Appendix 23.1
Greenhouse Gas Assessment
Rail Central

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Turley

Contents

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1. Introduction

1.1 This Greenhouse Gas (GHG) Assessment has been prepared by Turley Sustainability to support PEIR Chapter 23 Climate Change Mitigation for Rail Central.

Purpose of the Greenhouse Gas Assessment

1.2 The aim of this report is to describe the potential GHG emissions from the Proposed Development, as well as the upstream and downstream emissions associated with the proposed operation of the rail freight interchange.

Structure of the Report

1.3 The remainder of the GHG assessment is structured as follows:

- **Chapter 2: Methodology -** explains the assessment methodology and steps followed in undertaking this assessment of GHG emissions.
- **Chapter 3: The Proposed Development -** sets out the activities within the Proposed Development.
- **Chapter 4: Scope 1 Emissions Sources –** details the direct GHG emissions that occur as a result of the construction and operation of the development.
- **Chapter 5: Scope 2 Emissions Sources** - details the indirect GHG emissions that occur as a result of the use of purchased electricity, heat or steam consumed in the construction and operation of the development.
- **Chapter 6: Scope 3 Emissions Sources** – details other relevant indirect GHG emissions that occur as a result of the construction and operation of the development.

2. Methodology

Overview of Approach

2.1 This assessment of greenhouse gas emissions is guided by a number of principles as set out in the IEMA Guidance *Assessing Greenhouse Gas Emissions and Evaluating their Significance* (Ref 1). in relation to defining a baseline and completing the assessment.

2.2 In defining the baseline 'current' and 'future' baseline GHG emissions need to be considered. The IEMA guidance states that *'The ultimate goal from establishing a baseline is being able to assess and report the net GHG impact of the proposed project'*. Whilst the IEMA guidance sets out that the current baseline relates to emissions that currently occur on the development site, it also refers to alternative approaches such as those set out in the GHG Project Protocol (Ref 2). These include the assessment of emissions that would otherwise occur elsewhere in a counterfactual scenario.

2.3 This assessment adopts a hybrid approach, including within the baseline the emissions associated with the existing site; emissions that would have otherwise occurred in a counterfactual scenario are relevant to certain emission sources (e.g. freight, employee commuting and the operation of warehousing facilities) and where there is a difference in emissions, these are considered within the assessment, resulting in the net emissions being recorded and compared with the overall baseline.

2.4 IEMA guidance sets out that an assessment process which involves determining the goal and scope of the study, setting study boundaries, deciding on an assessment methodology, collecting the necessary calculation data and calculating/ determining the GHG emission inventory.

2.5 The goal and scope of the assessment are defined within the PEIR Chapter, including how GHG emissions information assessed in this Appendix will be interpreted and used in decision-making.

2.6 An assessment methodology and assessment boundaries have been developed through the application of the Greenhouse Gas Protocol Corporate Standard (Ref 2), known as the 'GHG Protocol' from this point forward.

2.7 The GHG Protocol sets out several principles which have been adopted and applied throughout:

- **Relevance:** ensuring that the GHG inventory appropriately reflects GHG emissions and serves the decision-making needs of users
- **Completeness:** Accounts and reports on all GHG emission sources and activities within the chosen inventory boundary. Exclusions are disclosed and justified.
- **Consistency:** Use consistent methodologies to allow for meaningful comparisons of emissions.
- **Transparency:** Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions

and make appropriate references to the accounting and calculation methodologies and data sources.

- **Accuracy:** Ensure that the quantification of GHG emissions is systematically neither over nor under actual emissions, as far as can be judged, and that uncertainties are reduced as far as practicable.

2.8 The GHG Protocol Initiative is a multi-stakeholder partnership of businesses, non-governmental organisations (NGOs), governments, and others covered by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD). Launched in 1998, the Initiative's mission is to develop internationally accepted GHG accounting and reporting standards for business.

2.9 The standard provides guidance for organisations preparing GHG emissions inventories. It covers the accounting and reporting of the six greenhouse gases covered by the Kyoto Protocol:

- Carbon dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_20)
- Hydroflourocarbons (HFCs)
- Perflourocarbons (PFCs)
- Sulphur Hexaflouride (SF_6)

2.10 The greenhouse gases identified above result in different levels of warming over different timeframes. In order to express the impact of greenhouse gas emissions in a simple manner, ratios of global warming potential (GWP) for each gas are applied. The resulting carbon dioxide equivalent (CO_2e) figure describes the total warming impact of each gas relative to CO_2 over a set period. The ratios applied in this assessment are based on factors published by the Intergovernmental Panel on Climate Change (Ref 3) that describe the total warming impact relative to CO_2 over 100 years. The terms 'emissions' and 'GHG emissions' are used interchangeably in this report and are measured in units of CO_2e.

2.11 This approach is consistent with UK Government emission factors and emission reporting in line with the UK carbon budgets.

2.12 The standard advocates the selection of an appropriate boundary and the reporting of emissions within that boundary. Although there will be no single entity with either financial or operational control of the Proposed Development through construction and operation, an operational control approach has been adopted and applied in this context to the site itself.

Spatial Boundaries & Emission Sources

Existing Site

2.13 Prior to construction, Scope 1 and 2 existing site baseline emissions occur as a result of the combustion of fuels, release of gases and the purchase of electricity associated with activities currently being undertaken within the boundary of the Proposed Development. Scope 3 emissions include all other emissions upstream and downstream of the Proposed Development. Relevant emission sources identified are outlined below:

2.13.1 Scope 1 Emission Sources

2.13.1.1 Stationary combustion (e.g. production of heat in farming operations)

2.13.1.2 Mobile combustion (e.g. farming equipment, on-site transportation transportation)

2.13.1.3 Fugitive emissions (e.g. agricultural methane and fertilizer use)

2.13.2 Scope 2 Emissions Sources

2.13.2.1 Stationary combustion (e.g. use of purchased electricity)

2.13.3 Scope 3 Emission Sources

2.13.3.1 Mobile combustion (e.g. transportation of raw materials/ products/ waste, employee business travel, employee commuting, upstream and downstream transportation of goods)

2.13.3.2 Process emissions (e.g. production of purchased materials)

Note that the upstream and downstream transportation of goods relates both the existing use of the site, and in the wider context, existing transport movements across the wider freight network.

Construction Phase

2.14 During the construction phase, Scope 1 and 2 emissions occur as a result of the combustion of fuels, release of gases and the purchase of electricity associated with the construction of the Proposed Development within the site boundary. Scope 3 emissions include all other emissions upstream and downstream of the Proposed Development associated with its construction. This includes:

2.14.1 Scope 1 Emission Sources

2.14.1.1 Stationary combustion (e.g. production of heat in site cabins)

2.14.1.2 Mobile combustion (e.g. construction equipment, on-site construction transportation)

2.14.1.3 Fugitive emissions (e.g. HFCs during use of refrigeration and air-conditioning equipment)

2.14.2 Scope 2 Emissions Sources

2.14.2.1 Stationary combustion (e.g. use of purchased electricity, heat or steam)

2.14.3 Scope 3 Emission Sources

2.14.3.1 Mobile combustion (e.g. transportation of raw materials/ products/ waste, employee business travel, employee commuting, upstream and downstream transportation of goods)

2.14.3.2 Process emissions (e.g. Production of purchased materials)

Note that during the construction period (2019 – 2029), some operational emissions will occur as a result of the phased handover of completed site elements. These emissions are assessed as operational emissions, but reported separately under the construction phase.

Operational Phases

2.15 During the operational phases, Scope 1 and 2 emissions occur as a result of the combustion of fuels, release of gases and the purchase of electricity associated with the operation of the site within the boundary of the Proposed Development. Scope 3 emissions include all other emissions upstream and downstream of the Proposed Development associated with its operation. This includes:

2.15.1 Scope 1 Emission Sources

2.15.1.1 Stationary combustion (e.g. production of heat and/or electricity)

2.15.1.2 Mobile combustion (e.g. combustion of fuel in mobile plant)

2.15.1.3 Fugitive emissions (e.g. HFCs during use of refrigeration and air-conditioning equipment)

2.15.2 Scope 2 Emissions Sources

2.15.2.1 Stationary combustion (e.g. use of purchased electricity, heat or steam)

2.15.3 Scope 3 Emission Sources

2.15.3.1 Mobile combustion (e.g. transportation of raw materials/ products/ waste, employee business travel, employee commuting, upstream and downstream transportation of goods)

2.15.3.2 Process emissions (e.g. production of purchased materials)

2.16 The basic approach for calculating GHG emissions is to multiply an appropriate emissions factor by the relevant activity data. The applicability of activities and sources of this data are reviewed in detail in the following sections for each of the activities and emissions sources identified in Section 2.5 and 2.6.

2.17 The GHG emissions profile developed for the activities identified in Section 2.5 and 2.6 are then compared with local and national emissions profiles and carbon budgets to provide context for the scale of GHG emissions.

Temporal Boundaries

2.18 In accordance with Chapter 5, the following temporal ranges have been evaluated:

Table 2.1: Temporal boundaries

Timeframe	Construction	Operation 'Short-Term'	Operation 'Long-term'
Project Timeframe	2019-2029	2029-2039	2039-2089

2.19 However, in order not to double count emissions in 2019 and 2039, the following adjustment has been made:

Table 2.2: Adjusted Temporal Boundaries

Timeframe	Construction	Operation 'Short-Term'	Operation 'Long-term'
Project Timeframe	2019-2028	2029-2038	2039-2089

Baseline Assessments

Existing Site

Current Baseline (2018)

2.20 The current site baseline includes the on-site and upstream/ downstream emissions associated with the current use of the Proposed Development site.

Future Baseline (2019)

2.21 The future site baseline assesses the emissions associated with the use of the site immediately prior to consumption; this factors in any changes in emission factors for various fuels over the period between the current site baseline and the commencement of construction.

Cumulative Future Baseline (2019 – 2028)

2.22 A future cumulative baseline is also assessed, which provides an estimate of existing baseline emissions over time, were no development to go ahead. This is assessed on an annual basis, taking into account decarbonisation, but no change in site activities.

Construction (2019 – 2028)

2.23 The construction assessment is an estimate of emissions associated with construction activity of the scale and quantum proposed, with embedded mitigation measures included.

2.24 This assumes that the principles set out in the following documents are in place:

- Construction Environment Management Plan (CEMP)
- Green Infrastructure Plan (GIP)
- Parameters Plan (PP

2.25 The construction assessment is evaluated on an annual basis to allow consideration of the decarbonisation of fuel and electricity supplies and changes that are expected to alter activity data over the period. Both annual totals and a cumulative total for the construction phase are provided.

Construction Emissions after Additional Mitigation

2.26 Further emission reductions are assessed based on additional measures identified and committed to by the client.

Operation during Construction Phase (2019 – 2028)

2.27 The principles outlined in the following section covering short-term operation apply to the operational assessment during the construction period.

2.28 Emissions during the construction period are based on the proportion of development completed over this period.

Short-term Operation (2029 – 2038)

Operational Assessment

2.29 The phased development of the site means that some parts of the site will be operational during the construction period and therefore operational emissions are also assessed during the construction period.

2.30 The operational assessment is based on the quantum of completed units and the anticipated impact that this will have on the operation of the site itself.

2.31 The operational assessment assumes that embedded mitigation is in place and the principles outlined in the documents set out in Section 2.17 are included.

2.32 For buildings, the operational assessment is based on a Building Regulations compliant development (Part L 2013); once constructed, performance in terms of energy usage is not assumed to reduce further over the construction period (2019 – 2028).

2.33 For infrastructure, the operational assessment is based on assumed standard practices, unless other principles are established in the draft CEMP. These are adjusted for anticipated changes in performance and/ or emissions over the period.

2.34 For freight movements, the operational assessment assumes that although the quantity of freight may increase over time, this increase is demand-led and not as a result of the proposed development; there is therefore no net increase in freight assumed as a result of the development, but there will be a modal shift from road to rail. The road movements displaced by rail are calculated and the net difference in emissions is presented; where this results in reduced emissions, this is a saving as a result of the Proposed Development and is subtracted from the total emissions.

2.35 For passenger vehicle movements, the operational baseline assumes that 50% of local, 25% of wider-impact area and 10% of national journeys displace journeys from elsewhere; this is based on the assumptions o set out in Chapter 20, relating to employment additionality.

Operational Emissions after Additional Mitigation

2.36 Further emission reductions are assessed based on additional measures identified and committed to by the client.

Long-term Operation (2039 – 2089)

2.37 A quantitative assessment of emissions beyond 2038 has not been made as there is too much uncertainty around future operational trends, technologies and innovations, energy supplies and emission factors.

