) As provided by XXXXXX

(e) As measured (EA)

2.4.4 Nitrosamines

2.4.4.1 Expected emission concentrations of nitrosamines and nitramines have been provided by Fitchner (Calum Bezer, Fitchner, 16 July 2021 for the final EIA Project design) and are as follows:

- 0.000023 mg Nm^{-3} (1.3×10^{-6} g s^{-1}) for nitramines per flue; and
- 0.0000071 mg Nm^{-3} (4.0×10^{-7} g s^{-1}) for nitrosamines per flue.

2.4.4.2 For the purposes of the assessment, the combined emission of nitrosamines is assumed to be 0.000030 mg Nm^{-3} (sum of nitramines and nitrosamines).

2.4.5 Emission Concentrations for the Individual PCDD/F Congeners

2.4.5.1 The general term dioxins denotes a family of compounds, with each compound composed of two benzene rings interconnected with two oxygen atoms. There are 75 individual dioxins, with each distinguished by the position of chlorine or other halogen atoms positioned on the benzene rings. Furans are similar in structure to dioxins but have a carbon bond instead of one of the two oxygen atoms connecting the two benzene rings. There are 135 individual furan compounds. Each individual furan or dioxin compound is referred to as a congener and each has a different toxicity and physical properties with regard to its atmospheric behaviour. It is important, therefore, that the exposure methodology determines the fate and transport of PCDD/Fs on a congener specific basis. It does this by accounting for the varying volatility of the congeners and their different toxicities. Consequently, information regarding the PCDD/F annual mean ground level concentrations on a congener specific basis is required. For the purposes of the exposure assessment, the congener profile for the ERF is presented in Table 4, which is a standard profile for municipal waste incinerators derived by Her Majesty's Inspectorate of Pollution (HMIP), one of the predecessors of the EA. The international toxic equivalency factors are given and used to derive the toxic equivalent emission (I-TEQ).

Table 4: PCDD/F Congener Profile for the ERF

Congener	Annual Mean Emission Concentration (ng Nm^{-3}) (a)	I-TEF toxic equivalent factors)	Annual Mean Emission Concentration (ng I-TEQ Nm^{-3})
2,3,7,8-TCDD	0.0018	1	0.0019
1,2,3,7,8-PeCDD	0.015	0.5	0.0074
1,2,3,4,7,8-HxCDD	0.017	0.1	0.0017
1,2,3,7,8,9-HxCDD	0.013	0.1	0.0013
1,2,3,6,7,8-HxCDD	0.016	0.1	0.0016
1,2,3,4,6,7,8-HpCDD	0.1	0.01	0.001
OCDD	0.24	0.001	0.00024
2,3,7,8-TCDF	0.017	0.1	0.0017
2,3,4,7,8-PeCDF	0.032	0.5	0.016
1,2,3,7,8-PeCDF	0.017	0.05	0.00084
1,2,3,4,7,8-HxCDF	0.13	0.1	0.013
1,2,3,7,8,9-HxCDF	0.0024	0.1	0.00024
1,2,3,6,7,8-HxCDF	0.049	0.1	0.0049
2,3,4,6,7,8-HxCDF	0.052	0.1	0.0052
1,2,3,4,6,7,8-HpCDF	0.26	0.01	0.0026
1,2,3,4,7,8,9-HpCDF	0.024	0.01	0.00024
OCDF	0.24	0.001	0.00024
Total (ng I-TEQ m^{-3})			0.06000

(a) Congener profile from Table 7.2a DOE (1996) Risk Assessment of Dioxin Releases from Municipal Waste Incineration Processes Contract No. HMIP/CPR2/41/1/181

2.4.5.2 Information on PCB emissions has been obtained from the Defra report WR 0608[7]. Based on the information provided, a maximum emission concentration of 3.6 x 10^{-9} mg m^{-3} is assumed. It is not stated whether this is total PCBs or dioxin-like PCBs. Therefore, as a worst-case it is assumed to comprise entirely of dioxin-like PCBs. Furthermore, it is assumed that this is the total PCB emission and that these data are presented as the toxic equivalent concentration (i.e. 3.6 x 10^{-9} mg TEQ Nm^{-3}). For the dioxin-like PCBs, a toxic equivalent factor (TEF) of 0.1 has been used to provide an actual emission concentration (i.e. 3.6 x 10^{-8} mg Nm^{-3}). The same equivalence factor has been used to convert the total actual dose back to the total toxic equivalent dose.

[7] WR 0608 Emissions from Waste Management Facilities, ERM Report on Behalf of Defra (July 2011)

2.4.5.3 The emission rates for each substance as input to the IRAP model are provided in Table 5.

Table 5: PCDD/F Emission Rates used in the IRAP Model

Congener	Emission Rate for Each Flue (g s^{-1})
2,3,7,8-TCDD	1.1×10^{-10}
1,2,3,7,8-PeCDD	8.3×10^{-10}
1,2,3,4,7,8-HxCDD	9.8×10^{-10}
1,2,3,7,8,9-HxCDD	7.1×10^{-10}
1,2,3,6,7,8-HxCDD	8.8×10^{-10}
1,2,3,4,6,7,8-HpCDD	5.8×10^{-9}
OCDD	1.4×10^{-8}
2,3,7,8-TCDF	9.5×10^{-10}
2,3,4,7,8-PeCDF	1.8×10^{-9}
1,2,3,7,8-PeCDF	9.5×10^{-10}
1,2,3,4,7,8-HxCDF	7.4×10^{-9}
1,2,3,7,8,9-HxCDF	1.4×10^{-10}
1,2,3,6,7,8-HxCDF	2.7×10^{-9}
2,3,4,6,7,8-HxCDF	2.9×10^{-9}
1,2,3,4,6,7,8-HpCDF	1.5×10^{-8}
1,2,3,4,7,8,9-HpCDF	1.4×10^{-9}
OCDF	1.4×10^{-8}
Aroclor 1016/1254	2.0×10^{-9}

2.5 Dispersion Modelling Assumptions

2.5.1.1 The air quality assessment has relied upon the use of Atmospheric Dispersion Modelling System (ADMS) to estimate ground level concentrations of pollutants. The HHRA model has been designed to accept output files from the US EPA Industrial Source Complex (ISC) or American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) dispersion models, reflecting its North American origins and its need to follow the US EPA risk assessment protocol. The use of ADMS is consistent with the air quality assessment undertaken for the ERF and the emissions data and model set up are identical to that carried out for the air quality assessment in the ES (**Document Reference 6.2.5**). Therefore, to maintain consistency with the air quality assessment, it has been possible to use output from the ADMS model with IRAP using the following procedure:

- generation of ISC input files and output files for the study area;
- generation of ADMS output data using the approach outlined in the US EPA risk assessment protocol; and
- inserting the ADMS results into the ISC output files.

2.5.1.2 For the modelling, all emission properties, building heights, and other relevant factors for the ERF were retained from the air quality assessment in the ES (**Document Reference 6.2.5**). As the health risk assessment requires information on the deposition of substances to surfaces as well as airborne concentrations of substances, the ADMS dispersion model has also been used to predict the following:

- the airborne concentration of vapour, particle and particle bound substances emitted;
- the wet deposition rate of particle and particle bound substances; and
- the dry deposition rate of vapour, particle and particle bound substances.

2.5.1.3 For dry deposition of particles and particle bound contaminants, a fixed deposition velocity of 0.01 m s^{1} has been used. The ERF will likely be equipped with fabric filters for the removal of fine particles and the emitted particles are likely to be predominantly in the lower size range of 1 - 2 µm in diameter. For particles of this size, deposition velocities are likely to be of the order of 0.001 to 0.01 m s^{1}. Therefore, as a worst-case, for the ADMS modelling a value of 0.01 m s^{1} has been adopted. A gas dry deposition velocity of 0.005 m s^{1} is used for the gas phase. For wet deposition, the following washout coefficients are used:

- Gas phase – washout coefficient A at 0.00016 and washout coefficient B of 0.64;
- Particle phase – washout coefficient A at 0.00028 and washout coefficient B of 0.64; and
- Particle bound phase – washout coefficient A at 0.00010 and washout coefficient B of 0.64.

2.6 Dispersion Modelling Results

2.6.1.1 A summary of the key results from the ADMS dispersion model is presented in Table 6. These have been predicted using the 2015 Doncaster Airport meteorological data set. This year was selected, as out of the five years considered, it was the year that provided highest predicted annual mean concentrations and deposition rates.

Table 6: Maximum Annual Average Particle Phase Concentrations and Particle Phase Deposition Rates Estimated By ADMs

Pollutant	Max Annual Average Concentration [(a)]	Max Annual Average Deposition Rate [(b)]
PCDD/Fs	*(fg m^{-3})*	*(ng m^{-2} $year^{-1}$)*
2,3,7,8-TCDD	0.012	0.14
1,2,3,7,8-PeCDD	0.095	1.1
1,2,3,4,7,8-HxCDD	0.11	1.3
1,2,3,7,8,9-HxCDD	0.081	0.95
1,2,3,6,7,8-HxCDD	0.1	1.2
1,2,3,4,6,7,8-HpCDD	0.66	7.7

OCDD	1.5	18.2
2,3,7,8-TCDF	0.11	1.3
2,3,4,7,8-PeCDF	0.21	2.4
1,2,3,7,8-PeCDF	0.11	1.3
1,2,3,4,7,8-HxCDF	0.84	9.9
1,2,3,7,8,9-HxCDF	0.015	0.18
1,2,3,6,7,8-HxCDF	0.31	3.7
2,3,4,6,7,8-HxCDF	0.34	4
1,2,3,4,6,7,8-HpCDF	1.7	20
1,2,3,4,7,8,9-HpCDF	0.15	1.8
OCDF	1.5	18.2
Aroclor 1016/1254	0.23	2.7
Metals	***(ng m^{-3})***	***(mg m^{-2} a^{-1})***
Antimony	0.0097	0.11
Arsenic	0.0058	0.068
Cadmium	0.064	0.76
Chromium	0.054	0.64
Lead	0.071	0.84
Mercury	0.000045	0.00053
Nickel	0.097	1.1
Thallium	0.064	0.76
(a) Where 1 fg m^3 is equal to 1 x 10^{-15} g m^3		
(b) Where 1 ng m^{-2} $year^{-1}$ is equal to 1 x 10^{-9} g m^{-2} $year^{-1}$		

2.7 Estimation of Background Exposures

2.7.1 PCDD/Fs

2.7.1.1 The latest assessment of dietary exposure to PCCD/Fs was documented in 2003 based on the 2001 Total Diet Study (TDS)[8]. This estimated that the average intake for adults decreased from 1.8 pg TEQ kg^{-1} d^{-1} (1997) to 0.9 pg TEQ kg^{-1} d^{-1} in 2001. For younger children, the average exposure decreased from 4.0 pg TEQ kg^{-1} d^{-1} to 1.8 pg TEQ kg^{-1} d^{-1}. These reductions were likely due to the significant reduction in emissions during the 1990s from waste incineration facilities.

2.7.1.2 The 2001 TDS is twenty years old and there have been further reductions in emission since this study was published. This is evidenced by PCCD/F emissions data obtained from the UK National Atmospheric Emissions Inventory which indicates that total PCDD/F emissions in the UK decreased

8 Dioxins and dioxin-like PCBs in the UK Diet: 2001 Total Diet Study Samples, Food Survey Information Sheet 38/03 (July 2003)

from 523 g TEQ a^{-1} in 1997 to 335 g TEQ a^{-1} in 2001 and further to 181 g TEQ a^{-1} in 2019.

2.7.1.3 An updated TDS was undertaken in 2012[9] but this study did not consider dietary exposure to PCDD/Fs. The report provides the concentration of PCDD/Fs and dioxin-like PCBs in a range of food products. Using dietary intake data from the National Diet and Nutrition Survey[10] (NDNS) an estimate of the dietary exposure to PCDD/Fs has been calculated as follows:

- for each food group the ng TEQ kg^{-1} fat basis has been obtained from the 2001 and 2012 TDS for adults and children (4 to 10 years);
- the fat intake (%) for each receptor type (adults and children) has been obtained from the NDNS. Data for Years 5 to 6 were used corresponding with 2012. Data were normalised to 100%;
- the average daily fat intake was calculated based on a total fat intake of 67.8 g d^{-1} for an adult and 54.4 g d^{-1} for a child; and
- the intake was calculated by multiplying the PCDD/F concentrations in food (ng TEQ kg-1) by the intake g d^{-1} and then converting to units of pg TEQ kg^{-1} d^{-1}.

2.7.1.4 The results of this analysis are presented in Annex C. The analysis was also applied to the 2001 TDS to provide a comparison with published intakes. A summary of the results is presented in Table 7.

Table 7: Comparison of Published and Estimated Intakes of PCDD/FS and Dioxin-Like PCBs for 2001 and 2012

Scenario	Adult (pg TEQ kg^{-1} d^{-1})	Child (pg TEQ kg^{-1} d^{-1})
2001 TDS Published	0.9	1.8
2001 Estimated Intake	0.68	1.7
2012 Estimated Intake	0.47	1.11
2012 Estimate normalised to 2001	0.62	1.17

2.7.1.5 The 2001 estimates are slightly lower than the published estimates, particularly for the adult. Therefore, the 2012 estimates have been normalised based on the difference between the published and estimated 2001 data. This results in 2012 daily intakes of 0.62 and 1.17 pg TEQ kg^{-1} d^{-1} for the adult and child, respectively.

9 Organic Environmental Contaminants in the 2012 Total Diet Study Samples, Report to the Food Standards Agency, The Food and Environment Research Agency (December 2012)

10 https://www.gov.uk/government/statistics/ndns-results-from-years-7-and-8-combined

2.7.2 Trace Metals

2.7.2.1 The concentration of trace metals in food for the 2014 TDS has been published by The Food & Environment Research Agency[11]. This presents concentrations in foods in mg kg-1 as prepared. The results of the study are also presented as an Excel spreadsheet[12] which provides exposure levels for, 1.5 to 3 year olds, 4 to 10 year olds, 11 to 18 year olds and adults. For some food groups results are presented as a range as for some metals the measured concentration of the metal in the food group is below the detection limit of the analysis. The lower estimate of intake assumes the concentration is 0 mg kg^{-1} and the upper estimate assumes the metal concentrations is equal to the detection limit. In reality, the exposure estimate is likely to be between the range of values presented. A summary of the lower and upper intakes for each of the metals considered is presented in Table 8.

Table 8: Upper and Lower Intake of Trace Metals from the 2014 TDS

Metal	Adult		Child	
	Lower Intake (µg kg-1 d-1)	Upper Intake (µg kg-1 d-1)	Lower Intake (µg kg-1 d-1)	Upper Intake (µg kg-1 d-1)
Antimony	0.016	0.029	0.028	0.055
Arsenic	0.91	1	1.4	1.6
Cadmium	0.12	0.19	0.28	0.41
Chromium	0.42	1.1	1.3	2.3
Lead	0.062	0.11	0.12	0.2
Mercury	0.022	0.041	0.033	0.067
Nickel	1.7	1.9	3.6	4.1
Thallium	0.0084	0.082	0.022	0.16

[11] Total Diet Study of Metals and Other Elements in Food, Report for the UK Food Standards Agency (FS102081), The Food & Environment Research Agency (March 2015)

[12] https://www.food.gov.uk/research/research-projects/total-diet-study-metals-and-other-elements

3. INPUT PARAMETERS FOR THE IRAP MODEL

3.1 Introduction

3.1.1.1 Exposure of an individual to a chemical may occur either by inhalation or ingestion (including food, water and soil). Of interest is the total dose of the chemical received by the individual through the combination of possible routes, and the IRAP model has been developed to estimate the dose received by the human body, often referred to as the external dose.

3.1.1.2 Exposure to COPCs is a function of the estimated concentration of the substance in the environmental media with which individuals may come into contact (i.e., exposure point concentrations) and the duration of contact. The concentration at the point of contact is itself a function of the transfer through air, soil, water, plants and animals that form part of the overall pathway. Exposure equations have been developed which combine exposure factors (e.g., exposure duration, frequency and medium intake rate) and exposure point concentrations. The dose equations therefore facilitate estimation of the received dose and account for the properties of the route of exposure, i.e., ingestion and inhalation.

