

**APPENDIX 7B: Human Health Risk Assessment**

# South Humber Bank Energy Centre

South Marsh Road, Stallingborough, DN41 8BZ

**Appendix 7B: Human Health Risk Assessment**

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**Applicant: EP SHB Limited**  
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## 1.0 INTRODUCTION

- 1.1 This Appendix to the Air Quality Assessment (Chapter 7 in ES Volume I) is an assessment of the risk of effects on Human Health arising from changes in air quality from associated with the operation of the proposed South Humber Bank Energy Centre (referred to in this report as the Proposed Development), Grimsby. The study area for this assessment extends 10 km from the Site and includes parts of North East Lincolnshire, North Lincolnshire, East Riding of Yorkshire and West Lindsey District.
- 1.2 The potential health effects associated with emissions to air from the Proposed Development have been assessed assuming emissions at concentrations no greater than those included within the Industrial Emissions Directive (IED) 2010/75/EU (EU, 2010). The IED entered into force on 7th January 2011 and incorporated a number of directives, including the previous Waste Incineration Directive (WID) (EC, 2000), into a single overall directive. All European Union member states are required to transpose the directive into national legislation within two years. The emission limit values and operating conditions specified within WID have been retained within the IED and will continue to be applied in respect of any installation in England from 6 January 2013 until revised Best Available Techniques Achievable Emission Levels (BAT-AELs) are published in the relevant EU BAT Reference document (BREF Note), which may be tighter than IED Emission Limits. In practice, the mitigation employed to ensure compliance with permitted emission rates will deliver lower levels of emissions over the many operational hours throughout the life time of a plant.
- 1.3 The European Joint Research Centre (JRC) has published a revised BREF for the Waste Incineration section (JRC, 2017) in draft form. The BREF considers the current best practice emission controls across the European Union and includes emission limits that are expected to be reached by modern waste incineration plants. The Environment Agency has also conducted a review of group 3 metals emissions from municipal waste incineration facilities in the UK (EA, 2016). The emission limits set out in the BREF and the EA guidance have been used in this assessment.
- 1.4 The health effects associated with exposure to air pollutants has been considered at the population level and in terms of the potential effect on hypothetical individuals experiencing maximum levels of exposure. These different elements of the assessment require the application of distinct assessment methods and are reported here as separate sections of the report.
- 1.5 Section 2 provides an overview of how the magnitude of the predicted concentrations of particulate matter, nitrogen dioxide, sulphur dioxide, metals and organic substances have been estimated using dispersion modelling techniques. The current health of the population of the area surrounding the Proposed Development is summarised in Section 3. The predicted annual mean pollutant concentration values for one of the inputs to the assessment of population level health effects are discussed in Section 4. Finally, the potential for the Proposed Development to affect the total risk for carcinogenic and non-carcinogenic effects occurring is considered in Section 5.

## 2.0 ESTIMATED POLLUTION CONCENTRATIONS

### Overview

2.1 One of the required data inputs to the assessment is the predicted change in annual mean concentrations of PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, NO<sub>2</sub>, metals and organic substances across the assessment domain, due to the operation of the Proposed Development. In this instance, the dispersion model outputs have been taken from an ADMS model used to assess the air quality impacts of the Proposed Development (Chapter 7 in ES Volume I and Appendix 7A in ES Volume III), based on the design of the Proposed Development. The results have been provided as a spatial output for use with the Geographical Information System (GIS) and human health modelling software.

2.2 This section provides a summary of the inputs to the dispersion model.

#### Dispersion Model Setup

2.3 The assessment of emissions from the main stacks serving the Proposed Development has been undertaken using ADMS 5.2, supplied by Cambridge Environmental Research Consultants Limited. ADMS is a modern dispersion model that has an extensive published validation history for use in the UK (CERC, 2017). This model has been extensively used throughout the UK to demonstrate regulatory compliance.

2.4 The physical properties of the main stacks and the emissions data for input to the model were provided by EP SHB Ltd. The modelled pollutant emission rates (in g/s) are equivalent to the emission limits set out within Annex VI of the Industrial Emissions Directive, amended for the BREF BAT-AELs as appropriate, and have been calculated by multiplying the relevant daily average emission limit concentrations by the volumetric flow rate. The data is based on 100% Maximum Continuous Rating (MCR) case when firing the design fuel.