2.38 Qualitatively, it is our professional judgement that emissions post-2038 will reduce significantly; indeed, this will be necessary to meet the UK's legally binding targets set for GHG emission reductions by 2050. This qualitative assessment is based upon the following assumptions:

- By 2035 it is expected that emissions related to the use of electricity will reduce by almost 75% compared with current grid emissions (Ref 4).
- There is significant research currently being undertaken into the development of alternative fuels for HGVs and rail uses, which could have a significant impact on both road and rail freight emissions.
- Innovations and cost reductions in battery storage are likely to make the use of renewable energy and electric vehicles more viable in the medium- to long-term, resulting in a market-driven shift (as opposed to policy driven) in the commercial and transportation sectors to renewable fuels and low/ zero emission vehicles
- Many European cities and member states have made commitments relating to the types of vehicles that can be sold in the future, and this is supported by a growing number of manufacturer commitments to produce more vehicles to support cleaner fuels.
- Behaviour changes and the 'sharing economy', supported by disruptive IT infrastructure could reduce the number of private vehicles on the road, particularly in relation to employee commuting.
- Greater collaboration and consolidation of freight could reduce the requirement for shorter-distance freight movements, typically carried out by road; rail legs of such journeys would likely remain.
- Demand-side response and energy efficiency measures, particularly at replacement intervals, are likely to reduce the energy demand form buildings further.

Limitations of the Assessment

2.39 As this is a predictive assessment, there is inherent uncertainty in the results. As far as practicable, data specific to the Proposed Development has been used to develop the activity and emissions profiles, but in some cases this is not possible and other external sources of data are used. In accordance with the principles of the GHG Protocol, all assumptions and data uncertainties are disclosed.

Activity Data

2.40 Information pertaining to the detailed design of the scheme is not yet available, so where necessary, proxy data has been used to provide an estimate of activity for both baseline and estimated actual emissions. Assumptions made have been fully disclosed in the Data Sources sub-section for each category of emissions; any uncertainty around those assumptions has been assessed in the relevant Data Quality and Uncertainty sub-section.

Emission Factors

2.41 The primary source for current emission factors used in this report is the *UK Government GHG Conversion Factors for Company Reporting* (Ref 5), termed "*BEIS Emission Factors*" hereafter. The BEIS Emission Factors are produced annually and are provided for use by UK based organisations reporting on UK operations that occurred during the period 1st April 2016 to 31st March 2017. However, it should be noted that this data is two years out of date and relates to the period 1st April 2014 to 31st March 2015.

2.42 BEIS Emission Factors are based on various sources that are reviewed at different frequencies, some of which may not be annual. Where annual averages are provided, they may not be reflective of the actual supply that will be procured.

2.43 Assessments have been made of likely future emission factors based on data published by various sources relating to the decarbonisation of energy supplies.

2.44 For electricity, this includes *Updated energy and emissions projections: 2017* (BEIS, 2018), including *Figure 5.2: emissions intensity in gCO_2e per kWh electricity from 2017 to 2035*.

Beyond 2035, it is assumed that no further emissions reductions are made.

2.45 For gas, this includes:

- *Next steps for UK heat policy* (Ref 6), and the assumption that in order to meet the fifth carbon budget (central scenario), a reduction in heating emissions of 22% to 2030 relative to 2015 is required.
- *Decarbonising the Gas Network* (Ref 7), which references the above and sets out that the most likely transition to a lower carbon network up to 2030 would include a biomethane injection of up to 4%. Post 2030, a range of measures, including hydrogen, could achieve larger savings. Urgent research is required to understand the costs of and technical issues posed by a hydrogen gas gird, but Government and industry stakeholders advocate one of two broad strategies: hydrogen blending where up to 20% hydrogen could enter the grid, increasing as technologies mature and the supply chain develops; or 100% hydrogen switch which would rapidly achieve major carbon savings, but would require the conversion of all appliances (e.g. boilers)from natural gas to pure hydrogen.

It is therefore assumed that a linear reduction in emissions is achieved to 2030 by annual increases in the supply of biomethane to the gas grid. Beyond 2030, it is assumed that 20% hydrogen enters the grid, and that it is produced by electrolysis.

This has a reduction impact in terms of Scope 1 emissions, but increases Scope 3 emissions associated with WTT and T&D.

3. Site Description

3.1 Chapter 5 of the ES outlines the Proposed Development.

Proposed Development

3.2 The proposed development comprises of the following principal elements:

- Main SRFI Site
- J15a Works
- Other Minor Highways Works

3.3 Chapter 5 of the ES also describes the activities anticipated in relation to each element in further detail; these descriptions have been used to identify and assess the likely GHG impacts associated with the Proposed Development during construction and operation.

3.4 Data from other assessments has also been used to inform our assessment of activity data. Principally, this includes:

- Chapter 10 Agricultural Land
- Chapter 13 Ground Conditions
- Chapter 18 Noise & Vibration
- Chapter 19 Highways & Transportation
- Chapter 20 Socio Economics
- Chapter 22 Waste

General Assumptions

3.5 In accordance with site traffic forecasts produced by MDS Transmodal (Ref 8), it is assumed that the SRFI will operate for 335 days per year.

3.6 The Illustrative Masterplan has been used as the basis for the likely size of individual units.

3.7 The Illustrative Masterplan has also been used as the basis for an outline construction programme produce by Buckingham's, which has also been used in this assessment (and others).

4. Scope 1 Emissions

General Description

4.1 Scope 1 emissions are direct GHG emissions that occur as a result of the combustion of fuels or release of gases.

4.2 As summarised in Section 2.6, the following activities have been identified in relation to the existing use of the Proposed Development site:

- Stationary combustion (e.g. production of heat in farming operations)
- Mobile combustion (e.g. farming equipment, on-site transportation transportation)
- Fugitive emissions (e.g. agricultural methane and fertilizer use)

4.3 As summarised in Section 2.7, the following activities have been identified in relation to the construction of the Proposed Development:

- Stationary combustion (e.g. production of heat in site cabins)
- Mobile combustion (e.g. construction equipment, on-site construction transportation)
- Fugitive emissions (e.g. HFCs during use of refrigeration and air-conditioning equipment)

4.4 As summarised in Section 2.8, the following activities have been identified in relation to the operation of the Proposed Development:

- Stationary combustion (e.g. production of heat and/or electricity in buildings)
- Mobile combustion (e.g. combustion of fuel in mobile plant and equipment)
- Fugitive emissions (e.g. HFCs during use of refrigeration and air-conditioning equipment)

Existing Site

4.5 Stationary combustion: Production of heat and electricity

4.5.1 Description of Process

The site currently accommodates two farms and some small industrial uses.

It is assumed that heat is provided to all buildings that accommodate people and in addition, heat may be generated for use in some farming activities. It is, however, assumed that the provision of heat to industrial units is minimal, so only heat consumed in farming uses is considered here.

4.5.2 Data Sources

*Farm energy use statistics (*Ref 9), last updated in 2013, provide an estimate of energy consumed for different uses relating to different types of farm. The data is based on responses to an additional module on energy consumption within the annual Farm Business Survey. Around 200 farms submitted data, which is split into specific farm types.

This dataset includes an estimate of the quantity of heating oil consumed by the different farm types relevant to the proposed development site, set out in Table 4.5.1 below.

Table 4.5.1: Volume of fuel consumed per hectare of farmland by farming activity

Fuel Type	Cropland (cereals as proxy)	LFA Grazing Livestock
Heating oil [l]	0.1	0.4

The areas of each type of farmland (e.g. grazing land, cropland, grassland) have been assessed based on the Site Extents Plan (drawing 151171/D002), descriptions of the site from the Hydrock Survey and assumptions on activities carried out in each field based on aerial images of the site (for example, the location of the field identified for sheep grazing can be identified from above).

Table 4.5.2: Site area by farmland activity

Farming Activity	Area [ha]
Cropland	2,596
Grazing (sheep)	113
Total Area	**2,709**

Heating oil is assumed to refer to kerosene and the appropriate BEIS Emission Factor of 3.165 kgCO_2e/litre of fuel has been applied.

4.5.3 Calculation Procedure & Estimated Emissions

The estimated quantity of fuel consumed per hectare is multiplied by the area of each farm type.

Table 4.5.3: GHG emissions for use of fuel for the production of heat on the existing site

Farming Activity	Quantity of huel [l]
Cropland	260
Grazing (sheep)	45
TOTAL	**305**

Each fuel quantity is then multiplied by the BEIS Emission Factor for kerosene.

Table 4.5.3: GHG emissions for use of fuel for the production of heat on the existing site

Temporal Range	Total GHG emissions [tCO_2e]	Cumulative GHG Emissions [tCO2e]
Current Baseline (2018)	0.9	-
Future Baseline (2019)	0.9	
Construction (2019 – 2028)	-	9.65
Operation (2029 – 2038)	-	9.65
Total (2019 – 2038)	-	19.29

4.5.4 *Data Limitations & Uncertainty*

The activity data is representative of the mean energy use for a small sample of survey respondents (38 for cereals and 44 for LFA grazing livestock), which may not be representative of wider agricultural practices or the current practices on this specific site.

Assumptions have been made regarding the fuel type which may be incorrect.

4.6 Mobile combustion: Fuel use in mobile plant and equipment

4.6.1 *Description of Process*

Mobile equipment is used to carry out farming activities, such as the ploughing of fields.

4.6.2 *Data Sources*

As outlined in Section 4.5.2, *farm energy use statistics* (Ref 9), last updated in 2013, provide an estimate of energy consumed for different uses relating to different types of farm.

This dataset includes an estimate of the quantity of different fuels consumed by the different farm types; these are assumed to relate to mobile combustion uses and are outlined in Table 4.6.1.

Table 4.6.1: Volume of fuel used per hectare

Fuel type	Cropland (cereals as proxy)	LFA grazing livestock
Road fuel [l]	11	10.3
Red diesel [l]	106.9	15
Red diesel used by contractors [l]	8.7	2.2
LPG [kg]	2	0.5
Kerosene [l]	11.8	6.2

BEIS Emission Factors are applicable to all fuels identified above. Based on fuel descriptions, we have assumed that red diesel is also known as ‘Gas oil’, kerosene is known as ‘burning oil’ and road fuel is ‘forecourt diesel’.

4.6.3 *Calculation Procedure & Estimated Emissions*

The area of each type of farmland is multiplied by the fuel type and associated emission factor.

Table 4.6.2: Estimated annual fuel consumption for existing site

Farm Type	Annual fuel consumption by type			
	Road fuel [kWh]	Red diesel [litres]	Kerosene [litres]	LPG [kg]
Cropland	28,557	300,106	30,634	5,192
Grazing (sheep)	1,162	1,940	699	56
TOTAL	**29,718**	**302,046**	**31,333**	**5,249**

This is then multiplied by the annual emission factor for grid electricity. For illustrative purposes, the cumulative emissions that would be generated across each temporal range if the land were to remain in its current use have also been assessed.

Table 4.6.3: GHG emissions for use of fuel in plant and equipment at existing site

Temporal Range	GHG Emissions [tCO_2e]	Cumulative GHG Emissions [tCO2e]
Current Baseline (2018)	1,257	-
Future Baseline (2019)	1,257	-
Construction (2019 – 2028)	-	12,569
Operation (2029 – 2038)	-	12,569
Total (2019 – 2038)	-	25,137

4.6.1 *Data Limitations & Uncertainty*

The activity data is representative of the mean energy use for a small sample of survey respondents (38 for cereals and 44 for LFA grazing livestock), which may not be representative of wider agricultural practices.

Assumptions have been made regarding the fuel type and heat generation method, which may be incorrect.

4.7 Fugitive Emissions: Agricultural emissions

4.7.1 Description of Processes

There are a number of mechanisms by which GHG emissions are released during agricultural activity. These include:

- Nitrous oxide is produced from soil through microbial processes that convert nitrogen from nitrogen fertilizers, manure, and crop residues into various nitrogen gases, including N_2O, which is a GHG 298 times more potent than CO_2.
- Methane, 25 times more potent than CO_2, is also released as a result of the digestion processes of cattle.
- Soil disturbance during tillage tends to stimulate soil carbon loses through enhanced decomposition and erosion.

Whilst these emissions may be significant, they are dependent on a large number of local factors and practices of which we have no knowledge.

These emissions have therefore been scoped out for reasons of proportionality to the assessment.

Construction

4.8 Stationary combustion: Production of heat and electricity

4.8.1 Description of Process

It is possible that a small quantity of fuel will be consumed for the generation of heat and electricity during the early stages of the construction process, before an electricity supply is established. This would involve the use of generators to run site compound facilities.

Additional generators may be used to run other site plant.

Emissions associated with stationary combustion of fuels are included within the assessment of fuel use in mobile plant and equipment (Section 4.9)

4.9 Mobile combustion: Fuel use in plant and equipment

4.9.1 Description of Process

Fuels will be consumed in mobile plant and equipment used in the construction of the Proposed Development, including (but not limited to) cranes, diggers and piling rigs. In addition, some plant may be run off generators (used to generate electricity).

4.9.2 Data Sources

All UK listed companies are required, as a minimum, to provide an assessment of their annual Scope 1 and Scope 2 GHG emissions, alongside appropriate intensity metrics. Scope 1 and 2 emissions are those generated as a result of activities within the reporting organisations operational or financial control and for construction companies, typically include emissions related to their site operations.

Whilst a main contractor has not been selected for the construction of the rail freight terminal, data from main contractors who have been involved in similar-scale projects can be applied to estimate emissions; this is achieved by calculating emissions per £m revenue and using this as a proxy for project spend. A summary of Scope 1 data for a selection of appropriate main contractors is provided in Table 4.9.1.