3.1.1.3 For those substances that bio-accumulate, i.e., become more concentrated higher up the food chain, especially in body fats, the exposure to meats and milk is of particular significance.

3.1.1.4 The IRAP model user has the facility to adjust some of the key exposure factors. An example is the diet of the receptor and the proportion of which is local produce, which may be contaminated. Obviously, if a nearby resident eats no food grown locally, then that person's diet cannot be contaminated by the emissions from the source, in this case the ERF. It is conventional to investigate two types of receptors, a farmer and a resident. It is assumed that a farmer eats proportionately more locally grown food than a resident. Where the potential exists for the consumption of locally caught fish a fisher receptor may also be considered.

3.1.1.5 The receptor types can also be divided into adults and children. Children are important receptors because they tend to ingest soil and dusts directly and have lower body weights, so that the effect of the same dose is greater in the child than in the adult.

3.1.1.6 The IRAP model is designed to accept output files of airborne concentrations and deposition rates. From these, it proceeds to calculate the concentrations of the pollutants of concern in the environmental media, foodstuffs and the human receptor. The dose experienced by the human receptor can be compared to the tolerable daily intake (TDI) provided by the Committee on Toxicity for dioxins and dioxin like PCBs of 2 pg kg^{-1} d^{-1}. For trace metals, the impact is compared to background exposures from dietary sources.

3.1.1.7 The model requires a wide range of input parameters to be defined, these include:

- physical and chemical properties of the COPCs;
- site information, including site specific data; and
- receptor information – for each receptor type (e.g. adult or child, resident or farmer or fisher).

3.1.1.8 The HHRAP default values, which are incorporated into the IRAP model, have been used for the majority of these input values. These data are provided in the following sections.

3.2 Input Parameters for the COPCs

3.2.1.1 The IRAP model contains a database of physical and chemical parameters for each of the 206 COPCs. This database is based on default values provided by the HHRAP and all default values have been used for this assessment.

3.2.1.2 These parameters are used to determine how each of the COPCs behave in the environment and their presence and accumulation in various food products (meat, fish, animal products, vegetation, soil and water). For 2,3,7,8-TCDD (the most toxic of the PCDD/Fs), the default parameters are provided in Table 9.

Table 9: IRAP Input Parameters for 2, 3, 7, 8-TCDD

Parameter Description	Symbol	Units	2,3,7,8-TCDD
Chemical abstract service number	CAS No.	-	1746-01-6
Molecular weight	MW	g mole^{-1}	322
Melting point of chemical	T_m	K	578.7
Vapour pressure	V_p	atm	1.97×10^{-12}
Aqueous solubility	S	mg L^{-1}	1.93×10^{-5}
Henry's Law constant	H	atm-m^3 mol^{-1}	3.29×10^{-5}
Diffusivity of COPC in air	D_a	cm^2 s^{-1}	0.104
Diffusivity of COPC in water	Dw	cm^2 s^{-1}	5.6×10^{-6}
Octanol-water partition coefficient	K_ow	-	6309573
Organic carbon-water partition coefficient	K_oc	mL g^{-1}	3890451
Soil-water partition coefficient	Kd_s	mL g^{-1}	38904
Suspended sediments/surface water partition coefficient	Kd_sw	L kg^{-1}	291784
Bed sediment/sediment pore water partition coefficient	Kd_bs	mL g^{-1}	155618
COPC loss constant due to biotic and abiotic degradation	K_sg	a^{-1}	0.03
Fraction of COPC air concentration in vapour phase	f_v		0.664
Root concentration factor	RCF	mL g^{-1}	39999

Parameter Description	Symbol	Units	2,3,7,8-TCDD
Plant-soil bioconcentration factor for below ground produce	br_root_veg	-	1.03
Plant-soil bioconcentration factor for leafy vegetables	br_leafy_veg	-	0.00455
Plant-soil bioconcentration factor for forage	br_forage	-	0.00455
COPC air-to-plant biotransfer factor for leafy vegetables	bv_leafy_veg	-	65500
COPC air-to-plant biotransfer factor for forage	bv_forage	-	65500
COPC biotransfer factor for milk	ba_milk	day kg^{-1}	0.0055
COPC biotransfer factor for beef	ba_beef	day kg^{-1}	0.026
COPC biotransfer factor for pork	ba_pork	day kg^{-1}	0.032
Bioconcentration factor for COPC in eggs	Bcf_egg	-	0.06
Bioconcentration factor for COPC in chicken	Bcf_chicken	-	3.32
Fish bioconcentration factor	BCF_fish	L kg^{-1}	34400
Fish bioaccumulation factor	BAF_fish	L kg^{-1}	0
Biota-sediment accumulation factor	BSAF_fish	-	0.09
Plant-soil bioconcentration factor for grain	br_grain	-	0.00455
Plant-soil bioconcentration factor for eggs	br_egg	-	0.011
COPC biotransfer factor for chicken	ba_chicken	day kg^{-1}	0.019

3.3 Site and Site Specific Parameters

3.3.1.1 The IRAP health risk assessment model requires information relating to the location and its surroundings. The parameters required include the following:

- the fraction of animal feed (grain, silage and forage) grown on contaminated soils and quantity of animal feed and soil consumed by the various animal species considered;
- the interception fraction for above ground vegetation, forage and silage and length of vegetation exposure to deposition. The yield/standing crop biomass is also required; and
- input data for assessing the risks associated with exposure to breast milk, including:
  - body weight of infant;
  - exposure duration;
  - proportion of ingested COPC stored in fat;
  - proportion of mother's weight that is fat;
  - fraction of fat in breast milk;

  - fraction of ingested contaminant that is absorbed; and
  - half-life of dioxins in adults and ingestion rate of breast milk.
- other physical parameters (e.g. soil dry bulk density, density of air, soil mixing zone depth).

3.3.1.2 For all of these parameters the IRAP/EPA HHRAP default values have been used and these are presented in Annex A. Other site specific parameters are also required which are not provided by the IRAP model. These parameters were based on observed meteorological conditions for the ERF as follows:

- annual average evapotranspiration rate of 42.7 cm a^{-1} (assumed to be 70% of total precipitation);
- annual average precipitation of 61.0 cm a^{-1} (based on the average for the five year data set for the 2014 to 2018 meteorological data);
- annual average irrigation of 0 cm a^{-1};
- annual average runoff of 6.1 cm a^{-1} (assumed to be 10% of total precipitation);
- an annual average wind velocity of 4.5 m s^{-1} (average for the five years); and
- a time period over which deposition occurs of 30 years.

3.4 Receptor Information

3.4.1.1 Within the IRAP model there are three receptor types; Resident, Farmer and Fisher. Information relating to each receptor type (adult and/or child) is required by the model where these receptor types are used. The information required includes the following:

- food (meat, dairy products, fish and vegetables), water and soil consumption rates for each receptor type. However, only Fishers are assumed to consume fish and only Farmers are assumed to consume locally reared animals and animal products.
- fraction of contaminated food, water and soil which is consumed by each receptor type.
- input data for the inhalation exposure including: inhalation exposure duration, inhalation exposure frequency, inhalation exposure time; and inhalation rate.
- input data for the ingestion exposure including: exposure duration, exposure frequency, exposure time; and body weight of receptor.

3.4.1.2 For the purposes of this assessment the default IRAP/HHRAP parameters have been used mainly to define the characteristics of the receptors. The input data used are presented in Annex B. The only variation to this is the assumed body weight of a child receptor. The IRAP/HHRAP default value is 15 kg whereas in the UK a value of 20 kg is typically used. Therefore, a value of 20 kg has been used.

4. EXPOSURE ASSESSMENT

4.1 Exposure Criteria

4.1.1 PCDD/Fs

4.1.1.1 The World Health Organization (WHO) recommends a tolerable daily intake (TDI) for dioxins/furans of 1 to 4 pg I-TEQ kg-BW^{-1} d^{-1} (picogrammes as the International Toxic Equivalent per kilogram bodyweight per day)[13]. The TDI represents the tolerable daily intake for lifetime exposure and short-term excursions above the TDI would have no consequence provided that the average intake over long periods is not exceeded. The UK COT also provides a TDI for dioxins and dioxin-like PCBs of 2 pg I-TEQ kg-BW^{-1} d^{-1}.

4.1.2 Trace Metals

4.1.2.1 The predicted exposure of the ERF to trace metals has been assessed by comparison to UK background exposures as provided in Section 2.7.2.

4.1.3 Nitrosamines

4.1.3.1 Of the three nitrosamines included within the IRAP model, the highest carcinogenic risk occurs due to nitrosodipropylamine which has the highest ingestion cancer slope factor (CSF) and highest inhalation unit risk factor (URF) of the three COPCs. These are used to determine the risk associated with exposure to this COPC.

4.1.3.2 The risk of interest in this context is the extra lifetime risk associated with the total dose resulting from exposure to the ERF emissions. The IRAP model uses the CSF and URF values to calculate a cancer risk for the COPC and for each pathway for exposure.

4.1.3.3 The risk associated with the ingestion exposure (food, water and soil) of nitrosodipropylamine is calculated as follows:

$$Risk_{Ing,\ NPA} = ADD_{Ing,\ NPA} \bullet CSF_{Ing,\ NPA}$$

4.1.3.4 Where $ADD_{Ing,\ NPA}$ is the sum of the average daily dose of nitrosodipropylamine from all ingestion exposure routes.

4.1.3.5 The risk associated with the inhalation of nitrosodipropylamine is calculated as follows:

$$Risk_{Inh,\ NPA} = EC_{NPA} \bullet URF_{Inh,\ NPA}$$

4.1.3.6 Where EC_{NPA} is the predicted airborne concentration of nitrosodipropylamine at each receptor location.

4.1.3.7 The combined risk from ingestion and inhalation is compared to an annual risk of 1 x 10^{-6} (1 in 1 million), conventionally considered to be acceptable for

[13] Assessment of the Health Risk of Dioxins: Re-evaluation of the Tolerable Daily Intake (TDI), WHO Consultation, May 25-29 1998, Geneva, Switzerland

industrial regulation in the UK[14]. This is equivalent to a total lifetime risk over 70 years of 7 x 10^{-5}.

4.2 Selection of Receptors

4.2.1.1 In addition to defining specific locations for assessment, IRAP can be used to determine the location of the maximum impact over an area based on the results of the dispersion model. For each defined land-use area, IRAP selects the locations which represent the maximum predicted concentrations or deposition rates for the area selected. The locations of these various maxima are often co-located resulting in the selection of one to nine receptor locations per defined area. This approach is adopted by IRAP since the maximum receptor impact may occur at any one of the maximum concentration or deposition locations identified.

4.2.1.2 Residential exposure within the immediate vicinity of the ERF is limited due to the rural and industrial nature of the site. The nearest residential areas are small villages such as Flixborough to the northeast, Amcotts to the southwest, Grange to the south. In addition, the outskirts of the more urban area of Scunthorpe lies approximately 2 km to the southeast. Ten areas where residential exposure may occur have been defined based on residential areas around the ERF. These are the nearest residential settlements.

4.2.1.3 Beyond the industrial estate, the area is rural and has a land use that is dominated by agriculture. Two areas where the potential for farming exists have been defined. These include areas to the east and west of the River Trent.

4.2.1.4 For each type of receptor up to nine locations are selected based on the maximum predicted airborne concentration, maximum predicted wet deposition rate and maximum dry deposition rate for the gas phase, particle phase and particle bound phase. For the assessment, twenty-one Residential receptors and five Farmer receptors have been assessed. It is considered that the likelihood of locally caught fish being consumed is low and fisher receptors have not been included in the assessment. For all of the receptor types, adult and child receptors have been considered. The locations of the Resident and Farmer receptors are described in Table 10 and presented in Figure 3.

Table 10: Description of Resident and Farmer Receptors

Ref.	Name	Type	Easting	Northing
FE1	Farmer East 1	Farmer	486650	415600
FE2	Farmer East 2	Farmer	486200	414250
FW1	Farmer West 1	Farmer	485950	418100
FW2	Farmer West 2	Farmer	485900	418050
FW3	Farmer West 3	Farmer	485450	414500

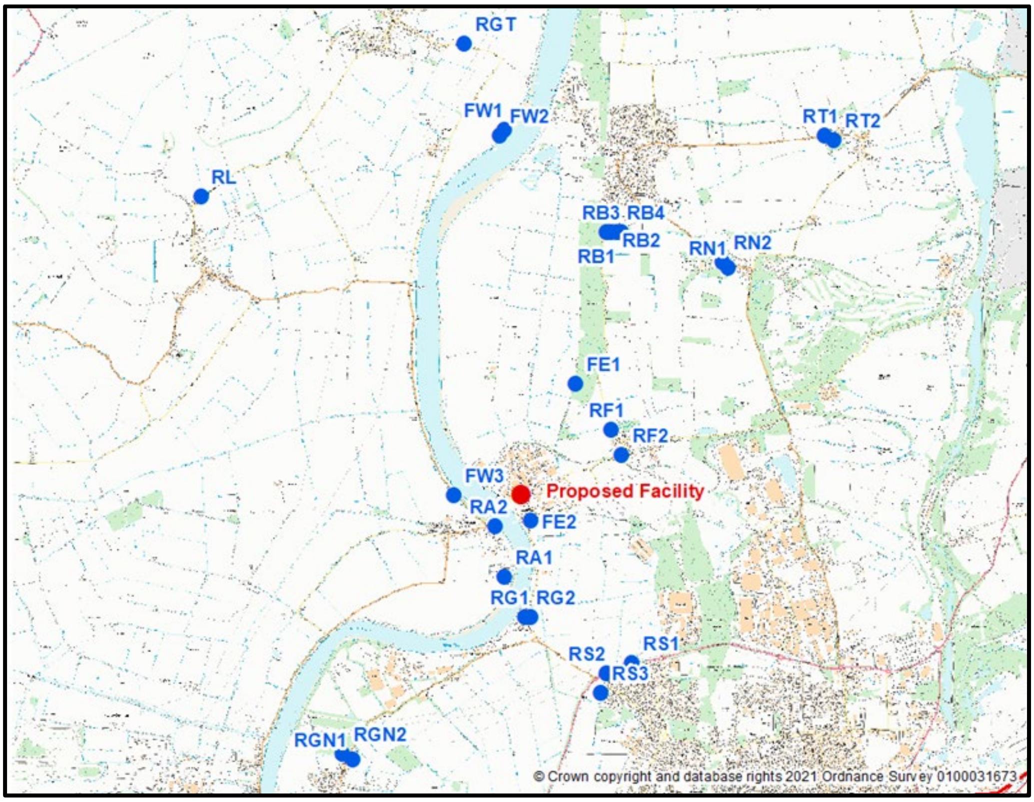
[14] Risk Assessment for Environmental Professionals, CIWEM Publication (December 2001)

Ref.	Name	Type	Easting	Northing
RA1	Resident Amcotts 1	Resident	485950	413700
RA2	Resident Amcotts 2	Resident	485850	414200
RB1	Resident Burton upon Stather 1	Resident	487100	417100
RB2	Resident Burton upon Stather 2	Resident	487000	417100
RB3	Resident Burton upon Stather 3	Resident	486950	417100
RB4	Resident Burton upon Stather 4	Resident	487050	417100
RF1	Resident Flixborough 1	Resident	487000	415150
RF2	Resident Flixborough 2	Resident	487100	414900
RGT	Resident Garthorpe	Resident	485550	418950
RG1	Resident Grange 1	Resident	486200	413300
RG2	Resident Grange 2	Resident	486150	413300
RGN1	Resident Gunness 1	Resident	484450	411900
RGN2	Resident Gunness 2	Resident	484350	411950
RL	Resident Luddington	Resident	482950	417450
RN1	Resident Normanby 1	Resident	488150	416750
RN2	Resident Normanby 2	Resident	488100	416800
RS1	Resident Scunthorpe 1	Resident	487200	412850
RS2	Resident Scunthorpe 2	Resident	486950	412750
RS3	Resident Scunthorpe 3	Resident	486900	412550
RT1	Resident Thealby 1	Resident	489100	418050
RT2	Resident Thealby 2	Resident	489200	418000

4.2.1.5 At other locations not specifically included in the assessment, the predicted intakes will be lower than predicted for the discrete receptors considered.