2.5 The meteorological site that was selected for the assessment was Humberside Airport Meteorological station, located approximately 13 km west of the Site, in flat terrain (see Chapter 7 in ES Volume I). The modelling for this assessment has utilised meteorological data for the period 2013 - 2017, with 2015 providing the worst-case results for long term impacts. The datasets were supplied by ADM Ltd, the UK agent for Trinity Consultants. The dispersion modelling output for each pollutant from this year were used as input for the GIS and health modelling software.

2.6 The Site is located to the north west of Grimsby adjacent to an existing power station on the south bank of the Humber Estuary. The area is a mix of open agricultural land and industrial developments. A surface roughness of 0.1m, corresponding agricultural land, has been selected to represent the local terrain.

2.7 Emissions of NO<sub>x</sub> from the main stacks will consist mainly of Nitric Oxide (NO) at the point of release, oxidising within the atmosphere to form NO<sub>2</sub> as it moves downwind. The modelling assessment has assumed a 70% NO<sub>x</sub> to NO<sub>2</sub> conversion rate at ground level in the calculation of long-term annual mean calculations. Emissions have been modelled such that they are not subject to dry and wet deposition or depleted through chemical reactions. This results in an over-estimation of impacts at receptors.

#### Receptor Grid

2.8 The contribution of emissions from the main stacks to ambient concentrations of pollutants have been modelled at points forming a Cartesian grid, in order to enable the generation of the spatial model output required for use with the GIS and health modelling software. A variable resolution grid was used in order to provide a higher resolution in the immediate area surrounding the Site. The receptor grid is centred on the main stacks, the details are presented in Table 1. The grid extends to 10 km from the stacks in all directions. The height of receptors within the grid was set at 1.5 m for impacts through respiration or at 0 m for impacts through other routes.

**Table 1: Modelled Domain: Variable Receptor Grid**

<b>SPACING (m)</b>	<b>DIMENSIONS (m)</b>	<b>NATIONAL GRID REFERENCE OF SW CORNER OF RECEPTOR GRID</b>
12.5	1,200 x 1,200	522571.7, 412870.9
50	4,800 x 4,800	520771.7, 411070.9
200	20,000 x 20,000	513171.7, 403470.9

### 3.0 BASELINE LOCAL HEALTH CONDITIONS

3.1 Health profiles are produced annually by the Association of Public Health Observatories (APHO), now part of Public Health England (PHE), and these provide a summary of the health of people within defined areas and a comparison of local health with average values for all areas of England. Health profiles have been obtained for the local authority areas of North East Lincolnshire (PHE, 2018a), North Lincolnshire (PHE, 2018b), West Lindsey District (PHE, 2018c), East Riding of Yorkshire (PHE, 2018d), and Lincolnshire County Council (PHE, 2018e) (as the non-metropolitan county authority for the area including West Lindsey District).

**Table 2: Life Expectancy**

COMMUNITY	FEMALE AVERAGE (YEARS <sup>a</sup> )	MALE AVERAGE (YEARS <sup>a</sup> )
England	83.1	79.5
North East Lincolnshire	82.6	77.7
North Lincolnshire	82.6	78.9
West Lindsey	84.2	80.0
East Riding of Yorkshire	83.5	80.1
Lincolnshire	83.2	79.6

<sup>a</sup> Values at birth (2014 - 2016) sourced from the Health Profile for the individual local authority

3.2 Local average life expectancy for people living within each local authority is similar to the national average (see Table 2), with North East Lincolnshire and North Lincolnshire slightly below the national average, and West Lindsey, East Riding of Yorkshire and Lincolnshire all slightly above the national average. There are various factors that may contribute to a lower or higher life expectancy, including life style or behavioural factors (such as smoking and diet) and environmental factors (such as air pollution).

3.3 There are well documented health inequalities between individual areas within each local authority. The most deprived areas within the North East Lincolnshire Council (NELC) administrative area have an average life expectancy for men that is 12.3 years shorter than for men in the least deprived areas, and 7.7 years for women (based on the Slope Index of Inequality (PHE, 2018a)). In North Lincolnshire Council (NLC) administrative area, the gap in life expectancy between the most deprived and the least deprived for men is 9.8 years and for women it is 8.3 years. The Site is located in North East Lincolnshire, and NELC and NLC possess the greatest gaps in life expectancies within the study area.