Table 4.9.1: Scope 1 emissions intensity of listed main contractors

Company	2016 Emissions Intensity [tCO_2e/£m turnover]	2015 Emissions Intensity [tCO_2e/£m turnover	2015 Emissions Intensity [tCO_2e/£m turnover]
Balfour Beatty (Ref 10)	30.10	35.20	36.00
Carillion (Ref 11)	34.70	36.20	39.24
Kier Group (Ref 12)	31.39	36.55	50.40
North Midland Construction (Ref 13)	35.54	36.93	39.63
Average	**32.93**	**36.22**	**41.32**

This data is not broken down by fuel use and includes the fuel used in generators for the generation heat and electricity (Section 4.8) and the fuel used in mobile combustion equipment.

As there are multiple fuels contained within each total, it is not possible to assess the likely activity data, but it is assumed that emissions factors relating to fuels used for construction purposes remain stable over the construction period; this is likely an over-estimate.

The data presented in Table 4.9.1 relates to the most recent reporting years for each organisation and shows a reduction of circa 8% in emissions over the last two reporting years. This is assumed to be as a result of commitments in place by each of the contractors identified above to reduce their GHG emissions.

The reduction in emissions related to fuels is likely to be the reason there is an increase in emissions associated with electricity (described in Section 4.8); over recent years there has been a push to reduce the use of generators on construction sites, particularly for supplies to site compounds, by switching to grid supplies as early as possible. This is in an effort to reduce GHG emissions and improve local air quality.

It is our view that although a circa 8% reduction in emissions has been achieved on average over the past two reporting periods, this reduction is likely to reduce year-on-year as opportunities to reduce emissions further become more limited. For this reason, we have assumed a lower annual reduction in emissions of 3% over the construction period. This would result in the achievement of an overall

20% reduction in emissions compared to 2019, which is in line with targets set elsewhere.

An initial target for fuel-related (i.e. Scope 1) emissions of 27.34tCO_2e/£m spend is therefore included within the CEMP, reducing to 22.33tCO_2e/£m spend by 2029; this is equal to a 2% year-on-year reduction. As it is included in the CEMP, this is therefore considered embedded mitigation and is the same as predicted baseline construction emissions.

No additional action is proposed to reduce emissions further at this stage.

An estimation of construction spend has been included in Chapter 20, but there is no breakdown of the £377m figure provided, so we have crudely assumed that this is proportional to the quantity of FTEs on site over time, as outlined in the Transport Assessment.

The profile of construction spend can be found in Appendix A.

4.9.1 Calculation Procedure & Estimated Emissions

The profiled emissions per £m of turnover are multiplied by the profiled construction spend. The total emission are summarised below as a total for the different periods covered by this ES.

<u>Table 4.9.2: GHG emissions for construction fuel use in plant and equipment</u>

Temporal range	GHG emissions with embedded mitigation [tCO_2e]	GHG emissions after additional mitigation [tCO_2e]
Construction (2019 – 2029)	94	94

A full breakdown of annual activity data and resultant emissions is provided in Appendix A of this document.

4.9.2 Data Limitations & Uncertainty

Given that that the construction period extends over many years, it is likely that improvements in the design and energy efficiency of plant and equipment will reduce over the period, reducing energy demand. There are also likely to be advances in fuel technology, particularly where as a result of air quality issues in the wider construction industry, there is a switch to less locally polluting fuels.

The emissions per £m turnover for the companies from whom data was obtained are all within a small range, which provides a good level of certainty regarding the use of this as a proxy.

Operation

4.10 Stationary combustion: Production of heat and electricity

4.10.1 Description of Process

Fuel will be combusted in the generation of heat for individual buildings; this will be generated via gas boilers.

Backup generators will be provided to generate electricity in case of a power failure, but their use is not considered to be material and they have been scoped out.

4.10.2 Data Sources

Warehousing

The Parameters Plan assumes that the industrial/ warehousing units will range in Gross External Area (GEA) from circa 24,000m^2 to 74,000m^2, with an average area of 52,634m^2.

The expected regulated hot water and space heating requirements of the proposed buildings on site can be estimated using calculation outputs for notional buildings (the compliance model) generated from the Standard Building Energy Model (SBEM), used for demonstrating compliance with Part L Conservation of Fuel and Power requirements.

Based on SBEM data from other logistics projects with similar-sized warehousing facilities, average energy consumption for regulated uses can be calculated and applied to the buildings at Rail Central; Table 4.10.1 outlines likely baseline heating energy for the baseline Building Regulation compliant scenario.

Table 4.10.1: Baseline heating energy demand for B8 uses of a similar size

B8 Units	Area	Heating [kWh/m^2]	Hot Water [kWh/m^2]
Sample Unit 1	26,363	8.49	15.49
Sample Unit 2	73,597	0.60	4.69
Sample Unit 3	91,323	0.51	5.10
Average	**63,428**	**3.20**	**8.43**

There is no embedded mitigation included within the proposals.

Residual mitigation measures include a commitment to reduce emissions by 10% over the requirements of Part L 2013. It is our view that in line with similar units developed elsewhere, the reductions would likely be as a result of improvements in the delivery of hot water and lighting. As the level of improvement proposed is a reduction in total regulated emissions, an assessment of the emissions associated with space heating, hot water, and the regulated electrical uses outlined in Section 4.11 must be made, using emissions factors set out in the Part L methodology. It is assumed that heat is generated by gas boilers and the emission factors used in accordance with the Standard Building Energy Model are therefore:

- Gas: 0.216 kgCO_2 per kWh
- Electricity: 0.519 kgCO_2 per kWh

Applying an 11% reduction in the energy required for hot water and lighting results in an overall 10% reduction emissions reduction; this assumes that all other energy consumption is as set out in Table 4.10.2 and Table 5.7.2.

Table 4.10.2: Estimated energy demand following residual mitigation

Average B8 Unit	Area	Heating [kWh/m^2]	Hot Water [kWh/m^2]
10% Reduction over Part L	63,428	3.20	7.50

It should be noted that a central assumption in relation to the displacement of freight is that the SRFI will not increase the quantity of freight across the network. This assumption also relates to warehousing space and MDS Transmodal state:

‘Firstly, a significant proportion of new-build warehousing is simply replacing existing capacity, which has become life-expired or reached the end of its useful economic life, on a like-for-like basis.’ and:

‘Alongside this, distributors have commissioned large single warehouse units to replace multiple smaller units, thereby generating economies of scale.

However, we are unable to identify or obtain data for the warehouse units that will potentially be replaced by the SRFI to confirm any level of saving made. We have therefore conservatively assumed that 50% of emissions are displaced by the new warehousing facilities at Rail Central, with the remaining 50% additional and accounted for as part of this assessment.

Ancillary Buildings

There will be a number of offices and ancillary buildings located around the site including the following (all in GEA):

- Rail freight terminal control building (585m^2)
- Express freight terminal control building (assume 585m^2)
- Traction and rolling stock depot (10,960m^2)
- Gatehouse (90m^2)
- Train maintenance depot (11,450m^2)
- Control centre (780m^2)
- Customs and administrative buildings (assume total area 300m^2)
- Workshops (assume total area 2,000m^2)

- Education and training facility (assume 2,000m^2).

It is assumed that the control buildings, control centre, customs and administrative buildings, gatehouse and education and training facility are office based (B1 Use Class) and that the traction and rolling stock depot, maintenance depot and workshops are general industrial (B2 Use Class).

Table 4.10.3: Baseline heating energy demand for B1 & B2 uses

B1 & B2 Units	Area	Heating [kWh/m^2]	Hot Water [kWh/m^2]
B1 Sample Unit	227	17.83	3.51
B2 Sample Unit	2,091	16.35	4.77

The construction timetable for these buildings is not known, but it is assumed that all buildings are operational by the end of 2021 once the rail freight terminal and express freight terminal are complete.

Part L emission factors have been used to assess the change in energy use required to achieve a % improvement over current Building Regulations, but they are not used to assess the emissions associated with the buildings in use for the following reasons:

- They are based on a three-year rolling average, last updated in 2011, and therefore do not reflect current or future emission projections.
- They include emissions upstream and downstream of those in-use, which we have taken into account elsewhere (see Section 6.19).

All GEAs are converted into Net Internal Areas (NIAs) for application of Part L data. The following factors have been applied:

- For industrial units (B2 and B8), NIA = 90% of GEA
- For office units (B1), NIA = 80% of GEA

BEIS Emission Factors have instead been applied.

4.10.1 *Calculation Procedure & Estimated Emissions*

The estimated energy consumption per sqm required for space heating and hot water is multiplied by the area of the B1, B2 and B8 units set out above to determine total energy consumption; this is assessed on an annual basis to take into account the quantum of floor space anticipated to be delivered throughout the construction period.

Table 4.10.4: GHG emissions for operational fuel use in the production of heat at full build-out

Building Use	Annual energy demand [kWh/year]	Annual energy demand after additional mitigation [kWh/year]
B1 Uses	74,092	74,092
B2 Uses	463,766	463,766
B8 Uses	3,608,798	3,321,088
TOTAL	**4,146,656**	**3,858,946**

The total annual energy consumption is then multiplied by the corresponding annual emission factor to provide an estimate of GHG emissions.

Table 4.10.5: GHG emissions for operational fuel use in the production of heat and electricity

Temporal range	GHG emissions with embedded mitigation [tCO_2e]	GHG emissions after additional mitigation [tCO_2e]
Construction (2019 – 2028)	3,151	2,962
Short-term Operation (2029 – 2038)	6,741	6,273
Long-term Operation (2039 – 2089)	Not assessed	Not assessed

4.10.2 *Data Limitations & Uncertainty*

The estimated energy demand is based on SBEM calculations for a range of units of a similar size to those outlined in the illustrative masterplan, however, as can be seen from Table 4.10.1, there is a wide variation in estimated consumption between smaller and larger B8 units. On balance, the average figure applied is considered to be reasonable and reflective of the average unit size proposed.

SBEM predictions of annual energy use are affected by a number of input parameters relating to the building location (e.g. orientation) and fabric specification. These can have a significant impact on estimated energy demand and may not reflect the as-built design of the buildings.

The ‘performance gap’ phenomenon is also well-publicised, with potentially significant differences arising between design emissions and those in use.

It is likely that over the lifetime of the buildings, heat generating plant will need replacing several times (likely every 15 years); at each replacement interval, plant is likely to be more efficient, further reducing energy demand. The predictions of consumption in the short- and long-term operational scenarios are therefore likely to over-estimate actual emissions.

The emissions as a result of the operation of warehousing unit sis likely to be an over-estimate as it is likely that more than 50% of the existing warehouse stock will be displaced by the new warehouse facilities proposed. Additionally, by displacing older warehousing stock with newer, more energy efficient buildings, further emissions savings are likely to be achieved.

4.11 Mobile combustion: Fuel use in mobile plant & equipment

4.11.1 Description of Process

Mobile plant and equipment will be operated, predominantly in the movement of goods between locations around the Proposed Development.

Specific equipment relating to the operation of the SRFI will be required; Chapter 18 identifies the following fuel-consuming equipment:

- Three reach stackers have been assumed to be operational on the intermodal platform from Konecranes (reach stackers for intermodal handling, 41 to 45 tons).
- Six tugs have been assumed shuttling trailers between the intermodal platform and warehouses.

However, we have been unable to source data for these items of plant from the manufacturer and on the basis of proportionality, have scoped their use out of this assessment.

5. Scope 2 Emissions

General Description

5.1 Scope 2 emissions are indirect GHG emissions that occur as a result of the use of purchased electricity

5.2 As summarised in Section 2.6, the following activities have been identified in relation to the existing use of the Proposed Development site:

- Stationary combustion (e.g. use of purchased electricity in existing buildings)

5.3 As summarised in Section 2.7, the following activities have been identified in relation to the construction of the Proposed Development:

- Stationary combustion (e.g. use of purchased electricity for site operations)

5.4 As summarised in Section 2.8, the following activities have been identified in relation to the operation of the Proposed Development:

- Stationary combustion (e.g. use of purchased electricity in occupied buildings and site infrastructure).

Existing Site

5.5 Stationary combustion: Use of purchased electricity in buildings & infrastructure

5.5.1 Description of Process

During the operational phase, electricity will be procured for use in buildings and on-site infrastructure (e.g. lighting, cranes).

5.5.2 Data Sources

As outlined in Section 4.5.2, *farm energy use statistics* (Ref 9), last updated in 2013, provide an estimate of energy consumed for different uses relating to different types of farm.

This dataset includes an estimate of the quantity of electricity consumed; this is set out in Table 5.5.1 below.

Table 5.5.1: Estimated volume of electricity consumption per hectare

Fuel Type	Cropland (cereals as proxy)	LFA Grazing Livestock
Electricity	115.5	66.1

No unit is provided for electricity consumption, but based on additional information provided within the report and datasets; we assume this is in kWh.

The 2017 BEIS Emission Factor is applied to electricity consumption in 2018 (current baseline) and 2019 (future baseline), with small adjustments made to take into account decarbonisation over the two periods.