4.2.1.6 It is assumed for the farmer receptors that land at the maximum predicted impact is used for both arable and pastureland and is considered to be representative of a worst-case.

Figure 3: Location of the Resident and Farmer Receptors



4.3 Assessment of Intake

4.3.1 Ingestion Dose

4.3.1.1 The ingestion intake is calculated as the Average Daily Dose (ADD) from all ingestion exposure routes (e.g. soil, above ground vegetables, meat and dairy products) where for example:

$$ADD_{Ing,TCDD} = \frac{I_{Ing,TCDD} \bullet ED \bullet EF}{AT \bullet 365}$$

Where: $ADD_{Ing,\ TCDD}$ = total ingestion dose for TCDD; ED is the exposure duration (dependent on the receptor type); EF is the exposure frequency (350 days per year); and AT is the average time, and for determining the TDI, is assumed to be equal to the ED. The total dose is the sum of the dose for each of the individual congeners.

4.3.2 Inhalation Dose

4.3.2.1 For inhalation, the ADD from inhalation exposure is calculated as follows:

$$ADD_{Inh,TCDD} = \frac{C_a \bullet IR \bullet ED \bullet EF}{AT \bullet 365}$$

Where: $ADD_{Inh,\ TCDD}$ is the total inhalation does for TCDD, C_a is the concentration of TCDD in air and IR is the daily inhalation rate. The total dose is the sum of the dose for each of the individual congeners.

4.4 Exposure to Dioxins and Furans

4.4.1 Comparison of Dioxin/Furan Exposure with WHO and UK COT Guidance

ERF Contribution to Intake

4.4.1.2 The average (lifetime) daily intake of dioxins/furans for the receptors considered is presented in Table 11. These are compared to the COT TDI for dioxins and dioxin-like PCBs of 2 pg I-TEQ kg-BW^{-1} d^{-1}.

Table 11: Comparison of Average Daily Intakes with the UK COT and Who's TDI for Dioxins/Furans (pg I-TEQ kg-BW-1 d-1)

Receptor Name	Adult	Child
Farmer East 1	0.033	0.048
Farmer East 2	0.027	0.04
Farmer West 1	0.012	0.018
Farmer West 2	0.013	0.018
Farmer West 3	0.011	0.016
Resident Amcotts 1	0.00061	0.0018
Resident Amcotts 2	0.00065	0.0019
Resident Burton upon Stather 1	0.00068	0.0019
Resident Burton upon Stather 2	0.00069	0.002
Resident Burton upon Stather 3	0.00069	0.002
Resident Burton upon Stather 4	0.00069	0.0019
Resident Flixborough 1	0.001	0.003
Resident Flixborough 2	0.0011	0.003
Resident Garthorpe	0.00037	0.0011
Resident Grange 1	0.00061	0.0017
Resident Grange 2	0.0006	0.0017
Resident Gunness 1	0.00015	0.00042
Resident Gunness 2	0.00015	0.00043
Resident Luddington	0.00015	0.00043
Resident Normanby 1	0.00056	0.0016
Resident Normanby 2	0.00056	0.0016
Resident Scunthorpe 1	0.00043	0.0012
Resident Scunthorpe 2	0.00048	0.0014
Resident Scunthorpe 3	0.00046	0.0013
Resident Thealby 1	0.00037	0.001
Resident Thealby 2	0.00036	0.001
WHO TDI	1 to 4 pg I-TEQ kg-BW^{-1} d^{-1}	
Committee on Toxicity (COT) TDI	2 pg I-TEQ kg-BW^{-1} d^{-1}	

4.4.1.3 The maximum contribution of the ERF to the COT TDI is 2.4% for the Farmer East 1 child receptor and 1.7% for the Farmer East 1 adult receptor. This assumes as a worst-case that these receptors produce their own home reared and home-grown food at the location of maximum impact for the area and represents an extreme worst-case.

4.4.1.4 For the residential receptors, the maximum contribution of the ERF to the COT TDI is 0.2% for Resident Flixborough 2 child receptor and 0.1% for Resident Flixborough 2 adult receptor.

Total Intake

4.4.1.5 The contribution of the ERF to total intake is provided as follows:

- predicted incremental intake due to emissions from the ERF;
- average daily background intake (i.e. that arising from other sources), referred to as the mean daily intake (MDI);
- the total intake (i.e. the sum of the predicted incremental intake and the MDI); and
- a comparison of the total intake with the TDI for dioxin/furans.

4.4.1.6 For the key receptors (i.e., those which represent the predicted highest exposure for the receptor types considered) the results are presented in Table 12. Results are presented for both adult and child receptors. The derivation of average background intakes is provided in Section 2.7.1.

4.4.1.7 A comparison of predicted intakes with the MDI and TDI is presented in Table 12. Results are presented for Farmer East 1 and Resident Flixborough 2 receptors where highest farmer and resident exposures are predicted.

Table 12: Comparison of Total Intake with the COT TDI

Receptor	Total Intake from the ERF (pg I-TEQ kg^{-1} d^{-1})	Total Intake ERF + MDI (pg I-TEQ kg^{-1} d^{-1})	ERF as %age of TDI	Total Intake as %age of TDI
Farmer East 1 Adult	0.033	0.65	0.017	0.327
Farmer East 1 Child	0.048	1.22	0.024	0.609
Resident Flixborough 2 Adult	0.0011	0.62	0.001	0.311
Resident Flixborough 2 Child	0.003	1.17	0.002	0.587
COT TDI	2	2	-	-

4.4.1.8 For inhalation and oral intake of PCDD/Fs for adults, total intake is well below the TDI. Background exposure represents approximately 31% of total exposure. At worst, the ERF contributes 1.7% to the TDI for adults. Therefore, the total combined intake is 32.7% for the farmer receptor.

4.4.1.9 For inhalation and oral intake of PCDD/Fs for children, the background intake is 58.5% of the TDI. At worst, the additional contribution from the ERF for a child is 0.048 pg TEQ kg^{-1} d^{-1} (2.4% of the COT TDI). Combined with the background exposure for a 20 kg child (1.17 pg TEQ kg^{-1} d^{-1}) the total intake would be well below the TDI (60.9%). Furthermore, it should be noted that the TDI for PCCD/Fs is set for the purposes of assessing lifetime exposure and these elevated background exposures for children are therefore not representative of long-term exposure. For the resident child, the exposure from the ERF is lower and the total intake represents 58.7% of the TDI for the highest residential receptor intake.

4.4.2 Infant Breast Milk Exposure to Dioxins and Furans

4.4.2.1 Another exposure pathway of interest is infant exposure to dioxins and furans via the ingestion of their mother's breast milk. This is because the potential for contamination of breast milk is particularly high for dioxin-like compounds such as these, as they are extremely lipophilic (fat soluble) and hence likely to accumulate in breast milk. Further, the infant body weight is smaller, and it could be argued that the effect is therefore proportionately greater than in an adult.

4.4.2.2 This exposure is measured by the Average Daily Dose (ADD) on the basis of an averaging time of one year. In the US, a threshold value of 50 pg kg^{-1} d^{-1} of 2,3,7,8-TCDD TEQ is cited as being potentially harmful. The IRAP model calculates the ADD that would result from an adult receptor breast feeding an infant. It should be noted that the ADD calculated by IRAP does not consider dioxin-like PCBs. A summary of the ADD for each of the infants of adult receptors considered for the assessment is presented in Table 13.

Table 13: Assessment of the Average Daily Dose for a Breast-Fed Infant of an Adult Receptor

Receptor Name	Average Daily Dose from Breast Feeding (pg kg^{-1} d^{-1} of 2,3,7,8-TCDD)
Farmer East 1	0.38
Farmer East 2	0.27
Farmer West 1	0.14
Farmer West 2	0.14
Farmer West 3	0.11
Resident Amcotts 1	0.0056
Resident Amcotts 2	0.0059
Resident Burton upon Stather 1	0.0063
Resident Burton upon Stather 2	0.0064
Resident Burton upon Stather 3	0.0064
Resident Burton upon Stather 4	0.0064
Resident Flixborough 1	0.0096
Resident Flixborough 2	0.0097

Receptor Name	Average Daily Dose from Breast Feeding ($pg\ kg^{-1}\ d^{-1}$ of 2,3,7,8-TCDD)
Resident Garthorpe	0.0034
Resident Grange 1	0.0056
Resident Grange 2	0.0055
Resident Gunness 1	0.0014
Resident Gunness 2	0.0014
Resident Luddington	0.0014
Resident Normanby 1	0.0051
Resident Normanby 2	0.0052
Resident Scunthorpe 1	0.004
Resident Scunthorpe 2	0.0044
Resident Scunthorpe 3	0.0043
Resident Thealby 1	0.0034
Resident Thealby 2	0.0033
US EPA Criterion	50
WHO criterion	1 to 4
UK criterion (COT)	2

4.4.2.3 The highest ADDs are calculated for the infants of farmer receptors and represent at worst less than 0.8% of the US EPA criterion of 50 $pg\ kg^{-1}\ d^{-1}$ of 2,3,7,8-TCDD. The calculated ADDs for residential receptors are lower compared to the farmer since the most significant exposure to dioxins/furans is via the food chain, particularly animals and animal products. The farmer receptors are assumed to consume contaminated meat and dairy products. However, residential receptors are only assumed to consume vegetable products which are less significant with regard to exposure to dioxins/furans. For residential receptors, the highest exposure occurs for infants of the Resident Flixborough 2 adult and are less than 0.1% of the US EPA criterion.

4.4.2.4 As a worst case, the ADD for the highest exposure for the infants of farmers (Farmer East 1) is 19% of the COT TDI. For these receptors it is assumed, as a worst-case, that all of the adult's food is reared and grown locally at the location of maximum impact in their area. However, as discussed previously, this is an extreme worst-case. Furthermore, the duration of exposure is short and the average daily intake over the lifetime of the individual would be substantially less.

4.4.2.5 The WHO recognises that breast-fed infants will be exposed to higher intakes for a short duration, but also that breast feeding itself provides associated benefits.

4.5 Exposure to Trace Metals

4.5.1.1 The average daily intake of trace metals for the farmer and resident receptors with the highest intake (Farmer East 1 and Resident Flixborough 2) are presented in Table 14 for the adult receptors and Table 15 for the child receptors. Results for all receptors are provided in Annex D. Estimated background intakes for trace metals are provided in Section 2.7.2.

Table 14: Comparison of Metal Intake with Background Intakes – Farmer East 1 and Resident Flixborough 2 Adult Receptors

Receptor/Metal	ERF Intake (µg kg^{-1} d^{-1})	Percentage of Lower Background Intake
Farmer East 1		
Antimony	2.4 x 10^{-9}	0.0%
Arsenic	1.7 x 10^{-5}	0.0%
Cadmium	1.1 x 10^{-4}	0.1%
Chromium	8.9 x 10^{-4}	0.2%
Lead	2.5 x 10^{-4}	0.4%
Total mercury	1.1 x 10^{-7}	0.0%
Nickel	1.1 x 10^{-3}	0.1%
Thallium	2.7 x 10^{-3}	32.6%
Resident Flixborough 2		
Antimony	1.7 x 10^{-9}	0.0%
Arsenic	4.6 x 10^{-6}	0.0%
Cadmium	5.1 x 10^{-5}	0.0%
Chromium	6.5 x 10^{-5}	0.0%
Lead	5.7 x 10^{-5}	0.1%
Total mercury	2.4 x 10^{-8}	0.0%
Nickel	7.7 x 10^{-5}	0.0%
Thallium	8.2 x 10^{-5}	1.0%

Table 15: Comparison of Metal Intake with Background Intakes – Farmer East 1 and Resident Flixborough 2

Receptor/Metal	ERF Intake (µg kg^{-1} d^{-1})	Percentage of Lower Background Intake
Farmer East 1		
Antimony	5.4 x 10^{-9}	0.0%
Arsenic	2.9 x 10^{-5}	0.0%
Cadmium	2.5 x 10^{-4}	0.1%

Receptor/Metal	ERF Intake (µg kg^{-1} d^{-1})	Percentage of Lower Background Intake
Chromium	1.4×10^{-3}	0.1%
Lead	4.9×10^{-4}	0.4%
Total mercury	2.0×10^{-7}	0.0%
Nickel	1.7×10^{-3}	0.0%
Thallium	3.2×10^{-3}	14.5%
Resident Flixborough 2		
Antimony	4.2×10^{-9}	0.0%
Arsenic	1.1×10^{-5}	0.0%
Cadmium	1.2×10^{-4}	0.0%
Chromium	1.8×10^{-4}	0.0%
Lead	1.4×10^{-4}	0.1%
Total mercury	6.1×10^{-8}	0.0%
Nickel	1.8×10^{-4}	0.0%
Thallium	2.9×10^{-4}	1.3%

4.5.1.2 For the Farmer East 1 adult receptor, predicted intakes vary between 0.0% and 32.6% of the lower background intake and 0.0% and 3.3% of the upper background intake. For the Resident Flixborough 2 adult receptor, predicted intakes vary between 0.0% and 1.0% of the lower background intake and 0.0% and 0.1% of the upper background intake.

4.5.1.3 For the Farmer East 1 child receptor, predicted intakes vary between 0.0% and 14.5% of the lower background intake and 0.0% and 2.0% of the upper background intake. For the Resident Flixborough 2 child receptor, predicted intakes vary between 0.0% and 1.3% of the lower background intake and 0.0% and 1.2% of the upper background intake.

4.5.1.4 Predicted intakes for thallium for farmer receptors are relatively high compared to the lower background intake. However, this represents worst-case conditions with the farmer receptor located at the point of maximum impact and consuming entirely home grown and home reared foods. Furthermore, this is for worst-case emissions for thallium which are assumed to be 50% of the Group 1 limit of 0.02 mg Nm^{-3}. As discussed in *Section 2.4.3*, information provided in the Tolvic report suggests that combined cadmium and thallium are 4% of the IED limit of 0.05 mg Nm^{-3}. Therefore, if this comprised entirely of thallium, an emission concentration of 0.002 mg Nm^{-3} would be more appropriate (a factor of five lower than assumed). For this more typical emission concentration, the intake of metals would be reduced to the following:

- 0.00054 µg kg^{-1} d^{-1} for the Farmer East 1 adult (6.4% of the lower intake and 0.7% of the upper background intake); and
- 0.00064 µg kg^{-1} d^{-1} for the Farmer East 1 child (2.9% of the lower intake and 0.4% of the upper background intake).

4.6 Exposure to Nitrosamines

4.6.1.1 The total lifetime risk calculated by IRAP resulting from exposure to nitrosamine emissions from the ERF for each of the receptors (adult and child) is presented in Table 16.

4.6.1.2 The highest carcinogenic risk is predicted for the Farmer East 2 adult and Resident Flixborough 2 adult. The additional, total, lifetime risks to these receptors are 1.2×10^{-8} (1 in 85,800,000) for the Farmer and 3.8×10^{-9} (1 in 264,152,000) for the Resident. Expressed as an annual risk of exposure to emissions from the ERF, these risk estimates become 1 in 6,006,000,000 for the Farmer East 2 adult and 1 in 18,490,640,000 for the Resident Flixborough 2 adult, assuming a lifetime of 70 years. Such risks are well within an annual risk of 1×10^{-6} (1 in 1 million), conventionally considered to be acceptable for industrial regulation in the UK.