**Table 3: Baseline Mortality Rates**

Community	Health Outcome per 100,000 Population <sup>a</sup>				Infant Deaths <sup>d</sup>
	Deaths: All Causes <sup>b</sup>	Early Deaths: Heart Disease And Stroke <sup>b</sup>	Early Deaths: Cancer <sup>b</sup>	Road Injuries And Deaths <sup>c</sup>	
England	333.8	73.5	136.8	39.7	3.9
North East Lincolnshire	401.1	91.4	165.6	45.3	3.0
North Lincolnshire	361.5	78.4	149.3	54.4	3.7
West Lindsey	302.4	74.9	123.2	67.9	4.1
East Riding of Yorkshire	303.2	71.4	124.5	54.3	2.4
Lincolnshire	329.5	79.0	133.8	52.4	3.0

<sup>a</sup> sourced from the Health Profile for the individual local authority. <sup>b</sup> values expressed as directly age standardised rate per 100,000 population under 75, 2014-2016. <sup>c</sup> values expressed as rate per 100,000 population 2014-2016. <sup>d</sup> rate per 1,000 live births 2014-2016 sourced from the Health Profile for the individual local authority.

- 3.4 Similar differences in the average male life expectancy were found between the most and least deprived areas of the local authority areas of North East Lincolnshire (12.3 years), North Lincolnshire (9.8 years), West Lindsey (7.0 years), East Riding of Yorkshire (6.9 years), and Lincolnshire (7.2 years) (based on the Slope Index of Inequality published in the Health Profile for each administrative area). Both the male and female average life expectancy values for all the local authority areas shown in Table 2 are within approximately 2 years of the average life expectancy for males and females in England as a whole.
- 3.5 The health outcomes for people living in the different local authority areas of the region set out in Table 3 are contrasted against the England average and considered for each administrative area in turn in the following sections for each administrative area.
- 3.6 An annual report on the health of the local population is undertaken on each administrative area in combination with the local National Health Service (NHS). This used to take the form of an annual report by the director of public health for the area but these are being gradually replaced by a Joint Strategic Needs Assessment (JSNA) report on the health and well-being of the local population. The health of the local population living within each local authority areas in the region is discussed in the following sections.

**Administrative Area of North East Lincolnshire Council**

- 3.7 Performance against various indicators of health for people living in North East Lincolnshire (NEL) is generally worse than the England average (PHE, 2018a).
- 3.8 The JSNA (NELC, 2016a) and Joint Health and Wellbeing Strategy (JHWS) (NELC, 2016b) have been prepared by NELC and the North East Lincolnshire Clinical Commissioning Group (NELCCG), and covers North East Lincolnshire. NEL has higher levels of deprivation compared to the national average, with over 35% of the population living in the bottom quintile (fifths) of the Index of Multiple Deprivation 2015 (PHE, 2018a). NEL is one of the 20% most deprived areas in England, and about 7,900 children (26%) live in low income families. The areas of highest deprivation (those within the lowest quintile) within the authority are in the East Marsh, South, Sidney Sussex, Freshney, Heneage, West Marsh, Immingham and Park wards, predominantly in Grimsby.
- 3.9 The Public Health Outcomes Framework (PHE, 2018f) gives the fraction of mortality attributable to particulate air pollution is 5.2% of all mortality in the authority in persons aged 30 years or

over, slightly lower than the national average of 5.3%, and higher than the regional (Yorkshire and Humber) average of 4.8%.

- 3.10 Early deaths from all causes have decreased for both men and women over the past 15 years, however it still remains higher than the England average. Many indicators are significantly worse than the England average, including child poverty, teenage pregnancy and obesity in both adults and children.
- 3.11 Many of the indices used in the health profile for the area are below the national average, and the JHWS identifies priorities to tackle many of the health inequalities within the area. These priorities include reducing smoking, improving screening and early detection of illness, tackling drug and alcohol misuse, and developing healthy habits and lifestyles.