5.5.3 *Calculation Procedure & Estimated Emissions*

The area of each type of farmland is multiplied by the estimated quantity of electricity required per hectare to determine the total quantity of electricity required on an annual basis.

Table 5.5.2: Estimated annual electricity consumption for existing site

Farm Type	Annual electricity consumption [kWh]
Cropland	299.846
Grazing (sheep)	7,455
TOTAL	**307,301**

This is then multiplied by the annual emission factor for grid electricity. For illustrative purposes, the cumulative emissions that would be generated across each temporal range if the land were to remain in its current use have also been assessed.

Table 5.5.3: GHG emissions for use of purchased electricity at existing site

Temporal Range	GHG emissions [tCO_2e]	Cumulative GHG emissions [tCO_2e]
Current Baseline (2018)	63	-
Future Baseline (2019)	60	-
Construction (2019 – 2028)	-	452
Operation (2029 – 2038)	-	226
Total Baseline (2019 – 2038)	-	678

5.5.4 *Data Limitations & Uncertainty*

The activity data is representative of the mean energy use for a small sample of survey respondents (38 for cereals and 44 for LFA grazing livestock), which may not be representative of wider agricultural practices.

Construction

5.6 Stationary combustion: Use of purchased electricity in buildings & infrastructure

5.6.1 *Description of Process*

During the construction phase, electricity will be procured for use across the site compound.

5.6.2 *Data Sources*

Main SRFI Site

The precise layout of the construction site, the number of site cabins, and the expected energy consumption of such cabins is yet to be determined.

As specific data is not currently available, data published by construction companies who are subject to the UK Mandatory Greenhouse Gas reporting requirements is used to provide an estimate of the quantity of emissions and electricity consumption per £million of turnover; this can then be multiplied by the expected construction expenditure at Rail Central to estimate site electricity consumption and emissions.

Table 5.6.1: Scope 2 emissions intensity of listed main contractors

Company	2016 Emissions intensity [tCO_2e/£m turnover]	2015 Emissions intensity [tCO_2e/£m turnover	2015 Emissions intensity [tCO_2e/£m turnover]
Balfour Beatty (Ref 10)	8.08	8.17	10.41
Carillion (Ref 11)	4.07	4.79	6.17
Kier Group (Ref 12)	3.68	4.84	5.42
North Midland Construction (Ref 13)	2.05	2.44	3.01
Average	**4.47**	**5.06**	**6.25**

By applying historic emission factors used in each reporting year, the annual energy consumption per £m turnover is calculated; these are reported in Table 5.6.2.

Table 5.6.2: Annual equivalent energy intensity

Company	2017 Energy intensity [kWh/£m turnover]	2016 Energy intensity [kWh/£m turnover	2015 Energy intensity [kWh/£m turnover]
Balfour Beatty	22,987	19,836	22,527
Carillion	11,566	11,618	13,345
Kier Group	10,476	11,744	11,725
North Midland Construction	5,822	5,922	6,503
Average	**12,713**	**12,280**	**13,525**

The reduction in emissions related to fuels is likely to be the reason there is an increase in emissions associated with electricity for Balfour Beatty, who are the greatest consumer (refer to Section 4.9); over recent years there has been a push to reduce the use of generators on construction sites, particularly for supplies to site compounds, by switching to grid supplies as early as possible. This is in an effort to reduce GHG emissions and improve local air quality.

We have assumed that as a baseline, electricity consumption will on average remain stable at 2017 levels, relying on grid decarbonisation to achieve emissions reductions.

A target of 12,713kWh/£m spend is therefore included within the CEMP; this is therefore considered embedded mitigation and is the same as the baseline construction emissions.

No additional action is proposed to reduce emissions further at this stage.

An estimation of construction spend has been included in Chapter 20, however there is no breakdown of the £377m figure provided, so we have crudely assumed that this is proportional to the quantity of FTEs on site over time, as outlined in the Transport Assessment.

The profile of construction spend can be found in Appendix A.

All companies used in this comparison have polices in place for the reduction of GHG emissions over the medium-term, but from the above data it appears that this is currently reliant on grid decarbonisation; an increase in average consumption in 2017 still results in emissions that are 12% lower than in 2016.

On this basis, we have applied the 2017 energy consumption figures and assumed no reduction in electricity consumption over the construction in the baseline; emissions reductions will be achieved however through the decarbonising electricity grid.

The above emissions will vary based on the type of electricity-consuming activities taking place across those businesses, and will also include any consumption associated with head-office and corporate functions. An average of the above figures is therefore calculated and is applied with caution.

Projected emission factors for electricity, taking into account future grid decarbonisation are applied over the construction period; a full breakdown is provided in Appendix A.

5.6.3 Calculation Procedure & Estimated Emissions

Annual electricity consumption is estimated based on the expected annual construction expenditure and the average electricity consumption per £m turnover of the construction companies identified in Table 5.6.3.

Annual electricity consumption is multiplied by the projected emission factors for electricity over each construction year.

Table 5.6.3: GHG emissions for the purchase of electricity during construction

Temporal range	Baseline GHG emissions [tCO_2e]	GHG emissions after embedded mitigation [tCO_2e]	GHG emissions after residual mitigation [tCO_2e]
Construction (2019 – 2028)	699	699	699

J15a works have an estimated construction spend in the region of £7.5m and £10m. There is no profile for this spend, so a conservative approach assuming £1m for each year of the project has been applied.

No data is available for the likely spend relating to the minor highways works and as these are thought to be small in comparison with the other works, they have been excluded from the assessment.

5.6.4 *Data Limitations & Uncertainty*

Given that that the construction period extends over many years, it is likely that improvements in the design and energy efficiency of site cabins and plug-in equipment will reduce over the period, reducing energy demand.

As outlined above, there is significant difference between the emissions per £m turnover for the companies from whom data was obtained; an average figure has been applied but this could either under- or over-estimate consumption.

Operation

5.7 Stationary combustion: Use of purchased electricity in buildings & infrastructure

5.7.1 *Description of Process*

During the operational phase, electricity will be procured for use in buildings and on-site infrastructure (e.g. lighting, cranes).

5.7.2 *Data Sources*

Main SRFI Site

Warehousing

The Parameters Plan assumes that the industrial/ warehousing units will range in area from circa 24,000m^2 to 74,000m^2, with an average area of 52,634m^2.

The expected regulated and unregulated electricity requirements of the proposed buildings on site can be estimated using calculation outputs for notional buildings (the compliance model) generated from the Standard Building Energy Model (SBEM), used for demonstrating compliance with Part L Conservation of Fuel and Power requirements.

Based on publically available SBEM data from other logistics projects with similar-sized warehousing facilities, average electricity consumption for regulated and unregulated uses can be calculated and applied to the buildings at Rail Central; Table 5.7.1 outlines likely baseline electricity for the baseline Building Regulation compliant scenario.

Table 5.7.1: Baseline electricity demand for B8 uses from similar projects

B8 Units	Area [m^2]	Cooling [kWh/m^2]	Auxiliary [kWh/m^2]	Lighting [kWh/m^2]	Equipment [kWh/m^2]
Sample Unit 1	26,363	0.00	0.53	17.13	31.02
Sample Unit 2	72,597	0.27	0.41	16.34	32.20
Sample Unit 3	91,323	0.40	0.28	14.23	31.07
Average	**63,428**	**0.22**	**0.41**	**15.90**	**31.43**

Electricity is assumed to be supplied by the grid and a grid average emission factors taking into account future decarbonisation are applied.

The same assumption that 50% of emissions associated with the operation of warehousing space made in Section 4.10 is made in relation to the use of electricity in the warehousing units.

Ancillary Buildings

There will be a number of offices and ancillary buildings located around the site including the following:

- Rail freight terminal control building (585m^2)
- Express freight terminal control building (assume 585m^2)
- Traction and rolling stock depot (10,960m^2)
- Gatehouse (90m^2)
- Train maintenance depot (11,450m^2)
- Control centre (780m^2)
- Customs and administrative buildings (assume total area 300m^2)
- Workshops (assume total area 2,000m^2)
- Education and training facility (assume 2,000m^2).

It is assumed that the control buildings, control centre, customs and administrative buildings, gatehouse and education and training facility are office based (B1 Use Class) and that the traction and rolling stock depot, maintenance depot and workshops are general industrial (B2 Use Class).

The construction timetable for these buildings is not known, but it is assumed that all buildings are operational by the end of 2021 once the rail freight terminal and express freight terminal are complete.

Table 5.7.2: Baseline electricity demand for B1 and B2 uses from similar projects

B1 & B2 Units	Area	Cooling [kWh/m^2]	Auxiliary [kWh/m^2]	Lighting [kWh/m^2]	Equipment [kWh/m^2]
Sample Unit 1: B2	3.647	0.00	0.22	23.53	31.28
Sample Unit 2: B2	537	0.00	2.93	20.36	31.93
Average B2	**2,091**	**0.00**	**1.58**	**19.45**	**31.61**
Sample Unit 3: B1	227	0.00	0.98	16.37	41.13
Average B1	**227**	**0.00**	**0.98**	**16.37**	**41.13**

Site Uses

In addition to the purchase of electricity for the operation of buildings, electricity will be required for other site uses, the most significant of which is likely to be lighting. The SRFI Operational Lighting Parameters Plan identifies the following areas with lighting requirements:

- Roundabout / Conflict Zone lighting (CE3)
- Main Access road lighting (ME4a)
- Site Access road lighting (S3)
- HGV parking lighting
- Car parking lighting
- Service Yard lighting
- Loading/Unloading lighting
- Checkpoints
- Express freight platform / Intermodal Terminal

Suggestions for the types of lighting are made, including the extensive use of LEDs, but no estimates on the quantities of each lighting type are available at this stage.

To estimate a baseline for operational emissions, we have applied data reported by SEGRO, a listed operator of industrial units and sites, who publish an annual Data Pack to support their sustainability reporting. In their most recently published report (Ref 14), they report an energy intensity figure of 66kWh/m^2/year for external common areas. This includes shared services to both tenant areas (e.g. tenant specific car parking areas) and non-tenant areas (site access etc.).

No annual consumption reduction assumptions have been made, but there may be opportunities to reduce electricity consumption in operation.

In addition, specific equipment relating to the operation of the SRFI will be required; Chapter 18 identifies the following equipment:

- Intermodal vehicle cranes – three electric rail mounted gantry cranes (RMG) have been assumed to be operational on the intermodal platform.
- One small general purpose electric forklift truck has been assumed to be operational at the rail served warehouse platforms of Units 5, 6 and 7. Based on data provided by Konecranes for a fully electric RMG (Ref 15)

It is our professional opinion that the emissions associated with the electric forklift will be minimal compared with the scale of other emissions assessed in this report and they have therefore been scoped out of this assessment.

The Rail Report sets out that at DIRFT, which handles a similar number of trains per day as expected at Rail Central, (9.3 compared with 8), container handling movements are in the region of 130,000 lifts per annum. A similar quantity of movements has been assumed at Rail Central on a pro-rata basis.

Table 5.7.3: Annual container movements at full capacity

Site	Trains per day	Annual intermodal container movements
DIRFT	9.3	c. 130,000
SRFI	8	c. 111,828

[Source: MDS Tranmodal Rail Central SFRI Draft Rail Report]

Environmental Product Declaration (EPD) data has been sought from Konecranes (Ref 15), which identifies that an RMG consumes on average 2kWh per container move (assuming a container weight of 20 tonnes).

Emission factors for electricity, taking into account grid decarbonisation, are applied.

5.7.3 *Calculation* Procedure *& Estimated Emissions*

The benchmark figures identified for building uses are multiplied by building areas; the benchmark figure for site uses is multiplied by the total area of buildings on site; and the total number of intermodal movements is multiplied by the electricity consumption per RMG movement to calculate the total estimated annual electricity consumption. This is presented for each use in Table 5.7.4.

Table 5.7.4: Annual electricity consumption at full operation

Use	Baseline annual electricity consumption [kWh/year]	Annual electricity consumption after residual mitigation [kWh/year]
B1 Uses	203,043	203,043
B2 Uses	1,156,119	1,156,119
B8 Uses	14,886,292	14,343,421
Site Electricity Uses	42,650,553	40,971,447
Site Infrastructure Uses	223,656	223,656
TOTAL	**59,119,663**	**58,897,685**

Annual electricity consumption is then multiplied by the relevant electricity emission factor.

Table 5.7.5: GHG emissions for purchased electricity during operation

Temporal range	GHG emissions with embedded mitigation [tCO_2e]	GHG emissions after additional mitigation [tCO_2e]
Construction (2019 – 2028)	30,166	28,427
Operation (2019 – 2038)	43,409	41,777
Operation (2039 – 2089)	Not assessed	Not assessed

5.7.4 Data Limitations & Uncertainty

SBEM predictions of annual energy use are affected by a number of input parameters relating to the building location (e.g. orientation) and fabric specification. These can have a significant impact on estimated energy demand and may not reflect the as-built design of the buildings.

The baseline for comparison is a ‘policy compliant’ solution; presently this is a building that meets the energy requirements of Part L 2013, illustrated through the SBEM data used above. The ‘performance gap’ between energy consumption and emissions predicted at design stage using this methodology, and observed performance in operation is well-documented but due to a lack of data has not been taken into account in this assessment.