Table 16: Total Lifetime Risk from Exposure to Nitrosamines for Resident and Farmer Receptors

Receptor Name	Total Lifetime Risk for Adult	Total Lifetime Risk for Adult
Farmer East 1	4.8×10^{-9}	1.9×10^{-9}
Farmer East 2	1.2×10^{-8}	4.7×10^{-9}
Farmer West 1	2.0×10^{-9}	7.8×10^{-10}
Farmer West 2	2.0×10^{-9}	7.9×10^{-10}
Farmer West 3	3.3×10^{-9}	1.3×10^{-9}
Resident Amcotts 1	2.6×10^{-9}	1.0×10^{-9}
Resident Amcotts 2	3.5×10^{-9}	1.4×10^{-9}
Resident Burton upon Stather 1	1.9×10^{-9}	7.8×10^{-10}
Resident Burton upon Stather 2	2.0×10^{-9}	8.0×10^{-10}
Resident Burton upon Stather 3	2.0×10^{-9}	8.1×10^{-10}
Resident Burton upon Stather 4	2.0×10^{-9}	7.9×10^{-10}
Resident Flixborough 1	3.5×10^{-9}	1.4×10^{-9}
Resident Flixborough 2	3.8×10^{-9}	1.5×10^{-9}
Resident Garthorpe	1.2×10^{-9}	4.9×10^{-10}
Resident Grange 1	2.3×10^{-9}	9.3×10^{-10}
Resident Grange 2	2.3×10^{-9}	9.3×10^{-10}

Receptor Name	Total Lifetime Risk for Adult	Total Lifetime Risk for Adult
Resident Gunness 1	5.3×10^{-10}	2.1×10^{-10}
Resident Gunness 2	5.5×10^{-10}	2.2×10^{-10}
Resident Luddington	5.5×10^{-10}	2.2×10^{-10}
Resident Normanby 1	1.6×10^{-9}	6.5×10^{-10}
Resident Normanby 2	1.6×10^{-9}	6.6×10^{-10}
Resident Scunthorpe 1	1.4×10^{-9}	5.6×10^{-10}
Resident Scunthorpe 2	1.7×10^{-9}	6.8×10^{-10}
Resident Scunthorpe 3	1.7×10^{-9}	6.7×10^{-10}
Resident Thealby 1	1.1×10^{-9}	4.3×10^{-10}
Resident Thealby 2	1.1×10^{-9}	4.2×10^{-10}
Criterion	7×10^{-5}	

5. SUMMARY AND CONCLUSIONS

5.1 Summary

5.1.1.1 The possible impacts on human health arising from dioxins and furans (PCDD/F) and dioxin-like PCBs and other emissions emitted from the ERF have been assessed under the worst-case scenario, namely that of an individual exposed for a lifetime to the effects of the highest airborne concentrations and consuming mostly locally farm produced food (e.g. grain, vegetables, dairy foods, eggs and meat). This equates to a hypothetical farmer consuming food grown on the farm, situated at the closest proximity to the ERF. Where there are no active farming areas in close proximity, a residential receptor is considered where it is assumed that the resident consumes locally grown vegetables.

5.1.1.2 The assessment has identified and considered the most plausible pathways of exposure for the individuals considered (farmer and resident). Deposition and subsequent uptake of the compounds of potential concern (COPCs) into the food chain is likely to be the more numerically significant pathway over direct inhalation.

5.1.1.3 For PCDD/Fs and dioxin-like PCBs, the maximum contribution of the ERF to the COT TDI is 2.4% for the farmer receptors and 0.1% for the residential receptors. For the farmer this assumes as a worst-case that these receptors are located at the closest farming area to the ERF and all of their food is reared and grown at this location and represents an extreme worst-case. Combined with the background intake of PCDD/Fs and dioxin-like PCBs (i.e. from other sources), the total intake (ERF + background) is well below the COT TDI.

5.1.1.4 For trace metals, predicted intakes vary between 0.0% and 32.6% of the lower background intake and 0.0% and 3.3% of the upper background intake for the worst-case farmer receptor. For the worst-case resident, predicted intakes vary between 0.0% and 1.3% of the lower background intake and 0.0% and 0.2% of the upper background intake. Relative to background intakes, the predicted intakes for child receptors are lower than for adult receptors. Highest intakes are predicted for thallium for farmer receptors. However, the predicted intakes represent worst-case conditions with the farmer receptor located at the point of maximum impact and consuming entirely home grown and home reared foods. Furthermore, predicted intakes are for worst-case emissions for thallium which are assumed to be 50% of the Group 1 limit of 0.02 mg Nm^{-3}. Actual emissions are likely to be substantially less than this as published in the 2020 annual report on UK Energy from Waste Statistics provided by Tolvik Consulting.

5.1.1.5 The highest carcinogenic risk from exposure to nitrosamines is predicted for the Farmer East 2 adult and Resident Flixborough 2 adult. Expressed as an annual risk, these risk estimates are 1 in 6,006,000,000 for the Farmer East 2 adult and 1 in 18,490,640,000 for the Resident Flixborough 2 adult, assuming a lifetime of 70 years. Such risks are well within an annual risk of

1 in 1 million, conventionally considered to be acceptable for industrial regulation in the UK.

5.2 Conclusions

5.2.1.1 The risk assessment methodology used in this assessment has been structured so as to create worst case estimates of risk. A number of features in the methodology give rise to this degree of conservatism. Taking into account the conservative nature of the assessment, it has been demonstrated that even for the maximally exposed individual, exposure to dioxins, furans and dioxin-like PCBs, nitrosamines and trace metals would not have an effect on human health that is any more than negligible at most. This provides considerable confidence that, for the wider population, any health effects arising from emissions of these substances would be effectively absent.

ANNEX A

SITE PARAMETERS

Annex A: Site Parameters Defined for the Health Risk Assessment

Parameter	Parameter Value	IRAP Symbol	Units
Soil dry bulk density	1 5	bd	g cm^{-3}
Forage fraction grown on contam. soil eaten by CATTLE	1 0	beef_fi_forage	--
Grain fraction grown on contam. soil eaten by CATTLE	1 0	beef_fi_grain	--
Silage fraction grown on contam. eaten by CATTLE	1 0	beef_fi_silage	--
Qty of forage eaten by CATTLE each day	8 8	beef_qp_forage	kg DW d^{-1}
Qty of grain eaten by CATTLE each day	0.47	beef_qp_grain	kg DW d^{-1}
Qty of silage eaten by CATTLE each day	2 5	beef_qp_silage	kg DW d^{-1}
Grain fraction grown on contam. soil eaten by CHICKEN	1 0	chick_fi_grain	--
Qty of grain eaten by CHICKEN each day	0 2	chick_qp_grain	kg DW d^{-1}
Fish lipid content	0 07	f_lipid	--
Fraction of CHICKEN's diet that is soil	0.1	fd_chicken	--
Universal gas constant	8 205e-5	gas_r	atm-m^3 mol^{-1} K^{-1}
Plant surface loss coefficient	18	kp	a^{-1}
Fraction of mercury emissions NOT lost to the global cycle	0.48	merc_q_corr	--
Fraction of mercury speciated into methyl mercury in produce	0 22	mercmethyl_ag	--
Fraction of mercury speciated into methyl mercury in soil	0 02	mercmethyl_sc	--
Forage fraction grown contam. soil, eaten by MILK CATTLE	1 0	milk_fi_forage	--
Grain fraction grown contam. soil, eaten by MILK CATTLE	1 0	milk_fi_grain	--
Silage fraction grown contam. soil, eaten by MILK CATTLE	1 0	milk_fi_silage	--
Qty of forage eaten by MILK CATTLE each day	13.2	milk_qp_forage	kg DW d^{-1}
Qty of grain eaten by MILK CATTLE each day	3 0	milk_qp_grain	kg DW d^{-1}
Qty of silage eaten by MILK CATTLE each day	4.1	milk_qp_silage	kg DW d^{-1}
Averaging time	1	milkfat_at	a
Body weight of infant	9.4	milfat_bw_infant	kg
Exposure duration of infant to breast milk	1	milkfat_ed	a
Proportion of ingested dioxin that is stored in fat	0.9	milkfat_f1	--
Proportion of mothers weight that is fat	0 3	milkfat_f2	--
Fraction of fat in breast milk	0 04	milkfat_f3	--
Fraction of ingested contaminant that is absorbed	0.9	milkfat_f4	--
Half-life of dioxin in adults	2555	milkfat_h	d
Ingestion rate of breast milk	0 688	milkfat_ir_milk	kg d^{-1}
Viscosity of air corresponding to air temp.	1 81e-04	mu_a	g cm^{-1} s^{-1}
Fraction of grain grown on contam. soil eaten by PIGS	1 0	pork_fi_grain	--
Fraction of silage grown on contam. soil and eaten by PIGS	1 0	pork_fi_silage	--
Qty of grain eaten by PIGS each day	3 3	pork_qp_grain	kg DW d^{-1}
Qty of silage eaten by PIGS each day	1.4	pork_qp_silage	kg DW d^{-1}
Qty of soil eaten by CATTLE	0 5	qs_beef	kg d^{-1}
Qty of soil eaten by CHICKEN	0 022	qs_chick	kg d^{-1}
Qty of soil eaten by DAIRY CATTLE	0.4	qs_milk	kg d^{-1}
Qty of soil eaten by PIGS	0 37	qs_pork	kg d^{-1}
Density of air	1 2e-3	rho_a	g cm^{-3}
Solids particle density	2.7	rho_s	g cm^{-3}
Interception fraction - edible portion ABOVEGROUND	0 39	rp	--
Interception fraction - edible portion FORAGE	0 5	rp_forage	--
Interception fraction - edible portion SILAGE	0.46	rp_silage	--
Ambient air temperature	298	t	K
Temperature correction factor	1 026	theta	--
Soil volumetric water content	0 2	theta_s	mL cm^{-3}
Length of plant expos. to depos. - ABOVEGROUND	0.16	tp	a
Length of plant expos. to depos. - FORAGE	0.12	tp_forage	a
Length of plant expos. to depos. - SILAGE	0.16	tp_silage	a
Average annual wind speed	3.9	u	m s^{-1}
Dry deposition velocity	0 5	vdv	cm s^{-1}
Dry deposition velocity for mercury	2.9	vdv_hg	cm s^{-1}
Wind velocity	3.9	w	m s^{-1}
Yield/standing crop biomass - edible portion ABOVEGROUND	2 24	yp	kg DW m^{-2}
Yield/standing crop biomass - edible portion FORAGE	0 24	yp_forage	kg DW m^{-2}
Yield/standing crop biomass - edible portion SILAGE	0 8	yp_silage	kg DW m^{-2}
Soil mixing zone depth	2 0	z	cm

ANNEX B

SCENARIO PARAMETERS

Annex B: Exposure Scenario Parameters

Parameter Description	Adult Resident	Child Resident	Adult Farmer	Child Farmer	Adult Fisher	Child Fisher	Units
Averaging time for carcinogens	70	70	70	70	70	70	a
Averaging time for noncarcinogens	30	6	40	6	30	6	a
Consumption rate of BEEF	0.0	0.0	0.00122	0.00075	0.0	0.0	kg kg^{-1} FW d^{-1}
Body weight	70	15	70	15	70	15	kg
Consumption rate of POULTRY	0.0	0.0	0.00066	0.00045	0.0	0.0	kg kg^{-1} FW d^{-1}
Consumption rate of ABOVEGROUND PRODUCE	0.00032	0.00077	0.00047	0.00113	0.00032	0.00077	kg kg^{-1} DW d^{-1}
Consumption rate of BELOWGROUND PRODUCE	0.00014	0.00023	0.00017	0.00028	0.00014	0.00023	kg kg^{-1} DW d^{-1}
Consumption rate of DRINKING WATER	1.4	0.67	1.4	0.67	1.4	0.67	L d^{-1}
Consumption rate of PROTECTED ABOVEGROUND PRODUCE	0.00061	0.0015	0.00064	0.00157	0.00061	0.0015	kg kg^{-1} DW d^{-1}
Consumption rate of SOIL	0.0001	0.0002	0.0001	0.0002	0.0001	0.0002	kg d^{-1}
Exposure duration	30	6	40	6	30	6	yr
Exposure frequency	350	350	350	350	350	350	d a^{-1}
Consumption rate of EGGS	0.0	0.0	0.00075	0.00054	0.0	0.0	kg kg^{-1} FW d^{-1}
Fraction of contaminated ABOVEGROUND PRODUCE	1.0	1.0	1.0	1.0	1.0	1.0	--
Fraction of contaminated DRINKING WATER	1.0	1.0	1.0	1.0	1.0	1.0	--
Fraction contaminated SOIL	1.0	1.0	1.0	1.0	1.0	1.0	--
Consumption rate of FISH	0.0	0.0	0.0	0.0	0.00125	0.00088	kg kg^{-1} FW d^{-1}
Fraction of contaminated FISH	1.0	1.0	1.0	1.0	1.0	1.0	--
Inhalation exposure duration	30	6	40	6	30	6	a
Inhalation exposure frequency	350	350	350	350	350	350	d a^{-1}
Inhalation exposure time	24	24	24	24	24	24	h d^{-1}
Fraction of contaminated BEEF	1	1	1	1	1	1	--
Fraction of contaminated POULTRY	1	1	1	1	1	1	--
Fraction of contaminated EGGS	1	1	1	1	1	1	--
Fraction of contaminated MILK	1	1	1	1	1	1	--
Fraction of contaminated PORK	1	1	1	1	1	1	--
Inhalation rate	0.83	0.30	0.83	0.30	0.83	0.30	m^3 h^{-1}
Consumption rate of MILK	0.0	0.0	0.01367	0.02268	0.0	0.0	kg kg^{-1} FW d^{-1}
Consumption rate of PORK	0.0	0.0	0.00055	0.00042	0.0	0.0	kg kg^{-1} FW d^{-1}
Time period at the beginning of combustion	0	0	0	0	0	0	a
Length of exposure duration	30	6	40	6	30	6	a

ANNEX C

ESTIMATION OF 2012 BACKGROUND PCDD/F INTAKES

Calculation of Dietary Intake of PCDD/Fs and Dioxin-like PCBs

Adult - 70 kg

Foodstuff	ng/kg WHO TEQ/kg fat basis	ng/kg fat WHO TEQ upper	NDNS Years 5-6 Total Fat Intake %	NDNS Years 5-6 Total Fat Intake % Normalised	Average Daily Fat Intake (g/d)	Intake pgTEQ/kgBW/d	Intake pgTEQ/kgBW/d	Intake Normalised for 2001 Discrepancy
Foodstuff	**2001**	**2012**				**2001 but 2012 Diet**	**2012**	**2012**
Bread	0 35	0 277	4 2	4 6	3 1	0 0155	0 0123	0 016
Cereals	0 26	0 134	17 1	18 6	12 6	0 0469	0 0241	0 032
Carcass Meat	0 73	0 534	6 3	6 9	4 6	0 0485	0 0355	0 047
Offal	7 32	1 925	0 2	0 2	0 1	0 0154	0 0041	0 005
Meat Products	0 42	0 203	9 7	10 6	7 2	0 0429	0 0208	0 027
Poultry	0 71	0 148	6 1	6 6	4 5	0 0456	0 0095	0 013
Fish	4 63	3 499	4 6	5 0	3 4	0 2245	0 1696	0 224
fats & Oils	0 19	0 124	9 7	10 6	7 2	0 0194	0 0127	0 017
Eggs	0 44	0 463	4 3	4 7	3 2	0 0199	0 0210	0 028
Sugar	0 45	0 919	3 8	4 1	2 8	0 0180	0 0368	0 049
Green Vegetables	0 84	1 577	0 5	0 5	0 4	0 0044	0 0083	0 011
Potatoes	0 4	0 186	5 2	5 7	3 8	0 0219	0 0102	0 013
Other vegetables	0 37	0 965	1 65	1 8	1 2	0 0064	0 0168	0 022
Canned vegetables	0 45	0 392	1 65	1 8	1 2	0 0078	0 0068	0 009
Fresh Fruit	0 95	1 535	0 45	0 5	0 3	0 0045	0 0073	0 010
Fruit Products	1 26	1 778	0 45	0 5	0 3	0 0060	0 0084	0 011
Milk	0 9	0 421	5	5 4	3 7	0 0474	0 0222	0 029
Milk& Dairy Products	0 89	0 452	8 7	9 5	6 4	0 0816	0 0414	0 055
Nuts	0 2	0 045	2 3	2 5	1 7	0 0048	0 0011	0 001
			91 9	100	67 8	0 68	0 47	0 62