### **Administrative Area of North Lincolnshire Council**

- 3.12 Performance against various indicators of health for people living in North Lincolnshire (NL) is generally mixed when compared to the England average (PHE, 2018b).
- 3.13 The JSNA (NLC, 2013) and Joint Health and Wellbeing Strategy (JHWS) (NLC, 2016) have been prepared by NLC and the North Lincolnshire Clinical Commissioning Group (NLCCG), and covers North Lincolnshire. North Lincolnshire has similar levels of deprivation compared to the England average, with a slightly higher proportion of the population living in the top two quintiles of the Index of Multiple Deprivation 2015 (PHE, 2018b), although a slightly lower proportion of the population live in the top and bottom quintiles. However, about 5,400 children (18%) are from low income families. The areas of highest deprivation (those within the lowest quintile) within the authority area are in the Brumby, Crosby and Park, Frodingham, Town, Ashby, Kingsway with Lincoln Gardens, Burthorpe upon Stather and Winterton, and Barton wards, predominantly in Scunthorpe.
- 3.14 The Public Health Outcomes Framework (PHE, 2018f) gives the fraction of mortality attributable to particulate air pollution as 5.1% of all mortality in the authority in persons aged 30 years or over, slightly lower than the national average of 5.3%, and higher than the regional (Yorkshire and Humber) average of 4.8%.
- 3.15 Early deaths from all causes have decreased for both men and women over the past 15 years, however it still remains slightly higher than the England average. Many indicators are significantly worse than the England average, including prevalence of smoking (as adults, at time of delivery/birth and in routine and manual occupations), physically active adults and excess weight in adults.
- 3.16 The JHWS focuses on 5 priority actions, including a focus on the 'best start' from conception to 2, addressing poverty and reducing the impact on people, improving literacy (including health literacy) and numeracy skills, improving the safety and vibrancy of the night time economy and advocating and modelling behaviour change. NLC also published an Annual Public Health Report (NLC, 2018). These reports focus on the main health priorities in the area, including smoking, mental health, and healthy lifestyles.

### **Administrative Area of West Lindsey District Council**

- 3.17 Performance against various indicators of health for people living in West Lindsey District (WLD) is varied when compared to the England average (PHE, 2018c).
- 3.18 West Lindsey District Council (WLDC) works with the Lincolnshire West Clinical Commissioning Group (LWCCG) through the Health and Wellbeing Board of Lincolnshire County Council (LCC), as the unitary authority, to produce the JSNA (LCC, 2017) and the JHWS (LCC, 2018), which cover the county of Lincolnshire. WLD has lower levels of deprivation compared to the England average, with a lower proportion of the population living in the lowest quintile of the Index of Multiple Deprivation 2015 (PHE, 2018b). However about 2,700 children (18%) live in low income families. The areas of highest deprivation (those within the lowest quintile) within the authority area in the Gainsborough South-West, Gainsborough East, and Gainsborough North wards, all in Gainsborough.
- 3.19 The Public Health Outcomes Framework (PHE, 2018f) gives the fraction of mortality attributable to particulate air pollution as 5.1% of all mortality in the authority in persons aged 30 years or

over, slightly lower than the national average of 5.3%, and lower than the regional (East Midlands) average of 5.7%.

- 3.20 Early deaths from all causes have decreased for both men and women over the past 15 years, and are slightly lower than the England average. There are a few indicators that are significantly worse than the England average: Killed and seriously injured on roads, smoking status at time of delivery, and children in low income families. The majority of indicators are similar to the England average, or are not significantly different.
- 3.21 Based on the outcomes of the JSNA, the JHWS has 7 priorities for improving the health of the residents of Lincolnshire: mental health and emotional wellbeing (children and young people), mental health (adults), carers, physical activity, housing and health, obesity and dementia.