It is likely that over the lifetime of the buildings, plant and equipment will need replacing several times; at each replacement interval, plant is likely to be more efficient, further reducing energy demand. The predictions of consumption in the short- and long-term operational scenarios are therefore likely to over-estimate actual emissions.

The predictions of consumption in the short- and long-term operational scenarios are therefore likely to over-estimate actual emissions.

6. Scope 3 Emissions

General Description

6.1 Scope 3 emissions occur upstream and downstream of the Proposed Development site.

6.2 As summarised in Section 2.6, the following activities have been identified in relation to the existing site baseline of the Proposed Development site:

- Mobile Combustion (e.g. transportation of goods and waste)
- Process emissions (e.g.. agrochemical production and use)

6.3 As summarised in Section 2.7, the following activities have been identified in relation to the construction of the Proposed Development:

- Mobile combustion (e.g. transportation of raw materials/ products/ waste, employee business travel, employee commuting)
- Process emissions (e.g. production of purchased materials, fuel and energy elated emissions)

6.4 As summarised in Section 2.8, the following activities have been identified in relation to the operation of the Proposed Development:

- Mobile combustion (e.g. transportation of raw materials/ products/ waste, employee business travel, employee commuting, upstream and downstream transportation of freight)
- Process emissions (e.g. fuel and energy elated emissions)

Existing Site

6.5 Mobile Combustion: Transportation of goods & waste

6.5.1 Description of Process

Goods are transported to the Proposed Development site (upstream) to facilitate farming and other business activity that currently takes place.

Goods (including crops and cattle) and waste are transported from the site for onward sale, distribution or disposal.

It is our professional judgement that the emissions associated with the transportation of goods and waste to and from the site are small in the context of the Proposed Development; the evaluation of such emissions would be disproportionate to this assessment and they have been scoped out.

6.6 Process Emissions: Agrochemical production and use

6.6.1 Description of Process

Agrochemicals are widely used in farming and the production of crops and their production is an emissions intensive process.

6.6.2 *Data Sources*

The report *Estimation of the greenhouse gas emissions from agricultural pesticide manufacture and use, (*Ref 16) prepared for the Crop Protection Association, provides an estimate of standard pesticide energy input to arable crops per hectare. This applies a weighted average of pesticide production energies per unit mass of the different types of pesticide.

This results in an average for different crop types of 1364 MJ per hectare. The report advises that a factor of 0.069 $kgCO_2e$ per MJ pesticide should be applied, resulting in an average of 94$kgCO_2e$ per hectare of arable crop.

For crops such as wheat and barley, pesticide use accounts for circa 8.9% of overall emissions associated with farming, and fertiliser use accounts for circa 49.7%. Using this ratio, we estimate the emissions associated with pesticide use to be in the region of 523$kgCO_2e$ per hectare of arable crop.

It is assumed that fields will be in rotation and that 30% of the fields will not be in use in any given year.

6.6.3 *Calculation Procedure & Estimated Emissions*

The emissions factors noted above are applied to the area of cropland.

<u>Table 6.6.3: GHG emissions for agrochemical production and use at the existing site</u>

Temporal Range	GHG emissions [tCO_2e]	Cumulative GHG emissions [tCO_2e]
Current Baseline (2018)	1,602	-
Future Baseline (2019)	1,602	-
Construction (2019 – 2028)	-	16,018
Operation (2029 – 2038)	-	16,018
Total (2019 – 2038)	-	32,036

6.6.4 *Data Limitations & Uncertainty*

The data presented above is based on a report published in 2009; production processes, associated emission assumptions, and usage patterns may have changed in the intervening period; the results presented above are likely to over-estimate emissions.

The authors of the original report identified that there was inherent uncertainty in the calculation process and that emissions depend on the specific crop and time of year.

Emissions for fertilizer production are inferred from the report and are not based on an assessment of any underlying data; however, it is our professional opinion that this approach is proportional to the assessment.

Construction

6.7 Mobile Combustion: Transportation of materials

6.7.1 Description of Process

Construction materials are transported to the Proposed Development site from various suppliers of building materials.

6.7.2 Data Sources

Main SRFI Site

For certain materials, average distances and emissions associated with transportation to the construction site are included within the assessment of material process emissions within Section 6.12. This relates to the following materials:

- Cladding
- Reinforced Concrete
- Precast Concrete

As this data is included elsewhere, it is not duplicated here.

Transportation to the construction site is known as stage A4 of a full Life Cycle Assessment (LCA), and is identified as a separate stage for the following materials:

- Precast concrete kerbs (6.62E-03kgCO_2e/kg)
- Plasterboard (1.28E-02kgCO_2e/kg)
- Tarmac (asphalt) (6.87E-03kgCO_2e/kg)
- Aggregate (3.78E-03kgCO_2e/kg)

Further information on the LCA assessment process and its relevance to this assessment can also be found in Section 6.12.

Material quantities and anticipated vehicle movements are identified within the Construction Materials Assessment Report produced by RPS Group along with the anticipated number of associated vehicle movements.

It is assumed that all remaining materials are transported by either an articulated lorry (A) or a tipper truck (T); the RPS report makes assumptions regarding the payload of each vehicle.

Only the vehicle movement assessed with delivering the material to site is considered here.

With the exception of steelwork, which is assumed to be supplied by British Steel, it is assumed that materials are available and sourced within a 100km radius of the site.

Rail steel is assumed to be transported from the British Steel site in Scunthorpe (216km), where it is manufactured (95% of UK steel rail is sourced from this location) and steel sections from either British Steel sites in Scunthorpe or Teesside (316km).

Table 6.7.1: Estimates of material travel distances from site of manufacturer to the Proposed Development

Material	Vehicle type	Average distance assumed [km]	Total quantity of materials [tonnes]	Total materials moved [tonne.km]
Steelwork	A	266	1,554	594,284
Pipes	A	100	245	34,800
M&E Fittings	A	100	602	3,000
Manholes	A	100	82	12,500
Fencing	A	100	327	1,820,000
Trees & Plants	A	100	159	1,820,000
Seeds	A	100	63	610,800
Rail track	A	216	Currently omitted	Currently omitted
TOTAL	**-**	**-**	**3,032**	**4,895,384**

Other Minor Highways Works

Section 6.12 outlines the data sources and process for quantifying materials associated with minor highways works and is not repeated here.

The transportation of asphalt and aggregates are covered by LCA Stage A4 data and the quantity of each material identified in Section 6.12 is multiplied by the A4 factor to calculate GHG emissions associated with the transportation of these materials.

No timeline is presented for these construction activities, so it is assumed these works are carried out across the construction phase and the total emissions are divided by the number of construction years to produce an annual figure.

Where data is obtained from an LCA, emissions are based on emissions factors in place at the time the LCA was produced. No adjustment has been made for this in our assessment.

Where emissions are assessed based on the distance travelled by HGV, annual emission factors taking into account decarbonisation, as presented in Section 6.14, are applied. Both direct and indirect (upstream) emissions are included for consistency with the LCA calculation; upstream emissions are therefore excluded from the assessment of FERA emissions in Section 6.18.

Material usage has been profiled throughout the construct period; a full breakdown of material tonnages and emissions by year can be found in Table C.5 of Appendix A for the Main SRFI site.

6.7.3 *Calculation Procedure & Estimated Emissions*

Where LCA Phase A4 data is available, this is multiplied by the tonnage of each material type.

For the movement of other materials, the total number of trips is multiplied by the estimated distance travelled and then multiplied by the emission factor for the anticipated average HGV fuel mix by year.

Table 6.7.2: GHG emissions for the transportation of materials

Temporal range	GHG emissions with embedded mitigation [tCO_2e]	GHG emissions after residual mitigation [tCO_2e]
Construction (2019 – 2028)	3,211	3,211

6.7.4 *Data Limitations & Uncertainty*

Data obtained from LCAs provides more accurate assumptions relating to the distances travelled as it is based on actual distances from manufacturing points to average customer locations. However, the emissions factors used are static and do not take into account the future decarbonisation of HGV transport, so are likely to produce an over-estimate of emissions.

Other distances travelled are estimates, with the exception of steel, which is considered to be an accurate reflection of the likely sourcing point for the material.

6.8 Mobile Combustion: Transportation of waste

6.8.1 *Description of Process*

Waste generated during construction will be segregated for recycling and transported to a local waste handling facility.

6.8.2 *Data Sources*

Chapter 23 of this ES sets out the assumptions in relation to the quantity of waste anticipated as a result of the construction of the Proposed Development. It identifies the following potential waste sources as:

- Site clearance: Vegetation
- Excavation: Made ground, soil and subsoil
- Construction (SRFI Site): General construction waste
- Construction (All highway works): Carriageway planings, materials from existing structures and drainage and general construction waste

Site clearance

The waste chapter does not attempt to quantify the vegetation waste beyond the fact that it is likely to exceed $100m^3$. As there is regional capacity for composting facilities, it is assumed that $100m^3$ will be moved locally by HGV.

Excavation Waste

The brief for the development is to retain all excavated material on site. There is a low probability that contaminated material that requires off-site treatment will be discovered, so it is therefore assumed that there are no vehicle movements associated with the transport of excavation waste.

Construction Waste (Main SRFI)

The vast majority of construction waste will be generated by the development of the main SRFI site, which for the purposes of the waste assessment includes the industrial units, maintenance depot and control buildings.

Using a benchmark of 12.6 tonnes/100m^2 GIA development, a total of 85,185 tonnes of waste is anticipated in the waste chapter. Converting to NIA, this equates to 13.82 tonnes/100m^2 NIA.

Given our assumptions relating to other buildings on site and the periods over which they will be constructed, we have applied this figure to all assume buildings (refer to Section 4.10), resulting in a total of 85,169 tonnes of waste generated over the construction period.

Additional mitigation includes a target to meet a reduced level of waste generation, consistent with BREEAM standards. A traget of 3.2 tonnes/100m^2 GIA development, or 3.5 tonnes/ 100m^2 NIA is applied as mitigation.

The waste chapter identifies a range of suitable waste and recycling locations within 10km of the site; it is therefore assumed tha the distance traveleld is 10km per vehicle movement. This results in the movement 851,690 tonne.kms of waste.

HGV emission factors calcualted in Volume 3 Appendix 23.1 for average HGV loading are applied. This assumes that large (>33t) articualted vehicles will be used to trasnport materials to site.

6.8.3 Calculation Procedure & Estimated Emissions

The total tonnage of materials estimated using the benchmark data is profiled throughout the construction period and multiplied by the average distance to calculate the tonne.km moved. This is multiplied by the emission factor described above.

Table 6.8.1: GHG emissions for the of transportation of waste during construction

Temporal range	GHG emissions after embedded mitigation [tCO_2e]	GHG emissions after residual mitigation [tCO_2e]
Construction (2019 – 2028)	73	19

6.8.4 Data Limitations & Uncertainty

Waste estimates are based on benchmark average data, which given that most construction companies have processes in place to reduce waste, may not necessarily be reflective of current average practices.

6.9 Mobile Combustion: Employee Business travel

6.9.1 Description of Process

Employees of the various parties involved in the construction of the development will be required to travel for meetings and site visits during the construction of the Proposed Development.

It is assumed that business trips relating to the development are included within the trips generated and assessed under employee commuting in Section 6.11.

6.10 Mobile Combustion: Employee commuting

6.10.1 Description of Process

The construction of the Proposed Development will employ up to 482 FTEs at the peak of activity, who will travel to the site on a daily basis.

6.10.2 Data Sources

The Framework Construction Traffic Management Plan produced by TPA to support the application sets out the estimated number of cars and LGVs that will travel to site on a daily basis for each of the construction phases; 90% of the vehicles are assumed to be cars, whilst 10% are LGVs.

The methodology applied to assess the annual average emissions of cars is described in Section 6.17 and the emission factors developed in relation to employee commuting during the operational phases of the development are applicable during the construction phase.

An emissions profile has not been developed for LGVs, and given the small proportion of trips estimated using LGVs, it is considered proportionate in this instance to apply the same emission factor as for cars.

6.10.3 Calculation Procedure & Estimated Emissions

The total number of vehicles for each day of each phase of development is multiplied by the number of working days over the period and then doubled to take into account an inbound and outbound journey. The resultant distance is multiplied by the relevant emission factor.

A full profile of assumed average annual emission factors taking into account the anticipated vehicle mix is provided in Tables D.1 to D.4 of Appendix D; annual distances travelled by each mode are provided in Tables A.5 to A.8.

Table 6.10.1: GHG emissions for employee commuting during construction

Temporal range	GHG emissions with embedded mitigation [tCO_2e]	GHG emissions after additional mitigation [tCO_2e]
Construction (2019 – 2028)	77,889	77,889

6.10.4 Data Limitations & Uncertainty

The application of average car emissions for LGVs is likely to under-estimate emissions associated with these vehicles. This is dues to the larger size of these vehicles and a potentially different decarbonisation trajectory.

Other limitations outlined in Section 6.17 are also applicable here.