Child - 20 kg, 4 to 10 years

Foodstuff	ng/kg WHO TEQ/kg fat basis	ng/kg fat WHO TEQ upper	NDNS Years 5-6 Total Fat Intake %	NDNS Years 5-6 Total Fat Intake % Normalised	Average Daily Fat Intake (g/d)	Intake pgTEQ/kgBW/d	Intake pgTEQ/kgBW/d	Intake Normalised for 2001 Discrepancy
Foodstuff	**2001**	**2012**				**2001 but 2012 Diet**	**2012**	**2012**
Bread	0 35	0 277	4 0	4 3	2 4	0 0413	0 0327	0 034
Cereals	0 26	0 134	21 0	22 8	12 4	0 1609	0 0829	0 088
Carcass Meat	0 73	0 534	3 6	3 9	2 1	0 0774	0 0567	0 060
Offal	7 32	1 925	0 1	0 1	0 1	0 0216	0 0057	0 006
Meat Products	0 42	0 203	9 5	10 3	5 6	0 1176	0 0568	0 060
Poultry	0 71	0 148	5 3	5 7	3 1	0 1109	0 0231	0 024
Fish	4 63	3 499	2 7	2 9	1 6	0 3684	0 2784	0 294
fats & Oils	0 19	0 124	8 9	9 6	5 2	0 0498	0 0325	0 034
Eggs	0 44	0 463	2 1	2 3	1 2	0 0272	0 0287	0 030
Sugar	0 45	0 919	4 9	5 3	2 9	0 0650	0 1327	0 140
Green Vegetables	0 84	1 577	0 4	0 4	0 2	0 0099	0 0186	0 020
Potatoes	0 4	0 186	5 8	6 3	3 4	0 0684	0 0318	0 034
Other vegetables	0 37	0 965	0 9	1 0	0 5	0 0098	0 0256	0 027
Canned vegetables	0 45	0 392	0 9	1 0	0 5	0 0119	0 0104	0 011
Fresh Fruit	0 95	1 535	0 3	0 3	0 2	0 0084	0 0136	0 014
Fruit Products	1 26	1 778	0 3	0 3	0 2	0 0111	0 0157	0 017
Milk	0 9	0 421	10 6	11 5	6 2	0 2811	0 1315	0 139
Milk& Dairy Products	0 89	0 452	9 8	10 6	5 8	0 2570	0 1305	0 138
Nuts	0 2	0 045	1 2	1 3	0 7	0 0071	0 0016	0 002
			92 3	100	54 4	1 70	1 11	1 17

ANNEX D

PREDICTED TRACE METAL INTAKES

Trace Metal Intake

Receptor	Receptor Type	Source	COPC	EFW Intake ug/kgBW/d	Lower Background ug/kgBW/d	%age	Upper Background ug/kg/d	%age
Farm East 1	farmer_adult	Total	Antimony	2 4E-09	0 016	0 0%	0 029	0 0%
Farm East 1	farmer_adult	Total	Arsenic	1 7E-05	0 91	0 0%	1 0	0 0%
Farm East 1	farmer_adult	Total	Cadmium	1 1E-04	0 12	0 1%	0 19	0 1%
Farm East 1	farmer_adult	Total	Chromium	8 9E-04	0 42	0 2%	1 1	0 1%
Farm East 1	farmer_adult	Total	Lead	2 5E-04	0 062	0 4%	0 11	0 2%
Farm East 1	farmer_adult	Total	Total mercury	1 1E-07	0 022	0 0%	0 041	0 0%
Farm East 1	farmer_adult	Total	Nickel	1 1E-03	1 7	0 1%	1 9	0 1%
Farm East 1	farmer_adult	Total	Thallium (l)	2 7E-03	0 0084	32 6%	0 082	3 3%
Farm East 1	farmer_child	Total	Antimony	5 4E-09	0 028	0 0%	0 055	0 0%
Farm East 1	farmer_child	Total	Arsenic	2 9E-05	1 4	0 0%	1 6	0 0%
Farm East 1	farmer_child	Total	Cadmium	2 5E-04	0 28	0 1%	0 41	0 1%
Farm East 1	farmer_child	Total	Chromium	1 4E-03	1 3	0 1%	2 3	0 1%
Farm East 1	farmer_child	Total	Lead	4 9E-04	0 12	0 4%	0 20	0 2%
Farm East 1	farmer_child	Total	Total mercury	2 0E-07	0 033	0 0%	0 067	0 0%
Farm East 1	farmer_child	Total	Nickel	1 7E-03	3 6	0 0%	4 1	0 0%
Farm East 1	farmer_child	Total	Thallium (l)	3 2E-03	0 022	14 5%	0 16	2 0%
Farm East 2	farmer_adult	Total	Antimony	6 0E-09	0 016	0 0%	0 029	0 0%
Farm East 2	farmer_adult	Total	Arsenic	1 4E-05	0 91	0 0%	1 0	0 0%
Farm East 2	farmer_adult	Total	Cadmium	8 7E-05	0 12	0 1%	0 19	0 0%
Farm East 2	farmer_adult	Total	Chromium	8 4E-04	0 42	0 2%	1 1	0 1%
Farm East 2	farmer_adult	Total	Lead	2 1E-04	0 062	0 3%	0 11	0 2%
Farm East 2	farmer_adult	Total	Total mercury	1 2E-07	0 022	0 0%	0 041	0 0%
Farm East 2	farmer_adult	Total	Nickel	9 0E-04	1 7	0 1%	1 9	0 0%
Farm East 2	farmer_adult	Total	Thallium (l)	3 2E-03	0 0084	37 5%	0 082	3 8%
Farm East 2	farmer_child	Total	Antimony	1 4E-08	0 028	0 0%	0 055	0 0%
Farm East 2	farmer_child	Total	Arsenic	2 4E-05	1 4	0 0%	1 6	0 0%
Farm East 2	farmer_child	Total	Cadmium	2 0E-04	0 28	0 1%	0 41	0 0%
Farm East 2	farmer_child	Total	Chromium	1 4E-03	1 3	0 1%	2 3	0 1%
Farm East 2	farmer_child	Total	Lead	4 0E-04	0 12	0 3%	0 20	0 2%
Farm East 2	farmer_child	Total	Total mercury	2 2E-07	0 033	0 0%	0 067	0 0%
Farm East 2	farmer_child	Total	Nickel	1 4E-03	3 6	0 0%	4 1	0 0%
Farm East 2	farmer_child	Total	Thallium (l)	3 7E-03	0 022	16 8%	0 16	2 3%
Farm West 1	farmer_adult	Total	Antimony	9 8E-10	0 016	0 0%	0 029	0 0%
Farm West 1	farmer_adult	Total	Arsenic	6 0E-06	0 91	0 0%	1 0	0 0%
Farm West 1	farmer_adult	Total	Cadmium	3 9E-05	0 12	0 0%	0 19	0 0%
Farm West 1	farmer_adult	Total	Chromium	3 2E-04	0 42	0 1%	1 1	0 0%
Farm West 1	farmer_adult	Total	Lead	9 1E-05	0 062	0 1%	0 11	0 1%
Farm West 1	farmer_adult	Total	Total mercury	4 0E-08	0 022	0 0%	0 041	0 0%
Farm West 1	farmer_adult	Total	Nickel	4 0E-04	1 7	0 0%	1 9	0 0%
Farm West 1	farmer_adult	Total	Thallium (l)	1 0E-03	0 0084	11 9%	0 082	1 2%
Farm West 1	farmer_child	Total	Antimony	2 2E-09	0 028	0 0%	0 055	0 0%
Farm West 1	farmer_child	Total	Arsenic	1 1E-05	1 4	0 0%	1 6	0 0%
Farm West 1	farmer_child	Total	Cadmium	9 0E-05	0 28	0 0%	0 41	0 0%
Farm West 1	farmer_child	Total	Chromium	5 2E-04	1 3	0 0%	2 3	0 0%
Farm West 1	farmer_child	Total	Lead	1 8E-04	0 12	0 1%	0 20	0 1%
Farm West 1	farmer_child	Total	Total mercury	7 4E-08	0 033	0 0%	0 067	0 0%
Farm West 1	farmer_child	Total	Nickel	6 1E-04	3 6	0 0%	4 1	0 0%
Farm West 1	farmer_child	Total	Thallium (l)	1 2E-03	0 022	5 3%	0 16	0 7%
Farm West 2	farmer_adult	Total	Antimony	9 9E-10	0 016	0 0%	0 029	0 0%
Farm West 2	farmer_adult	Total	Arsenic	6 1E-06	0 91	0 0%	1 0	0 0%
Farm West 2	farmer_adult	Total	Cadmium	3 9E-05	0 12	0 0%	0 19	0 0%
Farm West 2	farmer_adult	Total	Chromium	3 2E-04	0 42	0 1%	1 1	0 0%
Farm West 2	farmer_adult	Total	Lead	9 2E-05	0 062	0 1%	0 11	0 1%
Farm West 2	farmer_adult	Total	Total mercury	4 1E-08	0 022	0 0%	0 041	0 0%
Farm West 2	farmer_adult	Total	Nickel	4 0E-04	1 7	0 0%	1 9	0 0%
Farm West 2	farmer_adult	Total	Thallium (l)	1 0E-03	0 0084	12 0%	0 082	1 2%
Farm West 2	farmer_child	Total	Antimony	2 3E-09	0 028	0 0%	0 055	0 0%
Farm West 2	farmer_child	Total	Arsenic	1 1E-05	1 4	0 0%	1 6	0 0%
Farm West 2	farmer_child	Total	Cadmium	9 0E-05	0 28	0 0%	0 41	0 0%
Farm West 2	farmer_child	Total	Chromium	5 2E-04	1 3	0 0%	2 3	0 0%
Farm West 2	farmer_child	Total	Lead	1 8E-04	0 12	0 1%	0 20	0 1%
Farm West 2	farmer_child	Total	Total mercury	7 4E-08	0 033	0 0%	0 067	0 0%
Farm West 2	farmer_child	Total	Nickel	6 1E-04	3 6	0 0%	4 1	0 0%
Farm West 2	farmer_child	Total	Thallium (l)	1 2E-03	0 022	5 3%	0 16	0 7%
Farm West 3	farmer_adult	Total	Antimony	1 7E-09	0 016	0 0%	0 029	0 0%
Farm West 3	farmer_adult	Total	Arsenic	5 3E-06	0 91	0 0%	1 0	0 0%
Farm West 3	farmer_adult	Total	Cadmium	3 4E-05	0 12	0 0%	0 19	0 0%
Farm West 3	farmer_adult	Total	Chromium	3 1E-04	0 42	0 1%	1 1	0 0%
Farm West 3	farmer_adult	Total	Lead	8 0E-05	0 062	0 1%	0 11	0 1%

Trace Metal Intake

Receptor	Receptor Type	Source	COPC	EFW Intake ug/kgBW/d	Lower Background ug/kgBW/d	%age	Upper Background ug/kg/d	%age
Farm West 3	farmer_adult	Total	Total mercury	4 1E-08	0 022	0 0%	0 041	0 0%
Farm West 3	farmer_adult	Total	Nickel	3 5E-04	1 7	0 0%	1 9	0 0%
Farm West 3	farmer_adult	Total	Thallium (l)	1 1E-03	0 0084	12 8%	0 082	1 3%
Farm West 3	farmer_child	Total	Antimony	3 9E-09	0 028	0 0%	0 055	0 0%
Farm West 3	farmer_child	Total	Arsenic	9 2E-06	1 4	0 0%	1 6	0 0%
Farm West 3	farmer_child	Total	Cadmium	7 9E-05	0 28	0 0%	0 41	0 0%
Farm West 3	farmer_child	Total	Chromium	5 0E-04	1 3	0 0%	2 3	0 0%
Farm West 3	farmer_child	Total	Lead	1 6E-04	0 12	0 1%	0 20	0 1%
Farm West 3	farmer_child	Total	Total mercury	7 7E-08	0 033	0 0%	0 067	0 0%
Farm West 3	farmer_child	Total	Nickel	5 4E-04	3 6	0 0%	4 1	0 0%
Farm West 3	farmer_child	Total	Thallium (l)	1 3E-03	0 022	5 7%	0 16	0 8%
Res Amcotts 1	resident_adult	Total	Antimony	1 1E-09	0 016	0 0%	0 029	0 0%
Res Amcotts 1	resident_adult	Total	Arsenic	2 4E-06	0 91	0 0%	1 0	0 0%
Res Amcotts 1	resident_adult	Total	Cadmium	2 7E-05	0 12	0 0%	0 19	0 0%
Res Amcotts 1	resident_adult	Total	Chromium	3 7E-05	0 42	0 0%	1 1	0 0%
Res Amcotts 1	resident_adult	Total	Lead	3 0E-05	0 062	0 0%	0 11	0 0%
Res Amcotts 1	resident_adult	Total	Total mercury	1 4E-08	0 022	0 0%	0 041	0 0%
Res Amcotts 1	resident_adult	Total	Nickel	4 0E-05	1 7	0 0%	1 9	0 0%
Res Amcotts 1	resident_adult	Total	Thallium (l)	4 8E-05	0 0084	0 6%	0 082	0 1%
Res Amcotts 1	resident_child	Total	Antimony	2 9E-09	0 028	0 0%	0 055	0 0%
Res Amcotts 1	resident_child	Total	Arsenic	5 9E-06	1 4	0 0%	1 6	0 0%
Res Amcotts 1	resident_child	Total	Cadmium	6 5E-05	0 28	0 0%	0 41	0 0%
Res Amcotts 1	resident_child	Total	Chromium	1 0E-04	1 3	0 0%	2 3	0 0%
Res Amcotts 1	resident_child	Total	Lead	7 2E-05	0 12	0 1%	0 20	0 0%
Res Amcotts 1	resident_child	Total	Total mercury	3 5E-08	0 033	0 0%	0 067	0 0%
Res Amcotts 1	resident_child	Total	Nickel	9 7E-05	3 6	0 0%	4 1	0 0%
Res Amcotts 1	resident_child	Total	Thallium (l)	1 7E-04	0 022	0 8%	0 16	0 1%
Res Amcotts 2	resident_adult	Total	Antimony	1 6E-09	0 016	0 0%	0 029	0 0%
Res Amcotts 2	resident_adult	Total	Arsenic	2 1E-06	0 91	0 0%	1 0	0 0%
Res Amcotts 2	resident_adult	Total	Cadmium	2 4E-05	0 12	0 0%	0 19	0 0%
Res Amcotts 2	resident_adult	Total	Chromium	4 0E-05	0 42	0 0%	1 1	0 0%
Res Amcotts 2	resident_adult	Total	Lead	2 7E-05	0 062	0 0%	0 11	0 0%
Res Amcotts 2	resident_adult	Total	Total mercury	1 5E-08	0 022	0 0%	0 041	0 0%
Res Amcotts 2	resident_adult	Total	Nickel	3 6E-05	1 7	0 0%	1 9	0 0%
Res Amcotts 2	resident_adult	Total	Thallium (l)	5 2E-05	0 0084	0 6%	0 082	0 1%
Res Amcotts 2	resident_child	Total	Antimony	4 0E-09	0 028	0 0%	0 055	0 0%
Res Amcotts 2	resident_child	Total	Arsenic	5 2E-06	1 4	0 0%	1 6	0 0%
Res Amcotts 2	resident_child	Total	Cadmium	5 7E-05	0 28	0 0%	0 41	0 0%
Res Amcotts 2	resident_child	Total	Chromium	1 1E-04	1 3	0 0%	2 3	0 0%
Res Amcotts 2	resident_child	Total	Lead	6 4E-05	0 12	0 1%	0 20	0 0%
Res Amcotts 2	resident_child	Total	Total mercury	3 7E-08	0 033	0 0%	0 067	0 0%
Res Amcotts 2	resident_child	Total	Nickel	8 6E-05	3 6	0 0%	4 1	0 0%
Res Amcotts 2	resident_child	Total	Thallium (l)	2 1E-04	0 022	0 9%	0 16	0 1%
Res BuS 1	resident_adult	Total	Antimony	8 4E-10	0 016	0 0%	0 029	0 0%
Res BuS 1	resident_adult	Total	Arsenic	3 3E-06	0 91	0 0%	1 0	0 0%
Res BuS 1	resident_adult	Total	Cadmium	3 7E-05	0 12	0 0%	0 19	0 0%
Res BuS 1	resident_adult	Total	Chromium	4 2E-05	0 42	0 0%	1 1	0 0%
Res BuS 1	resident_adult	Total	Lead	4 1E-05	0 062	0 1%	0 11	0 0%
Res BuS 1	resident_adult	Total	Total mercury	1 6E-08	0 022	0 0%	0 041	0 0%
Res BuS 1	resident_adult	Total	Nickel	5 5E-05	1 7	0 0%	1 9	0 0%
Res BuS 1	resident_adult	Total	Thallium (l)	5 3E-05	0 0084	0 6%	0 082	0 1%
Res BuS 1	resident_child	Total	Antimony	2 1E-09	0 028	0 0%	0 055	0 0%
Res BuS 1	resident_child	Total	Arsenic	8 0E-06	1 4	0 0%	1 6	0 0%
Res BuS 1	resident_child	Total	Cadmium	8 9E-05	0 28	0 0%	0 41	0 0%
Res BuS 1	resident_child	Total	Chromium	1 1E-04	1 3	0 0%	2 3	0 0%
Res BuS 1	resident_child	Total	Lead	9 9E-05	0 12	0 1%	0 20	0 0%
Res BuS 1	resident_child	Total	Total mercury	4 0E-08	0 033	0 0%	0 067	0 0%
Res BuS 1	resident_child	Total	Nickel	1 3E-04	3 6	0 0%	4 1	0 0%
Res BuS 1	resident_child	Total	Thallium (l)	1 7E-04	0 022	0 8%	0 16	0 1%
Res BuS 2	resident_adult	Total	Antimony	8 6E-10	0 016	0 0%	0 029	0 0%
Res BuS 2	resident_adult	Total	Arsenic	3 4E-06	0 91	0 0%	1 0	0 0%
Res BuS 2	resident_adult	Total	Cadmium	3 7E-05	0 12	0 0%	0 19	0 0%
Res BuS 2	resident_adult	Total	Chromium	4 3E-05	0 42	0 0%	1 1	0 0%
Res BuS 2	resident_adult	Total	Lead	4 1E-05	0 062	0 1%	0 11	0 0%
Res BuS 2	resident_adult	Total	Total mercury	1 6E-08	0 022	0 0%	0 041	0 0%
Res BuS 2	resident_adult	Total	Nickel	5 6E-05	1 7	0 0%	1 9	0 0%
Res BuS 2	resident_adult	Total	Thallium (l)	5 3E-05	0 0084	0 6%	0 082	0 1%
Res BuS 2	resident_child	Total	Antimony	2 2E-09	0 028	0 0%	0 055	0 0%
Res BuS 2	resident_child	Total	Arsenic	8 1E-06	1 4	0 0%	1 6	0 0%