### **Administrative Area of East Riding of Yorkshire Council**

- 3.22 Performance against various indicators of health for people living the East Riding of Yorkshire (ERYC) is generally better than the England average (PHE, 2018d).
- 3.23 The JSNA (ERYC, 2018a) and the JHWS (ERYC, 2018b) have been prepared by ERYC and the East Riding of Yorkshire Clinical Commissioning Group (ERYCCCG) and covers the East Riding. The East Riding and significantly lower levels of deprivation compared to the England average, with over 50% of the population living in the top two quintiles of the Index of Multiple Deprivation 2015 (PHE, 2018d). Less than 25% of the population live in the bottom two quintiles. However about 6,100 children (12%) live in low income families. The areas of highest deprivation (those within the lowest quintile) within the authority area are in the Bridlington South, South East Holderness, Bridlington Central and Old Town, Goole South, Minster and Woodmansey, and St Mary's wards. These areas are within Bridlington, Beverley, Withersea and Goole.
- 3.24 The Public Health Outcomes Framework (PHE, 2018f) gives the fraction of mortality attributable to particulate air pollution as 4.7% of all mortality in the authority in persons aged 30 years or over, lower than the national average of 5.3%, and slightly lower than the regional (Yorkshire and Humber) average of 4.8%.
- 3.25 Early deaths from all causes have decreased for both men and women over the past 15 years, and are slightly lower than the England average. There are a few indicators that are significantly worse than the England average: Killed and seriously injured on roads, smoking status at time of delivery, and excess weight in adults. The majority of indicators are better than the England average, or are not significantly different.
- 3.26 The priority outcomes from the JSNA for the East Riding of Yorkshire are parenting, unpaid carers, isolation and loneliness and mental and emotional health across the life course.

### **Summary**

- 3.27 The predicted health effects in the assessment of exposure to particulate matter, nitrogen dioxide and sulphur dioxide is considered in the context of observed rates of disease and observed life expectancies on a national level. The methods used in this assessment could make use of either national statistics or local level statistics if such data exists. In this assessment national level statistics have been used, as there are benefits to determining baseline population disease rates on statistics that represent larger numbers of people. There may be differences in the values for the statistical parameters used between the local and national level datasets, but the associated difference in the calculated health effects under consideration would be small.
- 3.28 The assessment of health effects arising from the exposure to metals and organic substances associated with emissions to air from the Proposed Development calculates the additional risk of developing carcinogenic and non-carcinogenic health effects for individual receptors within the potentially exposed population.
- 3.29 The priority action areas for improving the health of people within each local authority area focuses on bringing forward changes to the policies on the social determinants of health namely, mental health, smoking and obesity. The four local authorities within the region have no specific

priority policies for improving the health of the local population by targeting a reduction in air pollution.

## 4.0 POTENTIAL FOR HEALTH EFFECTS FROM EXPOSURE TO PARTICULATE MATTER, NITROGEN DIOXIDE AND SULPHUR DIOXIDE

- 4.1 An assessment of the potential effects on human health due to the operation of the Proposed Development has been carried out with respect to the predicted change in population exposure to particulate matter, sulphur dioxide and nitrogen dioxide (Annex 1). This report applies approaches to the quantification of health effects from predicted pollutant concentrations published by the Department of Health's Committee on the Medical Effect of Air Pollutants (COMEAP) and the Clean Air for Europe (CAFE) programme.
- 4.2 The total population of an area extending 10 km from the location of the Proposed Development was considered in the assessment of acute effects associated with exposure to particulate matter, nitrogen dioxide and sulphur dioxide. The same total population was also used in the assessment of mortality effects associated with chronic exposure to fine particulate matter.
- 4.3 The assessment concluded that, for each pollutant under consideration, the effect of the Proposed Development emissions of particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>), nitrogen dioxide and sulphur dioxide on human health would be relatively small.
- 4.4 The main outcomes of the study are as follows:
- For cardiovascular and respiratory health effects, the effect of each pollutant considered is:
    - An average of 35 minutes of life lost as a result of the Proposed Development for the male population and 11 minutes for the female population for nitrogen dioxide alone;
    - An average of 16 minutes of life lost as a result of the Proposed Development for the male population and 5 minutes for the female population for particulate matter alone; and
    - An average of 31 minutes of life lost as a result of the Proposed Development for the male population and 15 minutes for the female population for the combination of nitrogen dioxide and particulate matter using mutually adjusted coefficients.
  - In comparison, the results published by COMEAP (2018) predict the mortality effects of long term exposure to air pollution to be equivalent to 28,000 – 36,000 deaths in the UK associated with a loss of total population life of 328,000 – 416,000 years. RCPCH and RCP reported that the total mortality burden due to outdoor air pollution is of the order of 40,000 early deaths per year, with a cost to the economy of over £20 Billion per year.
  - The estimated number of extra chronic bronchitis events, associated with the predicted change in concentration of particulate matter in the study area, is 0.034 per annum, which represents an increase of 0.0029% on the corresponding baseline rates for the entire exposed population. Additional cases of hospital admissions for cardiovascular and respiratory symptoms are predicted to rise by 0.005 per annum each. The estimated increase in the occurrence of lower respiratory symptoms in children is 0.008 per annum, which represents a 0.00002% increase on baseline rates. This can be considered as a relatively very slight effect on the health of the exposed population as a whole.
  - Rates of hospital admissions for cardiovascular symptoms, associated with the predicted change in concentration of nitrogen dioxide in the study area, are estimated to increase by 0.102 per annum which represents an increase of 0.005% on the corresponding baseline rates for the entire exposed population. This is considered insignificant when compared to the total incidence of heart disease in the entire population of England, attributable to factors such as diet and lifestyle.