6.11 Process Emissions: Production of construction materials

6.11.1 Description of Process

The processes involved in the manufacture of construction materials and products will involve energy and emissions. These form the first phase of what is commonly referred to as 'life-cycle impacts', 'embodied energy' or 'embodied carbon'.

6.11.2 Data Sources

Main SRFI Site

Material quantities for the project have been calculated by RPS based on the illustrative masterplan and assumptions regarding the build-up of buildings and roads. This was carried out for the purposes of assessing construction traffic impacts, but is equally relevant to the assessment of GHG impacts associated with the manufacture, transportation and end-of-life use of materials used in the construction of the Proposed Development.

The assessment breaks down the quantities of materials into the following categories:

- Estate Roads & Temporary Construction Access
- Bridges on A43 Road & to Northampton Road
- Buildings
- Landscaping
- Intermodal
- Express Freight Platform

The assessment excludes the rail track required to connect freight terminals to the wider rail network.

A summary of total material tonnages is provided in Table 6.12.1.

Assessments of embodied energy and GHG emissions are complex and are dependent on the manufacturer of each item procured and their specific processes.

In accordance with best-practice guidance published by the Royal Institute of Chartered Surveyors (Ref 17), the following hierarchy has been applied in obtaining data on the embodied GHG Emissions associated with the materials that will be used at Rail Central:

- Type III Environmental Declarations to EN 15804
- Type III Environmental Declarations to EN ISO 21930
- Type III Environmental Declarations to ISO 14067
- Type III Environmental Declarations to ISO 14025, ISO 14040 and ISO 14044
- Type III Environmental Declarations to PAS 2050
- Other published data.

Note that 'other published data' is in addition to the hierarchy identified by RICS, but given the stage in the project and the lack of detailed specification data at this stage, generic data has been utilised where data in accordance with the above standards is not available.

There are four distinct modules within a Life Cycle Assessment:

- A: Manufacturing to Installation
- B: In-use
- C: Demolition
- D: Reuse/ Recovery/ Recycling Potential

Not all assessments include the emissions associated with all phases, so this assessment includes the emissions associated with Phases A1-A3:

- A1: Raw material supply
- A2: Transport to factory
- A3: Manufacturing

Transport to site (A4) is accounted for in Section 6.8 (unless otherwise stated). Based on data available for some profiles, emissions associated with the remaining A – C categories is negligible. Phase D emissions, where available are accounted for as part of the decommissioning phase impacts.

Cladding

Michael Sparks Architects have confirmed that the most likely cladding manufacturer for the warehouse buildings is CA Group; CA is part of Tata Steel, who have produced Environmental Performance Declarations for their range of wall and roof cladding products (Ref 18). A weighted-average of the emissions associated with their standard Twin-Therm roof and wall products has been calculated, assuming that the quantities profiled by RPS include 30% roof and 70% walls.

Plasterboard

An average of the emissions associated with two common plasterboard manufacturers (Knauf and Gyproc) has been assessed based on EPDs produced by each manufacturer (Ref 19 & Ref 20).

Structural steel

Bauforumstahl, the independent steel promotional organisation in Germany has published an EPD (Ref 21) based on data collected from the biggest hot rolled steel sections and plates manufacturers in Europe. This 'European EPD' includes the most up to date embodied carbon data currently available for these products and is based on the Module D approach from BS EN 15804.

Rail track

Network Rail (Ref 22) state that 96% of rail steel in the UK is sourced from the British Rail plant in Scunthorpe, with the remainder sourced from elsewhere in Europe. British Steel do not provide any LCA data for their products, so data for generic hot-rolled steel set out in the Steel Construction Embodied Carbon (Tata Steel; The British Constructional Steelwork Association, 2014) report has been applied.

The quantity of rail steel is currently not available and at this stage has not been included in our calculations.

In-situ concrete

The Concrete Centre (part of the UK Mineral Products Association) has been undertaking work assessing embodied emissions with its members for several years and have targets in place for their reduction. Although in 2017, a report titled Specifying Sustainable Concrete (Ref 24) was published setting out embodied emissions for the components of concrete (i.e. cementitious materials, aggregates and reinforcement) as well as a number of reinforced concrete mixes, there is no data regarding how these figures have been calculated.

Referring back to an earlier publication titled '*Embodied carbon dioxide (CO2e) of concrete used in buildings'* (Ref 25), similar figures to those found in the 2017 document can be found, alongside a description of how they have been calculated.

This sets out that the scope of the data has been updated in accordance with PAS 2050 and ISO EN 15804 (Stages A1 – A4) and includes emissions associated with transport to site based on average industry data.

The following concrete grades have been assumed for the uses identified:

- GEN I: Blinding, mass fill, strip footings, mass foundations, trench foundationsC30: Pavements
- RC28/30: Reinforced foundations

- RC32/40: Structural: in situ floors, superstructure, walls, basements
- RC40/50: High-strength concrete

The breakdown of materials provided splits out in-situ concrete used in building construction (assumed to be 50% RC28/30 for foundations and 50% RC32/40 for floors); the drainage elements (assumed to be GEN I); intermodal and express freight platforms (assumed to be RC40/50); and roads (assumed to be RC40/50).

Data is provided for CEM I, a 30% fly ash substitution and a 50% GGBS substitution. Baseline embodied emissions are assumed to include CEM I without any cementitious material substitutions.

Although in-situ concrete and reinforcement have been accounted for separately in terms of material quantities, the emission factors for concrete in accordance with the assumptions above take into account the emissions associated with reinforcement for stages A1 – A4.

There is a significant opportunity to reduce emissions associated with the use of concrete on site through the specification of alternative cementitious materials (such as fly ash or GGBS) and/or the use of recycled aggregates. A requirement to identify opportunities to reduce embodied emissions is identified in the CEMP, and it is expected that the reduction of emissions associated with concrete will play a significant part in delivering further GHG reduction.

Precast concrete

Limited data has been obtained for precast concrete sections, and the reinforced precast concrete floor emissions stated in the MPA (Ref 25) document cited above have been applied.

Kerbs

The British Precast association has developed an EPD (Ref 26) for 1 tonne of UK manufactured generic precast concrete paving products (blocks, slabs, channels and kerbs).

Aggregates & Tarmac

Tarmac have developed EPDs for generic aggregates (Ref 27) and tarmac (Ref 28).

Other materials

Data for other materials has been obtained from the Inventory of Carbon and Energy, developed by the University of Bath (Ref 29). Until the introduction and mainstream use of EPDs, this was the main source for industry-wide cradle-gate emissions data for a wide variety of materials. This does not comply with any of the standards identified by RICs, but where data is otherwise unavailable, it is considered an appropriate source to use.

The quantities of M&E fittings and fencing have been identified, but we are not in a position to make any assumptions regarding likely materials for these items and they have therefore been excluded from the assessment.

Table 6.12.1: Material quantities and emission factors

Material type	Quantity [tonnes]	Emission factor [tCO_2e/kg]
Steelwork	37,426	1.735
Cladding[1]	8,423	2.467
Precast concrete[2]	9,351	0.171
Steel beams	586	1.735
Concrete in-situ (GEN I)[2]	1,838	0.077
Concrete in-situ (RC28/30)[2]	272,983	0.133
Concrete in-situ (RC32/40)[2]	272,983	0.134
Concrete in-situ (RC40/50)[2]	91,160	0.154
Aggregates	636,470	0.005
Reinforcement[3]	6,948	Incl. Concrete
Kerbs	3,046	0.131
Tarmac (asphalt)	94,870	0.066
Pipes	6,223	3.230
M&E fittings	13,863	Excluded
Manholes (ductile iron)	1,192	2.03
Fencing	1,859	Excluded
Plasterboard	520	0.278
Rail track	Currently omitted	Currently omitted

A full breakdown of materials and life cycle impact data can be found in Appendix C.

There is significant opportunity to reduce LCA emissions through the specification of materials with lower embodied impacts. Specific opportunities identified include the use of concrete with an alternative to cement such as fly ash or ground granulated blast furnace slag (GGBS); as by-products of other industries, the emissions associated with their production are significantly lower.

[1] Aggregated data and includes A4 Transportation to site and A5 Construction – Installation emissions.
[2] Aggregated data and includes A4 Transportation to site emissions.
[3] Included within reinforced concrete emissions.

Aggregates obtained from crushed materials found on site during the demolition phase, or the use of other recycled aggregates provides a further opportunity for reduction.

Additional mitigation recommendations include that a detailed LCA is undertaken that covers, as a minimum, the materials assessed in this report and that the final design delivers a 20% reduction in Stage A1 – A3 emissions compared to the baseline assessed here.

Other Minor Highway Works

TPA have produced a Technical Note describing the quantity (sqm) of physical minor highways works. This relates to:

- Junction One – M1 Junction 6
- Juntion 3 – A4500/ Upton Way/ Tollgate Way
- Junction 4 – A5076/ A5123/ Upton Way
- Junction 6 – A5076/ Hunsbury Hill Avenue/ Hunsbarrow Road/ Hunsbury Hill Road
- Junction 7 – Towcester Road/ A5076/ A5123/ Tesco
- Junction 9 – A45/ Eagle Drive/ Caswell Road
- Junction 10 - Barnes Meadow Interchange
- Junction 11 – A45/ A43/ Ferris Row
- Junction 12 – M1 Junction 15
- Junction 14 – Tove Roundabout
- Junction 15 - Abthorpe Roundabout
- Junction 19 – A5076/ Telford Way/ Walter Tull Way/ Duston Mill Lane
- Junction 20 – A5076/ High Street/ Dustom Mill
- Junction 25 – A508/ A5199

The proposed works include:

- Bridge-deck resurfacing
- Carriageway resurfacing
- Carriageway construction
- Footway/island construction
- Earthworks/ Re-grade

They also include site clearance work and other prelims, the installation of traffic signal equipment and the construction of verges; these are considered small components of the works and due to a lack of available information, have been scoped out of the assessment.

The resurfacing of existing bridges and carriageways is a benefit of the scheme and in all likelihood would have been required at some point as part of standard maintenance procedures. The SRFI will have the effect of reducing road transport, so on the whole, will marginally reduce the need for resurfacing across the wider road network. Emissions associated with the materials used have therefore been scoped out of the assessment.

The construction of new carriageways is considered additional, required to mitigate the local traffic impacts of the scheme. Emissions associated with the construction of new carriageways and footways have therefore been assessed, along with an assumption that they will require resurfacing after 25 years.

In terms of materials, carriageway construction is assumed to consist of:

- Surface course: 40mm asphalt
- Binder course: 60mm asphalt
- Base course: 250mm aggregate
- Sub-base course: 420mm aggregate

Similarly, assuming a light-vehicle footway/ cycleway with very occasional vehicle overrun (Ref 28):

- Surface course: 20mm asphalt
- Binder course: 50mm asphalt
- Sub-base: 225mm aggregate

Resurfacing associated with these roads is likely to be required after circa 25 years, however as stated above, road freight as a result of the development is expected to reduce, so the impact across the network will be lower than existing traffic impacts. On this basis, we have excluded the emissions associated with resurfacing these roads.

Table 6.12.2: Material quantities and emission factors

Material type	Quantity [tonnes]	Emission factor [tCO_2e/kg]
Aggregates	359	0.005
Tarmac (asphalt)	90	0.066

Junction 15a Works

No construction breakdown is currently available for the Junction 15a works, but an area of highways works totalling 8.4 hectares is identified on TPA drawing SK164.

Conservatively assuming that 100% of this area is the construction of carriageway to the same specification identified for the minor highways works above, Table 6.12.3 sets out the expected material quantities and emission factors.

Table 6.12.3: Material quantities and emission factors

Material type	Quantity [tonnes]	Emission factor [tCO_2e/kg]
Aggregates	20,160	0.005
Tarmac (asphalt)	90,048	0.066

6.11.3 *Calculation Procedure & Estimated Emissions*

The LCA stage A1 – A3 emissions intensity for each material/ product type has been multiplied by the quantity of each material/ product.

Table 6.12.4: GHG emissions for each project element

Temporal range	GHG emissions with embedded mitigation [tCO_2e]	GHG emissions after additional mitigation [tCO_2e]
Main SRFI Site		
Buildings	186,290	149,032
Infrastructure	31,749	25,399
J15a Works		
Infrastructure	2,015	1,612
Other Minor Highways Works		
Infrastructure	449	359

Table 6.12.5: GHG emissions for the production of materials used in construction

Temporal range	GHG emissions with embedded mitigation [tCO_2e]	GHG emissions after additional mitigation [tCO_2e]
Construction (2019 – 2028)	**220,504**	**176,402**

6.11.4 *Data Limitations & Uncertainty*

The quality of the data sources identified in Section 6.12.2 varies considerably, meaning that like-for-like comparisons cannot be made and there may be some under- or over-estimates of emissions.

Some data is several years old, and particularly where energy intensive processes are involved in the manufacture of products (e.g. steel and concrete), emissions will have reduced since the data was published as a result of decarbonisation of our energy supplies. This cannot be retrospectively calculated without a breakdown of fuel inputs, so is accepted as an over-estimate in the results.