Trace Metal Intake

Receptor	Receptor Type	Source	COPC	EFW Intake ug/kgBW/d	Lower Background ug/kgBW/d	%age	Upper Background ug/kg/d	%age
Res BuS 2	resident_child	Total	Cadmium	8 9E-05	0 28	0 0%	0 41	0 0%
Res BuS 2	resident_child	Total	Chromium	1 1E-04	1 3	0 0%	2 3	0 0%
Res BuS 2	resident_child	Total	Lead	1 0E-04	0 12	0 1%	0 20	0 0%
Res BuS 2	resident_child	Total	Total mercury	4 0E-08	0 033	0 0%	0 067	0 0%
Res BuS 2	resident_child	Total	Nickel	1 3E-04	3 6	0 0%	4 1	0 0%
Res BuS 2	resident_child	Total	Thallium (l)	1 7E-04	0 022	0 8%	0 16	0 1%
Res BuS 3	resident_adult	Total	Antimony	8 6E-10	0 016	0 0%	0 029	0 0%
Res BuS 3	resident_adult	Total	Arsenic	3 4E-06	0 91	0 0%	1 0	0 0%
Res BuS 3	resident_adult	Total	Cadmium	3 7E-05	0 12	0 0%	0 19	0 0%
Res BuS 3	resident_adult	Total	Chromium	4 3E-05	0 42	0 0%	1 1	0 0%
Res BuS 3	resident_adult	Total	Lead	4 1E-05	0 062	0 1%	0 11	0 0%
Res BuS 3	resident_adult	Total	Total mercury	1 6E-08	0 022	0 0%	0 041	0 0%
Res BuS 3	resident_adult	Total	Nickel	5 6E-05	1 7	0 0%	1 9	0 0%
Res BuS 3	resident_adult	Total	Thallium (l)	5 3E-05	0 0084	0 6%	0 082	0 1%
Res BuS 3	resident_child	Total	Antimony	2 2E-09	0 028	0 0%	0 055	0 0%
Res BuS 3	resident_child	Total	Arsenic	8 1E-06	1 4	0 0%	1 6	0 0%
Res BuS 3	resident_child	Total	Cadmium	8 9E-05	0 28	0 0%	0 41	0 0%
Res BuS 3	resident_child	Total	Chromium	1 1E-04	1 3	0 0%	2 3	0 0%
Res BuS 3	resident_child	Total	Lead	1 0E-04	0 12	0 1%	0 20	0 0%
Res BuS 3	resident_child	Total	Total mercury	4 0E-08	0 033	0 0%	0 067	0 0%
Res BuS 3	resident_child	Total	Nickel	1 3E-04	3 6	0 0%	4 1	0 0%
Res BuS 3	resident_child	Total	Thallium (l)	1 8E-04	0 022	0 8%	0 16	0 1%
Res BuS 4	resident_adult	Total	Antimony	8 5E-10	0 016	0 0%	0 029	0 0%
Res BuS 4	resident_adult	Total	Arsenic	3 3E-06	0 91	0 0%	1 0	0 0%
Res BuS 4	resident_adult	Total	Cadmium	3 7E-05	0 12	0 0%	0 19	0 0%
Res BuS 4	resident_adult	Total	Chromium	4 2E-05	0 42	0 0%	1 1	0 0%
Res BuS 4	resident_adult	Total	Lead	4 1E-05	0 062	0 1%	0 11	0 0%
Res BuS 4	resident_adult	Total	Total mercury	1 6E-08	0 022	0 0%	0 041	0 0%
Res BuS 4	resident_adult	Total	Nickel	5 6E-05	1 7	0 0%	1 9	0 0%
Res BuS 4	resident_adult	Total	Thallium (l)	5 3E-05	0 0084	0 6%	0 082	0 1%
Res BuS 4	resident_child	Total	Antimony	2 1E-09	0 028	0 0%	0 055	0 0%
Res BuS 4	resident_child	Total	Arsenic	8 0E-06	1 4	0 0%	1 6	0 0%
Res BuS 4	resident_child	Total	Cadmium	8 9E-05	0 28	0 0%	0 41	0 0%
Res BuS 4	resident_child	Total	Chromium	1 1E-04	1 3	0 0%	2 3	0 0%
Res BuS 4	resident_child	Total	Lead	9 9E-05	0 12	0 1%	0 20	0 0%
Res BuS 4	resident_child	Total	Total mercury	4 0E-08	0 033	0 0%	0 067	0 0%
Res BuS 4	resident_child	Total	Nickel	1 3E-04	3 6	0 0%	4 1	0 0%
Res BuS 4	resident_child	Total	Thallium (l)	1 7E-04	0 022	0 8%	0 16	0 1%
Res Flixborough 1	resident_adult	Total	Antimony	1 5E-09	0 016	0 0%	0 029	0 0%
Res Flixborough 1	resident_adult	Total	Arsenic	4 8E-06	0 91	0 0%	1 0	0 0%
Res Flixborough 1	resident_adult	Total	Cadmium	5 3E-05	0 12	0 0%	0 19	0 0%
Res Flixborough 1	resident_adult	Total	Chromium	6 5E-05	0 42	0 0%	1 1	0 0%
Res Flixborough 1	resident_adult	Total	Lead	5 9E-05	0 062	0 1%	0 11	0 1%
Res Flixborough 1	resident_adult	Total	Total mercury	2 4E-08	0 022	0 0%	0 041	0 0%
Res Flixborough 1	resident_adult	Total	Nickel	7 9E-05	1 7	0 0%	1 9	0 0%
Res Flixborough 1	resident_adult	Total	Thallium (l)	8 1E-05	0 0084	1 0%	0 082	0 1%
Res Flixborough 1	resident_child	Total	Antimony	3 8E-09	0 028	0 0%	0 055	0 0%
Res Flixborough 1	resident_child	Total	Arsenic	1 1E-05	1 4	0 0%	1 6	0 0%
Res Flixborough 1	resident_child	Total	Cadmium	1 3E-04	0 28	0 0%	0 41	0 0%
Res Flixborough 1	resident_child	Total	Chromium	1 7E-04	1 3	0 0%	2 3	0 0%
Res Flixborough 1	resident_child	Total	Lead	1 4E-04	0 12	0 1%	0 20	0 1%
Res Flixborough 1	resident_child	Total	Total mercury	6 0E-08	0 033	0 0%	0 067	0 0%
Res Flixborough 1	resident_child	Total	Nickel	1 9E-04	3 6	0 0%	4 1	0 0%
Res Flixborough 1	resident_child	Total	Thallium (l)	2 8E-04	0 022	1 3%	0 16	0 2%
Res Flixborough 2	resident_adult	Total	Antimony	1 7E-09	0 016	0 0%	0 029	0 0%
Res Flixborough 2	resident_adult	Total	Arsenic	4 6E-06	0 91	0 0%	1 0	0 0%
Res Flixborough 2	resident_adult	Total	Cadmium	5 1E-05	0 12	0 0%	0 19	0 0%
Res Flixborough 2	resident_adult	Total	Chromium	6 5E-05	0 42	0 0%	1 1	0 0%
Res Flixborough 2	resident_adult	Total	Lead	5 7E-05	0 062	0 1%	0 11	0 1%
Res Flixborough 2	resident_adult	Total	Total mercury	2 4E-08	0 022	0 0%	0 041	0 0%
Res Flixborough 2	resident_adult	Total	Nickel	7 7E-05	1 7	0 0%	1 9	0 0%
Res Flixborough 2	resident_adult	Total	Thallium (l)	8 2E-05	0 0084	1 0%	0 082	0 1%
Res Flixborough 2	resident_child	Total	Antimony	4 2E-09	0 028	0 0%	0 055	0 0%
Res Flixborough 2	resident_child	Total	Arsenic	1 1E-05	1 4	0 0%	1 6	0 0%
Res Flixborough 2	resident_child	Total	Cadmium	1 2E-04	0 28	0 0%	0 41	0 0%
Res Flixborough 2	resident_child	Total	Chromium	1 8E-04	1 3	0 0%	2 3	0 0%
Res Flixborough 2	resident_child	Total	Lead	1 4E-04	0 12	0 1%	0 20	0 1%
Res Flixborough 2	resident_child	Total	Total mercury	6 1E-08	0 033	0 0%	0 067	0 0%
Res Flixborough 2	resident_child	Total	Nickel	1 8E-04	3 6	0 0%	4 1	0 0%

Trace Metal Intake

Receptor	Receptor Type	Source	COPC	EFW Intake ug/kgBW/d	Lower Background ug/kgBW/d	%age	Upper Background ug/kg/d	%age
Res Flixborough 2	resident_child	Total	Thallium (l)	2 9E-04	0 022	1 3%	0 16	0 2%
Res G and F	resident_adult	Total	Antimony	5 3E-10	0 016	0 0%	0 029	0 0%
Res G and F	resident_adult	Total	Arsenic	1 7E-06	0 91	0 0%	1 0	0 0%
Res G and F	resident_adult	Total	Cadmium	1 9E-05	0 12	0 0%	0 19	0 0%
Res G and F	resident_adult	Total	Chromium	2 2E-05	0 42	0 0%	1 1	0 0%
Res G and F	resident_adult	Total	Lead	2 1E-05	0 062	0 0%	0 11	0 0%
Res G and F	resident_adult	Total	Total mercury	8 4E-09	0 022	0 0%	0 041	0 0%
Res G and F	resident_adult	Total	Nickel	2 8E-05	1 7	0 0%	1 9	0 0%
Res G and F	resident_adult	Total	Thallium (l)	2 8E-05	0 0084	0 3%	0 082	0 0%
Res G and F	resident_child	Total	Antimony	1 3E-09	0 028	0 0%	0 055	0 0%
Res G and F	resident_child	Total	Arsenic	4 0E-06	1 4	0 0%	1 6	0 0%
Res G and F	resident_child	Total	Cadmium	4 5E-05	0 28	0 0%	0 41	0 0%
Res G and F	resident_child	Total	Chromium	5 9E-05	1 3	0 0%	2 3	0 0%
Res G and F	resident_child	Total	Lead	5 0E-05	0 12	0 0%	0 20	0 0%
Res G and F	resident_child	Total	Total mercury	2 2E-08	0 033	0 0%	0 067	0 0%
Res G and F	resident_child	Total	Nickel	6 7E-05	3 6	0 0%	4 1	0 0%
Res G and F	resident_child	Total	Thallium (l)	9 3E-05	0 022	0 4%	0 16	0 1%
Res Grange 1	resident_adult	Total	Antimony	1 0E-09	0 016	0 0%	0 029	0 0%
Res Grange 1	resident_adult	Total	Arsenic	2 6E-06	0 91	0 0%	1 0	0 0%
Res Grange 1	resident_adult	Total	Cadmium	2 9E-05	0 12	0 0%	0 19	0 0%
Res Grange 1	resident_adult	Total	Chromium	3 7E-05	0 42	0 0%	1 1	0 0%
Res Grange 1	resident_adult	Total	Lead	3 2E-05	0 062	0 1%	0 11	0 0%
Res Grange 1	resident_adult	Total	Total mercury	1 4E-08	0 022	0 0%	0 041	0 0%
Res Grange 1	resident_adult	Total	Nickel	4 3E-05	1 7	0 0%	1 9	0 0%
Res Grange 1	resident_adult	Total	Thallium (l)	4 7E-05	0 0084	0 6%	0 082	0 1%
Res Grange 1	resident_child	Total	Antimony	2 6E-09	0 028	0 0%	0 055	0 0%
Res Grange 1	resident_child	Total	Arsenic	6 2E-06	1 4	0 0%	1 6	0 0%
Res Grange 1	resident_child	Total	Cadmium	6 9E-05	0 28	0 0%	0 41	0 0%
Res Grange 1	resident_child	Total	Chromium	1 0E-04	1 3	0 0%	2 3	0 0%
Res Grange 1	resident_child	Total	Lead	7 7E-05	0 12	0 1%	0 20	0 0%
Res Grange 1	resident_child	Total	Total mercury	3 5E-08	0 033	0 0%	0 067	0 0%
Res Grange 1	resident_child	Total	Nickel	1 0E-04	3 6	0 0%	4 1	0 0%
Res Grange 1	resident_child	Total	Thallium (l)	1 6E-04	0 022	0 7%	0 16	0 1%
Res Grange 2	resident_adult	Total	Antimony	1 0E-09	0 016	0 0%	0 029	0 0%
Res Grange 2	resident_adult	Total	Arsenic	2 5E-06	0 91	0 0%	1 0	0 0%
Res Grange 2	resident_adult	Total	Cadmium	2 8E-05	0 12	0 0%	0 19	0 0%
Res Grange 2	resident_adult	Total	Chromium	3 6E-05	0 42	0 0%	1 1	0 0%
Res Grange 2	resident_adult	Total	Lead	3 1E-05	0 062	0 1%	0 11	0 0%
Res Grange 2	resident_adult	Total	Total mercury	1 4E-08	0 022	0 0%	0 041	0 0%
Res Grange 2	resident_adult	Total	Nickel	4 2E-05	1 7	0 0%	1 9	0 0%
Res Grange 2	resident_adult	Total	Thallium (l)	4 6E-05	0 0084	0 5%	0 082	0 1%
Res Grange 2	resident_child	Total	Antimony	2 6E-09	0 028	0 0%	0 055	0 0%
Res Grange 2	resident_child	Total	Arsenic	6 0E-06	1 4	0 0%	1 6	0 0%
Res Grange 2	resident_child	Total	Cadmium	6 7E-05	0 28	0 0%	0 41	0 0%
Res Grange 2	resident_child	Total	Chromium	9 9E-05	1 3	0 0%	2 3	0 0%
Res Grange 2	resident_child	Total	Lead	7 5E-05	0 12	0 1%	0 20	0 0%
Res Grange 2	resident_child	Total	Total mercury	3 5E-08	0 033	0 0%	0 067	0 0%
Res Grange 2	resident_child	Total	Nickel	1 0E-04	3 6	0 0%	4 1	0 0%
Res Grange 2	resident_child	Total	Thallium (l)	1 6E-04	0 022	0 7%	0 16	0 1%
Res Gunness 1	resident_adult	Total	Antimony	2 3E-10	0 016	0 0%	0 029	0 0%
Res Gunness 1	resident_adult	Total	Arsenic	6 1E-07	0 91	0 0%	1 0	0 0%
Res Gunness 1	resident_adult	Total	Cadmium	6 7E-06	0 12	0 0%	0 19	0 0%
Res Gunness 1	resident_adult	Total	Chromium	8 4E-06	0 42	0 0%	1 1	0 0%
Res Gunness 1	resident_adult	Total	Lead	7 5E-06	0 062	0 0%	0 11	0 0%
Res Gunness 1	resident_adult	Total	Total mercury	3 4E-09	0 022	0 0%	0 041	0 0%
Res Gunness 1	resident_adult	Total	Nickel	1 0E-05	1 7	0 0%	1 9	0 0%
Res Gunness 1	resident_adult	Total	Thallium (l)	1 1E-05	0 0084	0 1%	0 082	0 0%
Res Gunness 1	resident_child	Total	Antimony	5 9E-10	0 028	0 0%	0 055	0 0%
Res Gunness 1	resident_child	Total	Arsenic	1 5E-06	1 4	0 0%	1 6	0 0%
Res Gunness 1	resident_child	Total	Cadmium	1 6E-05	0 28	0 0%	0 41	0 0%
Res Gunness 1	resident_child	Total	Chromium	2 3E-05	1 3	0 0%	2 3	0 0%
Res Gunness 1	resident_child	Total	Lead	1 8E-05	0 12	0 0%	0 20	0 0%
Res Gunness 1	resident_child	Total	Total mercury	8 6E-09	0 033	0 0%	0 067	0 0%
Res Gunness 1	resident_child	Total	Nickel	2 4E-05	3 6	0 0%	4 1	0 0%
Res Gunness 1	resident_child	Total	Thallium (l)	3 7E-05	0 022	0 2%	0 16	0 0%
Res Gunness 2	resident_adult	Total	Antimony	2 4E-10	0 016	0 0%	0 029	0 0%
Res Gunness 2	resident_adult	Total	Arsenic	6 1E-07	0 91	0 0%	1 0	0 0%
Res Gunness 2	resident_adult	Total	Cadmium	6 8E-06	0 12	0 0%	0 19	0 0%
Res Gunness 2	resident_adult	Total	Chromium	8 6E-06	0 42	0 0%	1 1	0 0%