The estimated increase in hospital admissions for respiratory symptoms is predicted to be by 0.001% on a baseline rate of 1,156 admissions per year. The predicted impact for the measure death brought forward is an increase of 0.001% on a baseline rate of 1,140 deaths brought forward per annum.

- The predicted impact for measured deaths brought forward, associated with the predicted change in concentrations of sulphur dioxide in the study area, is an increase of 0.0015% on a baseline rate of 1,140 deaths brought forward per annum. Rates of hospital admissions for respiratory symptoms are estimated to increase by 0.015 per annum, which represents a 0.000013% increase on baseline rates. The change in sulphur dioxide concentrations due to the Proposed Development can be considered as a relatively small effect on the health of the exposed population.

## 5.0 HEALTH EFFECTS ARISING FROM EMISSIONS OF METALS AND ORGANIC COMPOUNDS.

- 5.1 An assessment of the potential effects on human health due to the operation of the Proposed Development has been carried out with respect to the predicted change in population exposure to Chemicals of Potential Concern (COPCs), which include metals and organic substances (Annex 2). This report applies approaches to the quantification of health effects from predicted pollutant concentrations published by the United States Environmental Protection Agency (US EPA) Human Health Risk Assessment Protocol (HHRAP). Tolerable Daily Intake (TDI) values published by the UK Committee on Toxicity (COT) have also been used where appropriate for the quantification of health effects at selected receptors.
- 5.2 The method used to quantify potential health effects associated with the Proposed Development is presented in detail within Annex 2. Relevant receptor locations are shown on Figure 7B.2.1 within this annex.
- 5.3 The assessment of health effects from exposure to metals and organic substances associated with the operation of the Proposed Development are reported in turn.
- 5.4 The contribution of emissions from the Proposed Development to soil concentrations of each metal and the total dioxins/furans and dioxin-like PCBs are low. The impacts represent an additional contribution of less than 0.025% of the respective soil guideline concentration values for metals and less than 0.06% of the soil guideline concentration values for total dioxins/furans and dioxin-like PCBs.
- 5.5 A relatively low additional dietary intake of metals and dioxins/furans and dioxin-like PCBs, when compared to the typical dietary intake values, is predicted to be associated with the operation of the Proposed Development. The predicted additional dietary intake of total mercury in the hypothetical resident G&C\_2 and resident R3 receptor scenarios of less than  $1.8 \times 10^{-5} \mu\text{g kg-BW}^{-1}\text{d}^{-1}$  is markedly less than the equivalent typical UK dietary value of  $9.0 \times 10^{-2} - 1.0 \times 10^{-1} \mu\text{g kg-BW}^{-1}\text{d}^{-1}$ . The additional dietary intake of total dioxins/furans and dioxin-like PCBs at resident receptors is predicted to be approximately 0.03% of typical background UK dietary values, with the daily intake predicted to be approximately 5.6% of the COT TDI value at the farmer receptor location with the highest predicted impact, NELN\_C\_3;
- 5.6 A low additional exposure to total dioxins/furans and dioxin-like PCBs of infants via their mother's breast milk is predicted. Additional daily intake values at resident receptors are predicted to be 0.001% of the US EPA criteria and approximately 0.04% of the UK COT TDI value. At farmer receptors, the highest concentrations represent approximately 1.6% of the US EPA criteria, and 47.28% of the UK COT TDI at NELN\_C\_3;
- 5.7 The maximum predicted non-carcinogenic impact within an urban area would occur at the hypothetical receptor called G&C\_2 and the maximum predicted impact in a rural area would occur at the hypothetical receptor called NELN\_C\_1. The maximum predicted non-carcinogenic impact at any resident receptor would occur at receptor R3. The location of these three receptors and other receptors predicted to experience smaller impacts are illustrated on Figure 7B.2.1 within Appendix A.
- 5.8 A range of chemicals of potential concern have been assessed and of these arsenic, nickel, inorganic mercury and thallium are predicted as having the largest contribution to non-carcinogenic health effects via the inhalation and ingestion pathway. The exposure pathways predicted to contain the largest risk to non-carcinogenic health effects is by inhalation for the hypothetical resident receptor and the hypothetical farmer receptor. The total hazard indices for these hypothetical receptors locations are predicted to be approximately a factor of 15 - 100 below the reference dose at which there is an appreciable risk of health effects occurring over a 70 year lifetime.
- 5.9 The maximum predicted carcinogenic impact within an urban area would occur at the hypothetical receptor called G&C\_2 and the maximum predicted impact in a rural area would occur at the hypothetical receptor called NELN\_C\_3. The maximum predicted carcinogenic impact at any resident receptor would occur at receptor R3. These receptors represent locations