Certain materials include additional life-cycle stages; where this is the case, this is stated and where possible, accounted for elsewhere (e.g. in the calculation of transport emissions to site).

6.12 Process Emissions: Fuel and energy related emissions (FERA)

6.12.1 Description of Process

FERA emissions relate are as a result of fuel and energy consumption that are unaccounted for elsewhere in this assessment.

Well-to-tank (WTT) account for the upstream Scope 3 emissions associated with extraction, refining and transportation of the raw fuel sources prior to combustion.

Transmission and distribution (T&D) account for emissions associated with grid losses (the energy loss that occurs in getting the electricity from the power plant to organisations that purchase it).

6.12.2 Data Sources

Activity data is the same as is calculated in Section 4 and Section 5 of this report, relating to 'Scope 1' and 'Scope 2' emissions. Whilst upstream and downstream emissions will be associated with other 'Scope 3' emissions, we consider the assessment of those emissions to be outside the assessment boundary and disproportionate to the assessment. The relevant activity data can be found in sections:

- 4.8 Stationary Combustion - Production of heat and electricity
- 4.9 Mobile Combustion - Fuel use in plant & equipment
- 5.6 Purchased Electricity - Buildings & infrastructure

For 4.8 and 4.9, no activity data is available and emissions data is calculated based on benchmark emissions per £100m turnover. We have therefore scoped out related FERA emissions.

Whilst these emissions will be affected by changing fuel patterns and grid decarbonisation, the impact on overall emissions will be minimal, so we do not consider it proportionate to this assessment to develop a longer-term profile of emission actors. Current BEIS Emission factors, set out in Table 6.13.1 below, are therefore applied to all fuels consumed.

Table 6.13.1: FERA emission factors for fuels used in this assessment

Fuel	2017 emission factor	Unit
Well-to-tank (WTT)		
Grid Electricity (generation)	0.05605	$kgCO_2e/kWh$
Grid Electricity (T&D)	0.00524	$kgCO_2e/kWh$
Transmission & Distribution		
Grid Electricity	0.03287	$kgCO_2e/kWh$

6.12.3 Calculation Procedure & Estimated Emissions

Annual fuel and electricity consumption identified in Sections 4 and 5 is multiplied by the relevant WTT and T&D emission factors.

Table 6.13.2: GHG emissions from fuel and energy related uses during construction

Temporal Range	GHG emissions with embedded mitigation [tCO_2e]	GHG emissions after additional mitigation [tCO_2e]
Construction (2019 – 2028)	451	451

6.12.4 Data Limitations & Uncertainty

Efforts to reduce losses are likely to be made over time by power distributors, which will result in lower T&D emissions in the future.

The changing mix of fuels for gas and electricity distribution may have an impact on the WTT figures over the longer term.

Uncertainty associated with the activity data is outlined in Sections 4 and 5.

Operation

6.13 Mobile Combustion: Transportation of freight

6.13.1 Description of Process

Freight will be transported to (upstream of) and from (downstream of) the development, as a consequence of the operation of the rail freight terminal. In the counterfactual scenario, the same quantity of freight would be moved via alternative modes.

6.13.2 Data Sources

A separate assessment of freight emissions is presented in Volume 3, Appendix 23.3 of this PEIR and should be referred to in relation to data sources for this section. A summary of the resultant emissions is reproduced in Appendix E of this document.

Only direct emissions associated with the transportation of freight are included in this section; upstream emissions associated with the production and transportation of fuels are assessed in Section 6.18.

6.13.3 Calculation Procedure & Estimated Emissions

As above, the separate technical Appendix should be referred to for a full assessment of freight emissions and their calculation. Emissions are presented here in summary:

Table 6.13.3: GHG Emissions for the transportation of freight

Temporal Range	GHG emissions with embedded mitigation [tCO_2e]	GHG emissions after additional mitigation [tCO_2e]
Construction (2019 – 2028)	-57,139	-57,139
Operation (2028 – 2038)	-203,052	-203,052

6.13.4 Data Limitations & Uncertainty

Refer to Volume 3, Appendix 23.3.

6.14 Mobile Combustion: Transportation of waste

6.14.1 Description of Process

Waste will be generated by the businesses operating from the Proposed Development; this will transported to local waste facilities.

6.14.2 Data Sources

The waste chapter assumes 5 litres of waste will be generated per week per m^2 of industrial unit; this equates to $0.26m^3$ per m^2 per year.

This quantity is also applied to the other assumed building areas identified in Section 4.10.

Assuming that the majority of waste collected is general refuse, Environment Agency conversion factors (Ref 31) assume that $1m^3$ = 1 tonne.

The waste chapter identifies a range of suitable waste and recycling locations within 10km of the site; it is therefore assumed tha the distance traveleld is 10km per vehicle movement.

Tonne.km are calculated by multiplying the total tonnage of waste by the total distance travelled. Average articulated (>33t) HGV emission factors as applied in Section 6.14 are applied to the total tonne.km moved to calculate annual emissions.

6.14.3 Calculation Procedure & Estimated Emissions

The annual benchmark waste quantity is multiplied by the completed and operational building areas to assess the total annual quantity of waste generated. This is divided by the assumed tonnage of waste per waste collection trip to determine the total number of trips required, which is then multiplied by the assumed distance to a waste facility to assess the total distance travelled.

Table 6.15.1: Annual operational waste at full operation

Waste Type	Waste tonnes [t]	Waste moved [tonne.km]
Operational waste	168,017	1,680,173

This is then multiplied by the appropriate annual emission factor for HGV transport.

Table 6.15.2 GHG emissions for the transportation of waste during operation

Temporal range	GHG emissions with embedded mitigation [tCO_2e]	GHG emissions after additional mitigation [tCO_2e]
Construction (2019 – 2028)	544	544
Short-term Operation (2029 – 2038)	1,350	1,350

6.14.4 Data Limitations & Uncertainty

Waste quantities are estimated on benchmark data which may not reflect the actual waste generated in use; the types and quantities of waste generated will depend on the types of companies operating from the Proposed Development site and any policies in place for waste reduction.

6.15 Mobile Combustion: Employee business travel

6.15.1 Description of Process

Employees will travel to and from the Proposed Development for business purposes.

Business travel during the operation of the development has been scoped out of the assessment on the basis that estimations of such emissions are highly dependent on the businesses that will occupy the Proposed Development, none of which are currently known.

Assumptions regarding the total number of daily trips to and from the development are provided within the transport assessment; this is based on data from a number of sources, including similar developments elsewhere. It is therefore sensible to assume that some of these trips include travel for business purposes and this assessment, covered in further detail in Section 6.17 adequately covers business travel.

6.16 Mobile Combustion: Employee commuting

6.16.1 Description of Process

A significant number of people will eventually be employed at the Proposed Development, all of whom will travel to and from the site on a regular basis.

6.16.2 Data Sources

The Transport Assessment produced by TPA and included within this PEIR, sets out the anticipated trip attraction as a result of the completed development (Table 6.17.1) and likely mode shares (Table 6.17.2).

Table 6.17.1: Summary of person trip attraction

Trips	Daily (24 hour)		
	Arr	Dep	Total
Total Person Trips	8,136	8,006	16,142

[Source: Transport Assessment Table 8.6]

This results in the generation of 0.023 trips per sqm of industrial floor space.

The Transport Assessment also provides a breakdown of modal share for these trips. Walking and cycling are likely to account for 4% of the total journeys, with travel by public transport accounting for a further 1.5%. As there are zero emissions associated with walking and cycling, and the proportion of travel by public transport is insignificant, this assessment only addresses the contribution of privately owned vehicles.

Table 6.17.2: Rail Central baseline mode shares

Method of Travel to Work	Rail Central (Baseline)
Total Vehicles	90.5%
(Single Occupancy Vehicles)	*(86.5%)*
(Car Share)	*(8.0%)*
Public Transport (incl. Taxi)	1.5%
Walking	3.0%
Cycling	1.0%

[Source: Transport Assessment Table 8.9]

Census data for South Northamptonshire (Ref 32) provides a breakdown of the distance travelled by each mode; the proportions travelled by single occupancy vehicles and passengers for each distance range are shown below:

Table 6.17.3: Distances travelled to work by car in South Northamptonshire

Distance travelled to work	Average distance assumed [km]	Total trips	% of single occupancy vehicles	% of multiple passenger vehicles
Less than 2km	1	4,828	6.8%	0.6%
2km to less than 5km	2.5	3,182	7.4%	0.7%
5km to less than 10km	7.5	7,478	23.0%	1.5%
10km to less than 20km	15	9,348	23.6%	1.4%
20km to less than 30km	25	4,159	10.5%	0.6%
30km to less than 40km	35	2,013	5.1%	0.2%
40km to less than 60km	50	1,536	4.0%	0.1%
60km and over	60	2,795	5.2%	0.1%

[Source: Census 2011 DC7701EWla - Method of travel to work (2001 specification) by distance travelled to work (Ref 32)]

Sub-national road transport fuel consumption statistics (Ref 33) set out the tonnes of oil equivalent of different fuel types used at local authority level in 2015 (the most recent year for which data is available) on different types of road; this indicates that in 2015, 53% of vehicle fuel was diesel and 47% was petrol; this data includes hybrid vehicles (petrol and diesel).

Element Energy was appointed by the Low Carbon Vehicle Partnership in 2014 to carry out analysis regarding in the short-term, how to comply with the Renewable Energy Directive; and in the longer-term, to develop a Fuels Roadmap for transport fuels to deliver carbon reductions to 2030. The final report (Ref 34) responded to a Department for Transport ‘call for evidence on advanced fuels.

This analysis assessed the likely mix of vehicles on the road considering policies current at the time. It presented two scenarios for 2030, one assuming that 30% of new passenger cars would be electric vehicles (EV) and another assuming a higher uptake at 60%; the former presenting moderate uptake, and the latter considered what would be required to meet the targets set by the Carbon Plan. At the time, the 30% target appeared more likely, but we now consider the 60% the most likely scenario (this is explored further in Section 6.17.4).

Table 6.17.4: New car/ van EV sale scenarios

Emission scenario	2015	2020	2030	2050
Moderate ambition	<1%	3%	30%	100%
CCC Targets	<1%	9%	60%	100%

Table 6.17.5: Projected vehicle stocks over time (in thousands)

Vehicle stock	2020	2025	2030	2050
Electric	300	1,500 – 2,500	4,000 – 8,000	20,000 – 25,000
Hydrogen	2	180 - 350	680 – 1,400	4,200 – 16,800
Liquid fuel	30,000	32,000	32,000	6,000 – 31,000

[Source: Transport Energy Infrastructure Roadmap to 2050]

Liquid fuels include gasoline, diesel, LPG and bio-propane; methane is assumed for use in non-passenger vehicles only so has been excluded from the table above.

The data presented in the report assumes that vehicle ownership will continue to rise, which does not align with current trends (see Section 6.17.4 for further discussion); however this is assumed to be the case for the sake of assessing proportions of vehicles on the road and providing a conservative estimate of lower emission vehicles.

Assuming a scenario where there is high EV uptake and hydrogen and liquid fuels are deployed at the lower estimate levels, the proportion of each vehicle stock on the road over the periods identified is as follows:

Table 6.17.6: Proportion of each vehicle stock over time assuming high EV deployment

Vehicle stock	2020	2025	2030	2050
Electric	0.99%	7.21%	19.67%	71.02%
Hydrogen	0.01%	0.52%	1.67%	11.93%
Liquid fuel	99.00%	92.27%	78.66%	17.05%

This provides a low short-term estimate, as the 2020 figures have already been exceeded according to vehicle sales data from the Society of Vehicle Manufacturers and Traders (Ref 35); however, this is deemed to provide a reasonable breakdown of vehicle ownership over the medium- to long-tern. Estimates of proportions for intervening periods are made using a linear interpolation of the figures above.

There is no estimate available for the average emissions associated with all vehicles in use, but historic average in use emissions data published by SMMT (Ref 35) can be compared with new car emissions and this indicates that from

2012 onwards, average emissions are circa 20% higher than the new car emissions each year. As the vast majority (circa 99%) of vehicles currently on the road are internal combustion engine (ICE), this difference is added to the estimate of emissions from new ICE vehicles up to 2030 to provide an estimate of average ICE emissions for all vehicles. This assumes then that all electric and hydrogen vehicles are new.

As there is no estimate available for the emissions associated with ICE vehicles post-2030, it is assumed that no further advancements are made to reduce emissions further after this point, and the average emissions associated with ICE vehicles begin to converge to the average new ICE emissions allowing for an 8 year replacement period.

Estimates of hydrogen emissions are based on data published by UKH2Mobility (Ref 36), a partnership between UK industry leaders and Government. Estimates are based on a hydrogen production mix roadmap for 2030 which is forecast to deliver 51% via water electrolysis, 47% by steam methane reforming and 2% using existing capacities.

Table 6.17.7: Estimate of average in use emissions for different vehicle types

Vehicle fuel type	**Average vehicle emissions [gCO_2/km]**			
	2020	**2025**	**2030**	***2050***
Internal Combustion Engine (new)	117	101	86	86
Internal Combustion Engine (average)	140	122	104	86
Hybrid Electric Vehicles	105	90	76	*76*
Plug-in Electric Vehicles	36	31	26	*26*
Hydrogen	55	45	35	*35*

As outlined in Section 6.14, freight is demand-based and the quantity of freight moved is not affected by the delivery of additional industrial units. On this basis, some of the journeys included in this assessment will displace journeys that would have otherwise been made elsewhere.