Trace Metal Intake

Receptor	Receptor Type	Source	COPC	EFW Intake ug/kgBW/d	Lower Background ug/kgBW/d	%age	Upper Background ug/kg/d	%age
Res Gunness 2	resident_adult	Total	Lead	7 6E-06	0 062	0 0%	0 11	0 0%
Res Gunness 2	resident_adult	Total	Total mercury	3 4E-09	0 022	0 0%	0 041	0 0%
Res Gunness 2	resident_adult	Total	Nickel	1 0E-05	1 7	0 0%	1 9	0 0%
Res Gunness 2	resident_adult	Total	Thallium (l)	1 1E-05	0 0084	0 1%	0 082	0 0%
Res Gunness 2	resident_child	Total	Antimony	6 1E-10	0 028	0 0%	0 055	0 0%
Res Gunness 2	resident_child	Total	Arsenic	1 5E-06	1 4	0 0%	1 6	0 0%
Res Gunness 2	resident_child	Total	Cadmium	1 6E-05	0 28	0 0%	0 41	0 0%
Res Gunness 2	resident_child	Total	Chromium	2 3E-05	1 3	0 0%	2 3	0 0%
Res Gunness 2	resident_child	Total	Lead	1 8E-05	0 12	0 0%	0 20	0 0%
Res Gunness 2	resident_child	Total	Total mercury	8 7E-09	0 033	0 0%	0 067	0 0%
Res Gunness 2	resident_child	Total	Nickel	2 4E-05	3 6	0 0%	4 1	0 0%
Res Gunness 2	resident_child	Total	Thallium (l)	3 8E-05	0 022	0 2%	0 16	0 0%
Res Luddington	resident_adult	Total	Antimony	2 4E-10	0 016	0 0%	0 029	0 0%
Res Luddington	resident_adult	Total	Arsenic	6 3E-07	0 91	0 0%	1 0	0 0%
Res Luddington	resident_adult	Total	Cadmium	7 0E-06	0 12	0 0%	0 19	0 0%
Res Luddington	resident_adult	Total	Chromium	8 8E-06	0 42	0 0%	1 1	0 0%
Res Luddington	resident_adult	Total	Lead	7 8E-06	0 062	0 0%	0 11	0 0%
Res Luddington	resident_adult	Total	Total mercury	3 4E-09	0 022	0 0%	0 041	0 0%
Res Luddington	resident_adult	Total	Nickel	1 0E-05	1 7	0 0%	1 9	0 0%
Res Luddington	resident_adult	Total	Thallium (l)	1 1E-05	0 0084	0 1%	0 082	0 0%
Res Luddington	resident_child	Total	Antimony	6 0E-10	0 028	0 0%	0 055	0 0%
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APPENDIX C COMMITTEE ON THE MEDICAL EFFECTS OF AIR POLLUTANTS (COMEAP) ASSESSMENT

NORTH LINCOLNSHIRE GREEN ENERGY PARK

North Lincolnshire Green Energy Park

Appendix C: COMEAP Assessment

March 2022

Project No.: EN010116

The business of sustainability

ERM

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Acronyms and Abbreviations

Name	Description
AELs	Associated Emission Levels
BAT	Best Available Techniques
COMEAP	Committee on the Medical Effects of Air Pollutants
DCO	Development Consent Order
EA	Environment Agency
EPA	Environmental Protection Agency
ERF	Energy Recovery Facility
HHRA	Human Health Risk Assessment
HHRAP	Human Health Risk Assessment Protocol
IED	Industrial Emissions Directive
km	kilometres
mg	milligram
MWe	Megawatts
NHS	National Health Service
NLGEP	North Lincolnshire Green Energy Park
NO_x	Oxides of Nitrogen
NO_2	Nitrogen Dioxide
NSIP	Nationally Significant Infrastructure Project
ONS	Office for National Statistics
PM	Particulate Matter
RR	Relative Risk
RDF	Refuse Derived Fuel
SoS	Secretary of State
µm	micrometre
US	United States

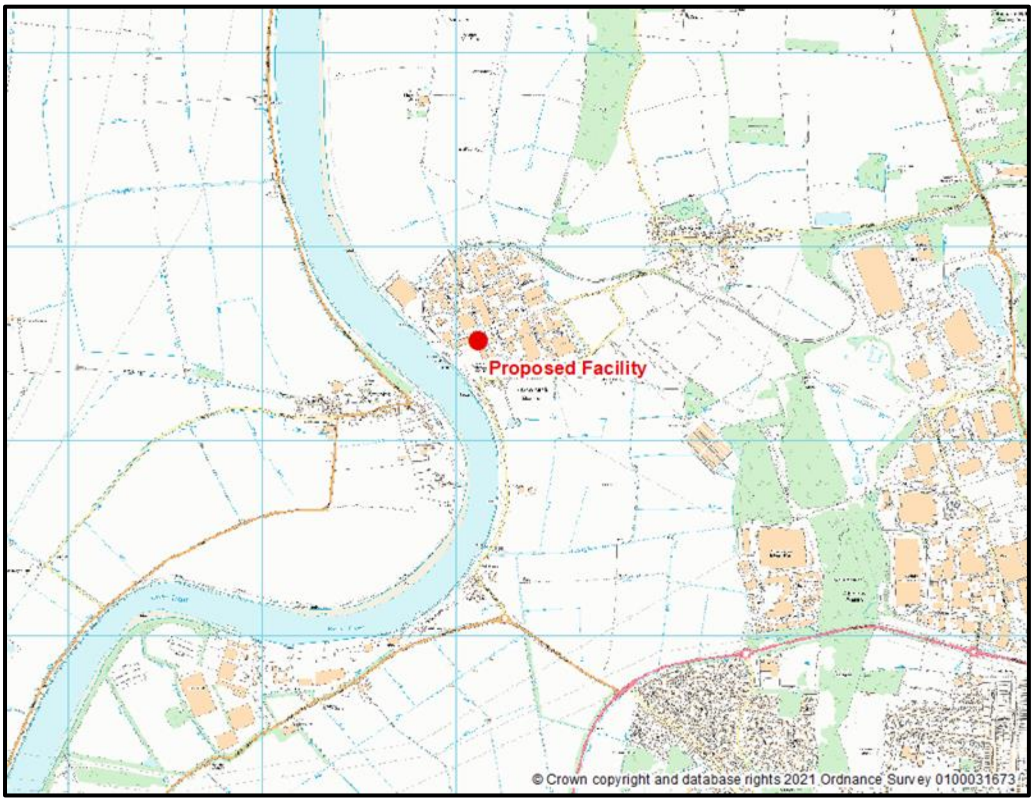
1. INTRODUCTION

1.1 Background

1.1.1.1 The Applicant has commissioned an assessment to consider the effects on human health of exposure to emissions to air from the North Lincolnshire Green Energy Park (NLGEP). The focus of the assessment is the health effects associated with the emissions to air of the oxides of nitrogen (NO_x) and fine particles (PM_{10} and $PM_{2.5}$) from the energy recovery facility (ERF).

1.1.1.2 The location of the ERF is presented in Figure 1. The site is located within an area dominated by industrial use but with agricultural land and residential areas beyond these industrial areas.

Figure 1: Location of the North Lincolnshire Green Energy Park Energy Recovery Facility



1.2 The Proposed Facility

1.2.1.1 The ERF will be capable of efficiently recovering energy stored within waste products. The ERF will have a capacity to convert up to 760,000 tonnes of waste per year, into electricity, with a maximum output of up to 95 megawatts (MWe). Energy is released through combustion of the waste and the heat released by the combustion process is utilised within a boiler to generate steam, used to drive a steam turbine and electricity generator.

1.2.1.2 The waste used to fuel the Facility is known as refuse derived fuel (RDF), made up of municipal solid waste, or commercial or industrial waste of a similar composition, that has undergone treatment and sorting to remove a proportion of any biogenic content and any waste that could be recycled.

1.2.1.3 The main ERF building will house the following key components:

- tipping hall;
- bunker hall;
- boiler hall;
- turbine hall (with air cooled condensers / air blast coolers on the roof);
- flue gas treatment plant;
- district heating equipment;
- switchyard;
- water treatment facility;
- bottom ash hall;
- administration and control room, offices;
- exterior storage tanks for ammonia, diesel and fire water; and
- CO2 capture plant, storage and utilisation.

1.2.1.4 The NLGEP is a Nationally Significant Infrastructure Project (NSIP) under the Planning Act 2008. This is because it is a land-based power generation Facility generating more than 50 megawatts (MWe). Consent for the Facility requires a Development Consent Order (DCO) to be submitted to the Planning Inspectorate. It will determine the application on behalf of the Secretary of State (SoS) and make recommendations to the SoS regarding the consent. The SoS will make the decision on whether to award consent. The operation of the Facility will be regulated by the Environment Agency (EA) under the Environmental Permitting (England and Wales) Regulations 2016.

1.2.1.5 Emissions to air from the Facility will be via three 120 m high flues contained within a common wind shield. Emissions to air from the ERF facility will be governed by the Industrial Emissions Directive[1] (IED). In the absence of site-specific emissions monitoring data for the proposed ERF, the relevant Best Available Techniques (BAT)-Associated Emission Levels (AELs) were used for the assessment. These were obtained from the most recent BAT-conclusions document for waste incineration (European Parliament, 2019).

1.2.1.6 This assessment of health effects from NO_x, PM_{10} and $PM_{2.5}$ emissions supplements the air quality assessment and the human health risk assessment (HHRA) provided for the Facility.

1.2.1.7 The air quality assessment of emissions from the Facility has been provided by the Applicant (**Document Reference 6.2.5**). The air quality assessment provides a comparison of predicted concentrations for pollutant emissions at off-site locations with background air quality and air quality standards and guidelines for the protection of human health. The emissions from the Facility would contain a number of substances that cannot be evaluated in terms of their effects on human health simply by reference to ambient air quality standards. Health effects could occur through exposure routes other than purely inhalation. Therefore, the Applicant has also provided a human health risk assessment[2] to predict the direct and indirect exposure to dioxin/furan emissions from the Facility based on the United States (US) Environmental Protection Agency (EPA) Human Health Risk Assessment

[1] The Industrial Emissions Directive (2010/75/EU)

[2] North Lincolnshire Green Energy Park: Human Health Risk Assessment, Gair Consulting Ltd Report Reference C10-P32-R01 (November 2021)

Protocol (HHRAP)[3] methodology. In addition, the impact of trace metal emissions is provided for those metals included in the HHRAP methodology (arsenic, antimony, cadmium, chromium, mercury, nickel, lead and thallium). As the proposed Facility will be equipped with an amine solvent-based post combustion carbon capture system, emissions of nitrosamines have been considered also for the HHRA. Therefore, this assessment of health effects arising from NO_x and particle emissions supplements the air quality and human health risk assessments.

1.3 Purpose of the Assessment

1.3.1.1 This assessment has been undertaken to support the DCO application for the Facility. It considers the effect on mortality from exposure to nitrogen dioxide (NO_2) and particles of less than 2.5 µm in diameter ($PM_{2.5}$). The assessment also provides an assessment of the increases in hospital admissions due to the additional exposure to particles of less than 10 µm in diameter (PM_{10}).

[3] US EPA Office of Solid Waste (September 2005) Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities

2. METHODOLOGY FOR ESTIMATING EXPOSURE TO EMISSIONS

2.1 Introduction

2.1.1.1 The assessment has considered the impact of emissions from the Facility from population exposure to NO_2, PM_{10} and $PM_{2.5}$. For NO_2 and $PM_{2.5}$, the assessment has considered the effect of emissions on mortality. For PM_{10}, the effect of emissions on the increase in hospital emissions for respiratory and cardiovascular disease is provided.

2.2 Emissions and Dispersion Modelling Input Data

2.2.1 Emission Parameters

2.2.1.1 Emissions from the Facility are assumed to be emitted via three separate flues within a multi-flue stack. However, as a worst-case each flue is assumed to emit individually rather than as a combined emission source. Emission parameters assumed for the assessment are consistent with those used for the air quality assessment and human health risk assessment as summarised in Table 1.

Table 1: Summary of the Emission Parameters for Dispersion Modelling

Parameter	Individual Flue Emissions
Number of sources	3
Stack location grid reference	486116, 414518 486118, 414516 486119, 414519
Stack height (m)	120
Temperature of emission (PoPC)	130
Actual flow rate (mP3P s-1P)	76.6
Emission velocity at stack exit (m sP-1P)	16.0
Normalised flow rate (NmP3P s-1P) (a)	56.5
Flue/effective stack diameter (m)	2.47
Reference conditions of 273K, 1 atmosphere, dry and 11% oxygen	

2.2.1.2 All other model input parameters (e.g. terrain, building downwash etc.) are identical to the air quality assessment provided for the Facility. Dispersion modelling was undertaken for five years of meteorological data obtained from Doncaster Airport (2014 to 2018).