with larger risks to carcinogenic health effects predicted to be associated with the Proposed Development than at any other of the other resident and farmer receptor scenarios.

- 5.10 A range of chemicals of potential concern have been assessed and of these arsenic and cadmium are predicted as having the largest contribution to carcinogenic health effects via the ingestion pathway for resident type receptors, while benzo[a]pyrene and total dioxins/furans and dioxin-like PCBs are predicted as having the largest contribution to carcinogenic health effects via the ingestion pathway for farmer type receptors.
- 5.11 The largest risk of carcinogenic health effects is predicted to occur for arsenic via the inhalation exposure pathway in the hypothetical resident and farmer receptor scenarios. The ingestion of milk and inhalation are predicted to be the exposure pathways with the largest risk of carcinogenic health effects in the hypothetical farmer and resident receptor scenarios respectively. The total lifetime risk at these locations is a 1 in 6,599,379 for receptor G&C\_2, 1 in 4,382,214 for R3, 1 in 51,287 for NELN\_C\_3 and 1 in 607,940 for NELN\_C\_2 risk of developing cancer over the entire lifetime of an individual receptor, which translates into an annual risk of 1 in 461,956,558, 1 in 306,754,972, 1 in 3,590,088 and 1 in 42,555,778 respectively. This is well within the acceptable annual risk of 1 in 1,000,000 for UK industrial operations (CIWEM, 2001).

## 6.0 CONCLUSIONS

- 6.1 The change in annual mean concentrations of particulate matter, nitrogen dioxide and sulphur dioxide, experienced by the population located within 10 km of the Site has been used to estimate effects on the health of the population as a whole. The assessment considers a total population of 148,000 within this urban and rural study area. The assessment concluded that predicted impacts associated with emissions of particulate matter, nitrogen dioxide and sulphur dioxide do not represent a significant effect when compared to the local baseline health of the population in each local authority area.
- 6.2 The HHRA assessment protocol has been widely applied to quantify the carcinogenic and non-carcinogenic risk to human health from exposure of the local community to emissions of metals (elemental Sb, As, Cd, Cr, Hg, Pb and Ni) and organic substances (PCDD/F congeners and PAHs (B[a]P, B[a]A, B[b]F and Chrysene) chemicals of potential concern. The assessment concluded that the maximally exposed individuals within North East Lincolnshire and surrounding areas, would not be subject to a significant additional carcinogenic risk or non-carcinogenic hazard as a consequence of being exposed to metals and organic substances emitted to air from the Proposed Development.
- 6.3 In order to deliver improvements to the quality of life and overall life expectancy of the local population the local health authorities have identified a number of priority areas to target. The areas identified as being able to deliver the greatest benefit to public health do not specifically relate to exposure to pollutants in ambient air but instead focus on wider social and economic determinants of health. The magnitude of the impacts predicted from the operation of the proposed development is so small that the Proposed Development is not considered to represent a significant risk to the health of the local population.

## 7.0 REFERENCES

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