2.2.2 Emission Concentrations

2.2.2.1 Emissions of NO_x and particles are assumed to be at the BAT-AELs. For NO_x an emission concentration of 120 mg Nm^{-3} has been assumed. In accordance with Environment Agency guidance, it is assumed that 70% of NO_x is converted to NO_2. These assumptions are likely to be conservative especially since the Facility would not be able to operate continuously at the maximum emission limit and ensure compliance with the BAT-AEL.

2.2.2.2 For particles, it is assumed that all particles are at a concentration of 5 mg Nm^{-3} and are comprised entirely of $PM_{2.5}$ and/or PM_{10}. Particles emitted from the Facility will comprise a range of sizes including larger particles. Therefore, the assumption that all of the particles are in the finer fractions represents a worst-case.

2.3 Assessment of Health Effects

2.3.1 Relative Risk

2.3.1.1 The assessment predicts the population weighted concentrations of NO_2, PM_{10} and $PM_{2.5}$ for population estimates within each Census Output Area. The sum of these population weighted concentrations is divided by the area population to derive the population weighted concentration for the study area. The area for the study consists of a 20 km radius around the Facility.

2.3.1.2 The Relative Risk (RR) quantifies the ratio of a health outcome at one level of exposure to a pollutant with that at a level 10 µg m^{-3} higher (RR10). Current relative risk values have been obtained from Ricardo Energy and Environment[4] and are based on the recommendations of the Committee on the Medical Effects of Air Pollutants (COMEAP). The long-term RR10 coefficients used in the assessment are provided in Table 2.

Table 2: Long-Term RR10 Coefficients FOR NO_2, PM_{10} AND $PM_{2.5}$ Pollutant

Pollutant	Health Effect	RR10
NO_2	Chronic mortality	1.023
PM_{10}	Respiratory hospital admissions	1.008
PM_{10}	Cardiovascular hospital admissions	1.008
$PM_{2\ 5}$	Chronic mortality	1.060

2.3.1.3 The RR10 is then scaled to a Relative Risk for population-weighted concentration for the area (RRc) using the formula below, where c is the population-weighted concentration:

$$RRc = RR10^{c/10}$$

2.3.1.4 RRc is converted to the Attributable Fraction (AF) using the formula below:

$$AF = \frac{RRc - 1}{RRc}$$

2.3.1.5 The Attributable Fraction is defined as the proportion of instances that a health outcome can be attributed to a risk factor, which in this study is the long-term exposure to NO_2, PM_{10} or $PM_{2.5}$. For example, the proportion of deaths attributable to an increase in NO_2 of 10 µg m^{-3} is 0.023/1.023 x 100 = 2.2% assuming a Relative Risk of 1.023 as provided in Table 2.

2.3.1.6 To obtain the number of annual deaths and hospital admissions attributable to the long-term exposure of NO_2 and particle emissions from the Facility, the Attributable Fraction is multiplied by the relevant baseline rate.

[4] Air Quality Damage Cost Update 2020, Ricardo Energy and Environment, Report for Defra (April 2020)

2.3.2 Baseline Deaths and Hospital Admissions

Baseline Deaths

2.3.2.2 Information on non-accidental deaths over the age of thirty for each local authority area within the study area for 2019 was obtained from the Office for National Statistics (ONS)[5] This was used to determine a baseline rate (per 100,000) for calculating the number of deaths brought forward, attributable to emissions from the Facility. Deaths are available for 2020 but 2019 data was used to avoid any influence from the COVID19 pandemic. A summary of the data for the six local authority areas within the study area is provided in Table 3 for the study area were estimated to be 1,020 per 100,000 population.

Table 3: Calculation of Baseline Deaths for the Study Area for 2019

Local Authority	Local Authority Population	Study Area Population	Local Authority Deaths	Estimated Study Area Deaths
Bassetlaw	117,459	1,369	1,200	14
Doncaster	311,890	28,686	3,029	279
East Riding of Yorkshire	341,173	86,015	3,751	946
North Lincolnshire	172,292	165,750	1,699	1,634
Selby	90,620	1,584	764	13
West Lindsey	95,667	11,661	1,005	123
Total	1,129,101	295,065	11,448	3,009
Total per 100,000	-	-	*1,014*	*1,020*

Baseline Hospital Admissions

2.3.2.3 Respiratory and cardiovascular hospital admissions for 1st April 2019 to 31st March 2020 for England were obtained from the National Health Service (NHS)[6] for England. The values were used for calculating the number of respiratory and cardiovascular hospital admissions attributable to emissions from the Facility. A summary of the data for 2019 to 2020 is provided in Table 4 and compared to data for 2018 to 2019 to ensure there is no influence on the early 2020 data from the COVID19 pandemic.

Table 4: Calculation of Baseline Hospital Admissions for England

Parameter	England 1st April 2018 to 31st March 2019	England 1st April 2019 to 31st March 2020
Total hospital admissions	17,127,498	17,202,558
Respiratory admissions	1,094,428	1,125,884
Respiratory admissions (% of total)	6.4%	6.5%
Cardiovascular admissions	947,224	964,163
Cardiovascular admissions (% of total)	5.5%	5.6%

[5] Mortality statistics – underlying cause, sex and age – Nomis – Official Labour Market Statistics ([redacted]

[6] Hospital Admitted Patient Care Activity, 2019-20: [redacted]

Parameter	England 1st April 2018 to 31st March 2019	England 1st April 2019 to 31st March 2020
Population of England	56,000,000	56,300,000
Respiratory admissions (per 100,000)	1,954	2,000
Cardiovascular admissions (per 100,000)	1,691	1,713
Respiratory admissions for the study area	4,995	5,112
Cardiovascular admissions for the study area	4,324	4,377

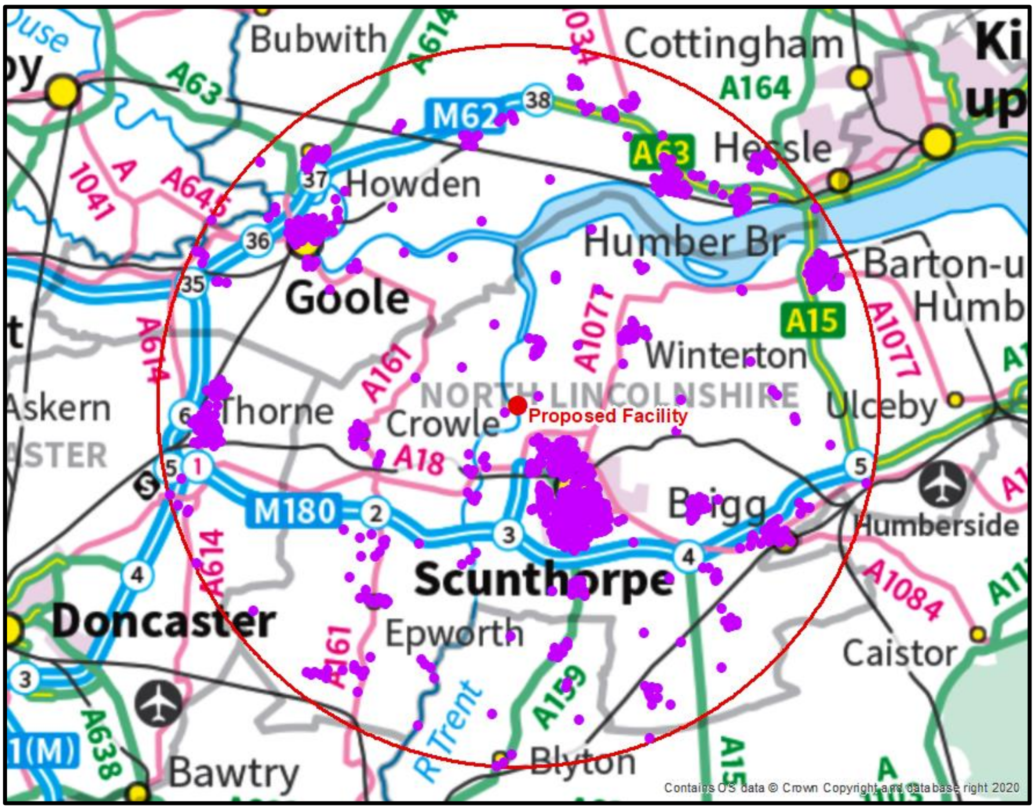
2.3.2.4 Data for 2018/2019 are comparable to 2019/2020. The number of hospital admissions for respiratory and cardiovascular diseases was estimated by dividing the admissions by the population estimate for England provided by ONS. For 2019/2020, respiratory and cardiovascular admissions of 2,000 and 1,713 per 100,000 population were estimated. Data for England were used as information on a local authority basis was not available.

3. EXPOSURE ASSESSMENT

3.1 Population Exposure

3.1.1.1 The population weighted centroids for the study area (20 km radius around the Facility) were obtained from the ONS[7]. These are presented in Figure 2. This identified 780 population centroids with populations varying between 102 and 2,062 and a total population of 255,608. Concentrations of NO_2, PM_{10} and $PM_{2.5}$ were predicted for each population weighted centroid. The Census Output Area population estimates were obtained by ONS for 2019[8].

Figure 2: Location of the Population Weighted Centroids



3.2 Predicted Concentrations

Highest annual mean concentrations of NO_2, PM_{10} and $PM_{2.5}$ occur for a population centroid within the village of Flixborough with a population of 260. Predicted annual mean concentrations of NO_2 at this location are 0.35 µg m^{-3} and 0.021 µg m^{-3} for PM_{10} and $PM_{2.5}$. In the absence of local monitoring data, these are compared to the Defra 2021 mapped background concentrations in Table 5.

Table 5: Comparison of Predicted Facility Contribution with Background Concentrations – Highest Centroid Concentration

Pollutant	Facility Contribution (µg m^{-3})	Defra Background Concentration (µg m^{-3})	Facility as Percentage of Background

[7] Output Areas (December 2011) Population Weighted Centroids: Office of National Statistics

[8] Census Output Area Population Estimates for 2019: Office of National Statistics

NO_2	0.35	8.2	4.3%
PM_{10}	0.021	14.6	0.1%
$PM_{2.5}$	0.021	8.1	0.3%

3.2.1.1 The highest population weighted concentration occurs to the north of Scunthorpe where predicted annual mean concentrations are 0.11 µg m^{-3} for NO_2 and 0.0066 for PM_{10} and $PM_{2.5}$. The population at this centroid is 911. A comparison of the predicted contribution from the Facility at this location with the Defra mapped background concentrations is presented in Table 6.

Table 6: Comparison of Predicted Facility Contribution with Background Concentrations – Highest Population Weighted Centroid

Pollutant	Facility Contribution (µg m^{-3})	Defra Background Concentration (µg m^{-3})	Facility as Percentage of Background
NO_2	0.11	10.5	1.0%
PM_{10}	0.0066	14.2	<0.1%
$PM_{2.5}$	0.0066	8.4	0.1%

3.3 Population Weighted Concentrations

3.3.1.1 For the study area, the population weighted concentration for each pollutant has been derived as the sum of the population weighted concentration for each centroid divided by the total population of the study area. These are as follows:

- 0.061 µg m^{-3} for NO_2; and
- 0.0036 µg m^{-3} for PM_{10} and $PM_{2.5}$.

3.4 Predicted Health Effects

3.4.1 Chronic Mortality

3.4.1.1 For NO_2 and $PM_{2.5}$ the effect of the Facility emissions on chronic mortality is provided in Table 7.

Table 7: Estimate of Chronic Mortality for the Facility Contribution

Parameter	Annual NO_2	Annual $PM_{2.5}$
Population weighted concentration (µg m^{-3})	0.061	0.0036
RR10 (per 10 µg m^{-3})	1.023	1.060
AF	0.00014	0.00021
Baseline deaths (per 100,000)	1,020	1,020
Attributed annual deaths (per 100,000)	0.14	0.021
Deaths brought forward annually	0.36	0.055

3.4.1.2 As the relative risk coefficients per 10 µg m^{-3} change in concentration (RR10) for chronic mortality are available for NO_2 and $PM_{2.5}$, calculations for attributable deaths have been calculated for both pollutants. The resulting number of attributable deaths for NO_2 is higher (6.7 times higher) than for $PM_{2.5}$. Therefore, only the NO_2 attributable deaths and mortality should be taken used as a measure of the total mortality. According to COMEAP[9], it is advised that the higher of the two calculated values should be used to represent the effect of the two pollutants in combination. This is because the health effects of the two air pollutants are correlated with each other in the epidemiological studies. Consequently, both the NO_2 and $PM_{2.5}$ relative risk coefficients may include effects of other pollutants and each other. Adding the NO_2 and $PM_{2.5}$ effects together would over-estimate health effects.

3.4.1.3 The attributed annual deaths arising from emissions from the Facility is 0.36 within the population considered. This can be compared to the total non-accidental deaths for over 30 year olds of 3,009 for the study area and represents 0.01% of the total. Therefore, as a fraction of the total deaths the Facility contribution is extremely small. It should be borne in mind that this expression of the effect on mortality is a ‘shorthand’ one. The reality is that the effect is actually a loss of ‘life years’ across the whole population, which equates to 0.36 of a death.

3.4.2 Hospital Admissions

3.4.2.1 For PM_{10}, the effect of the Facility on respiratory and cardiovascular hospital admissions is provided in Table 8.

3.4.2.2 The number of attributable annual hospital admissions for respiratory and cardiovascular disease is 0.015 and 0.013 admissions, respectively. This compares to estimated baseline respiratory and cardiovascular admissions for the study area of 5,112 and 4,377, respectively. Therefore, the increase in admissions represents less than 0.001% of respiratory and cardiovascular admissions for the study area and is an extremely small increase.

Table 8: Estimate of Hospital Admissions for the Facility Contribution

Parameter	PM_{10} Respiratory Hospital Admissions	PM_{10} Cardiovascular Hospital Admissions
Population weighted PM_{10} concentration (µg m^{-3})	0.0036	0.0036
RR10 (per 10 µg m^{-3})	1.008	1.008
AF	0.0000029	0.0000029
Baseline hospital admissions (per 100,000)	2,000	1,713
Attributed annual hospital admissions (per 100,000)	0.0057	0.0049
Increase in admissions annually	0.015	0.013

[9] Associations of Long-term Average Concentrations of Nitrogen Dioxide with Mortality, a report by the Committee on the Medical Effects of Air Pollutants (2018)

4. SUMMARY AND CONCLUSIONS

4.1 Summary

4.1.1.1 The assessment has considered the health effects in the local population of emissions from the Facility that result in exposure to NO_2, PM_{10} and $PM_{2.5}$. For NO_2 and $PM_{2.5}$, the assessment has considered the effect of emissions on mortality. For PM_{10}, the effect of emissions on the increase in hospital emissions for respiratory and cardiovascular disease is provided. These are the health outcomes and pollutants that are most strongly associated with each other, according to the current understanding of the epidemiological evidence.

4.1.1.2 The attributed annual deaths arising from emissions from the Facility is 0.36. This can be compared to the total non-accidental deaths for over 30 year olds of 3,009 for the study area and represents 0.01% of the total. Therefore, as a fraction of the total deaths the Facility contribution would be extremely small. This result is, in fact, a convenient expression of the effect on mortality, which is more correctly described as a loss of life years experienced across the whole population. In other words, it is not actually the case that 0.36 individuals would die prematurely each year. An alternative expression of the result might be that more people experience a shortening of life measured in hours.

4.1.1.3 The number of attributable annual hospital admissions for respiratory and cardiovascular disease is 0.015 and 0.013 admissions, respectively. This compares to estimated baseline respiratory and cardiovascular admissions for the study area of 5,112 and 4,377, respectively. Therefore, the increase in admissions represents less than 0.001% of respiratory and cardiovascular admissions for the study area and is an extremely small increase.

4.2 Conclusions

4.2.1.1 The assessment has demonstrated that the number of deaths bought forward and the increase in hospital admissions would be extremely small at 0.01% of total deaths for the study area and an increase of less than 0.001% of hospital admissions, respectively. These changes to the health outcomes locally would be negligible and it can be concluded that the health effects caused by emissions of NO_x and PM from the Facility can also be described as negligible.