The socio-economic assessment assumes the following displacement of employment:

- 50% (local level/ South Northamptonshire)
- 25% (wider impact area)
- 10% (national level)

By applying the percentages of the average journey distances travelled to work by car in South Northamptonshire from Table 6.17.3 to the expected trip generation figures for single occupancy and car share journeys, and then taking into account the displacement levels above, the additional trips generated as a result of the development are calculated and presented in Table 6.17.8.

Table 6.17.8 Additionality of commuting journeys in relation to Rail Central

Distance travelled to work	Level	Additional Single Occupancy Trips	Additional Car Share Trips
Less than 2km	Local	590	77
2km to less than 5km	Local	642	83
5km to less than 10km	Local	1,561	185
10km to less than 20km	Local	2,040	174
20km to less than 30km	Wider	1,369	102
30km to less than 40km	Wider	662	42
40km to less than 60km	Wider	519	19
60km and over	National	808	33
Total	**-**	**8,190**	**715**

Multiplying by average trip distances and dividing by the total calculated employment NIA of 646,221m^2 allows a ratio to be calculated that can be used to multiply by the quantity of development completed throughout the construction period. This results in 0.2728 km/m^{2}NIA for single occupancy journeys and 0.0174 km/m^2 NIA for car share trips.

6.16.3 *Calculation Procedure & Estimated Emissions*

Walking and cycling are assumed to have zero emissions and therefore require no further assessment.

An estimate of the annual distance travelled in single occupancy vehicles and by passengers has been made based on the total number of trips per sqm GFA that will be generated as a result of the proposed development, multiplied by the proportion of journeys carried out by each mode for each distance band, multiplied by the average distance for each band.

This is multiplied by the proportion of journeys that are attributable to the Proposed Development.

Table 6.17.9: Annual distances travelled at full operation

Journey type	Distance travelled [km]
Single occupancy vehicle	56,737,753
Multiple occupancy vehicle	1,809,035

The annual average in-use fuel mix calculated for each year using the data outlined in Section 6.17.4 is applied to the total distance travelled.

Car share journeys are assumed to comprise of two passengers, ‘halving’ the emissions per journey.

This results in the following emissions directly associated with the Proposed Development:

Table 6.17.10: GHG emissions from employee commuting during operation

Temporal range	GHG emissions with embedded mitigation [tCO_2e]	GHG emissions after additional mitigation [tCO_2e]
Construction (2019 – 2028)	28,559	28,559
Short-term Operation (2029 – 2038)	47,132	47,132
Long-term Operation (2039 – 2089)	Not assessed	Not assessed

6.16.4 Data Limitations & Uncertainty

Data is reported in CO_2 and does not take into account other GHG emissions.

A number of assumptions have been made due to the limited data available regarding future vehicle fuel pathways. A discussion of the likely uncertainties is outlined below.

The fleet and fuel mix is likely to change over the period of operation for a number of key reasons: in the short-term, concerns over the emissions associated with diesel and their impact on air quality are likely to result in incentives for the replacement of those vehicles with cleaner alternatives (e.g. diesel vehicle scrappage schemes or higher taxes on diesel cars or fuel); and in the medium-term, ultra-low emission vehicle (ULEV) uptake is expected to increase significantly. In addition, the growth of the ‘sharing economy’ and the potential impacts of autonomous vehicles could change patterns of vehicle ownership and increase the portion of vehicle sharing.

Over the medium-term, EU targets in place for the emissions of new vehicles will also reduce the average CO_2 emission per km for petrol and diesel vehicles.

The Vehicle Fuel Roadmap was produced in 2015 and in the short space of time since this was commissioned, there have been significant shifts in the new vehicle market that are likely to have significant impacts on the forecast modal share.

By December 2017, alternative fuel vehicles reached 5.6% of the new car market share, an increase of 37% compared with the previous year. At the same time, sales of diesel vehicles were down 31.1%, petrol vehicles down 2.1% (Ref 35).

New Bloomberg Finance’s *Electric Vehicle Outlook in 2017* (Ref 38) cites battery costs falling faster than expected and rising commitments from automakers as the reason for increasing their EV forecast in 2017 over their 2016 forecast. The report predicts that by 2040, 54% of new car sales and 33%

of the global car fleet will be electric. EV sales to 2025 will remain relatively low, and inflection point in adoption between 2025 and 2030 will occur as EVs become economical on an unsubsidized total cost of ownership across mass-market vehicle classes.

Other forecasts predict widely different, but upward estimates:

- Exxon Mobil Corp. (Ref 39) raised its 2017 forecast for 2040 to 100 million EVs (from 64.8 million in 2016).
- BP (Ref 40) projects 100 million by 2035 (from 71.4 million in 2016).
- ING Economics Department (Ref 41) predict that all new cars sold in Europe will be electric by 2030.

The International Energy Agency (IEA) (Ref 42) predicts that in the next 10 to 20 years the electric car market will likely transition from early deployment to mass market adoption. Assessments of country targets, OEM announcements and scenarios on electric car deployment seem to confirm these positive signals; indicating that the electric car stock may range between 9 million and 20 million by 2020 and between 40 million and 70 million by 2025.

Given the significant uncertainty around the market share and market penetration of electric vehicles and other scenarios that could affect emissions, the estimate of emissions presented here is considered to be a conservative one.

6.17 Fugitive Emissions: Refrigerants

6.17.1 Description of Process

It is likely that some goods being transported will require refrigeration, both within vehicles and buildings. This could lead to the release of fugitive gases with high global warming potential.

It is assumed however that all refrigeration equipment will meet current European Standards, limiting the use of gases with the most significant potential for impact, and that refrigeration and air-conditioning equipment will be serviced to reduce the potential for leaks.

This has therefore been scoped out of the assessment.

6.18 Process Emissions: Fuel and energy related emissions (FERA)

6.18.1 Description of Process

FERA emissions relate are as a result of fuel and energy consumption that are unaccounted for elsewhere in this assessment.

Well-to-tank (WTT) account for the upstream Scope 3 emissions associated with extraction, refining and transportation of the raw fuel sources prior to combustion.

Transmission and distribution (T&D) account for emissions associated with grid losses (the energy loss that occurs in getting the electricity from the power plant to organisations that purchase it).

6.18.2 Data Sources

Activity data is the same as is calculated in Section 4 and Section 5 of this report, relating to 'Scope 1' and 'Scope 2' emissions. Whilst upstream and downstream emissions will be associated with other 'Scope 3' emissions, we consider the assessment of those emissions to be outside the assessment boundary and disproportionate to the assessment. The relevant activity data can be found in sections:

- 4.10 Stationary Combustion - Production of heat and electricity
- 4.11 Mobile Combustion - Fuel use in plant & equipment
- 5.7 Purchased Electricity - Buildings & infrastructure
- 6.14 Mobile Combustion - Transportation of freight

Profiled emission factors as set out in Appendix B Table B.2 are applied to the consumption of gas, electricity and vehicle fuels.

6.18.3 Calculation Procedure & Estimated Emissions

Annual fuel and electricity consumption identified in Sections 4 and 5 is multiplied by the relevant WTT and T&D emission factors.

Table 6.19.2: GHG emissions from fuel and energy related uses during operation

Temporal range	GHG emissions with embedded mitigation [tCO_2e]	GHG emissions after additional mitigation [tCO_2e]
Construction (2019 – 2028)	-3,851	-5,506
Short-term Operation (2029 – 2038)	-15,139	-17,338
Long-term Operation (2039 – 2089)	Not assessed	Not assessed

6.18.4 Data Limitations & Uncertainty

Efforts to reduce losses are likely to be made over time by power distributors, which will result in lower T&D emissions in the future.

The changing mix of fuels for gas and electricity distribution may have an impact on the WTT figures over the longer term.

Uncertainty associated with the activity data is outlined in Sections 4 and 5.

Appendix A: Profiled Emissions by Phase

Table A.1: Site Baseline Emissions (2018 – 2028)

Existing site	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Construciton Spend (£m)	18	0	25	50	53	42	38	51	66	32	0
Construction area (buildings)			25,441	17,761	116,286	84,879	90,405	109,753	124,667	77,030	0
4.5: Stationary Combustion - Production of heat											
Agricultural use of heating oil (l)	305	305	305	305	305	305	305	305	305	305	305
Annual GHG Emissions [tCO$_2$e]	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***
Cumulative GHG Emissions [tCO$_2$e]	***0.96***	***0.96***	***1.93***	***2.89***	***3.86***	***4.82***	***5.79***	***6.75***	***7.72***	***8.68***	***9.65***
4.6 Mobile Combustion - Plant & equipment											
Road fuel [l]	29,718	29,718	29,718	29,718	29,718	29,718	29,718	29,718	29,718	29,718	29,718
Red diesel [l]	279,212	279,212	279,212	279,212	279,212	279,212	279,212	279,212	279,212	279,212	279,212
Red diesel used by contractors [l]	22,834	22,834	22,834	22,834	22,834	22,834	22,834	22,834	22,834	22,834	22,834
LPG [kg]	5,249	5,249	5,249	5,249	5,249	5,249	5,249	5,249	5,249	5,249	5,249
Kerosene [l]	31,333	31,333	31,333	31,333	31,333	31,333	31,333	31,333	31,333	31,333	31,333
Annual GHG Emissions [tCO$_2$e]	***1,257***	***1,257***	***1,257***	***1,257***	***1,257***	***1,257***	***1,257***	***1,257***	***1,257***	***1,257***	***1,257***
Cumulative GHG Emissions [tCO$_2$e]	***-***	***1,257***	***2,514***	***3,771***	***5,027***	***6,284***	***7,541***	***8,798***	***10,055***	***11,312***	***12,569***
5.5 Purchased Electricity - Buildings & infrastructure											
Agricultural electricity consumption [kWh]	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301
Annual GHG Emissions [tCO$_2$e]	***63***	***60***	***56***	***53***	***45***	***44***	***46***	***43***	***35***	***37***	***33***
Cumulative GHG Emissions [tCO$_2$e]	***63***	***123***	***178***	***231***	***276***	***321***	***367***	***410***	***445***	***482***	***515***
Annual Scope 1 & 2 GHG Emissions [tCO$_2$e]	***1,318***	***1,313***	***1,310***	***1,303***	***1,302***	***1,304***	***1,301***	***1,293***	***1,295***	***1,291***	***1,318***
Cumulative Scope 1 & 2 GHG Emissions [tCO$_2$e]	***-***	***1,318***	***2,631***	***3,941***	***5,245***	***6,547***	***7,851***	***9,152***	***10,445***	***11,739***	***13,030***
6.2 Process Emissions: Agrochemical production & use											
Pesticide production and use	244	244	244	244	244	244	244	244	244	244	244
Fertilizer production and use	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358
Annual GHG Emissions [tCO$_2$e]	***1,602***	***1,602***	***1,602***	***1,602***	***1,602***	***1,602***	***1,602***	***1,602***	***1,602***	***1,602***	***1,602***
Cumulative GHG Emissions [tCO2e]	***-***	***1,602***	***3,204***	***4,805***	***6,407***	***8,009***	***9,611***	***11,212***	***12,814***	***14,416***	***16,018***
6.3 Fuel and energy related emissions (FERA)											
5.5 Electricity [kWh]	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301
Annual GHG Emissions [tCO$_2$e]	29	29	29	29	29	29	29	29	29	29	29
Annual GHG Emissions [tCO$_2$e]	***-9***	***29***	***29***	***29***	***29***	***29***	***29***	***29***	***29***	***29***	***29***
Annual Scope 3 GHG Emissions [tCO$_2$e]	***1,631***	***1,631***	***1,631***	***1,631***	***1,631***	***1,631***	***1,631***	***1,631***	***1,631***	***1,631***	***1,631***
Cumulative Scope 3 GHG Emissions [tCO2e]	***-***	***1,631***	***3,261***	***4,892***	***6,523***	***8,154***	***9,784***	***11,415***	***13,046***	***14,676***	***16,307***
Annual Baseline GHG Emissions [tCO$_2$e]	**2,944**	**2,941**	**2,934**	**2,933**	**2,935**	**2,932**	**2,924**	**2,925**	**2,922**	**2,944**	**2,941**
Cumulative Baseline GHG Emissions [tCO$_2$e]	**-**	**2,948**	**5,892**	**8,834**	**11,767**	**14,700**	**17,635**	**20,567**	**23,490**	**26,416**	**29,338**

Table A.2: Site Baseline Emissions (2029 – 2038)

Existing Site	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Construction Spend (£m)	0	25	50	53	42	38	51	66	32	0
Construction area (buildings)		25,441	17,761	116,286	84,879	90,405	109,753	124,667	77,030	0
4.5: Stationary Combustion - Production of heat										
Agricultural use of heating oil (l)	305	305	305	305	305	305	305	305	305	305
Annual GHG Emissions [tCO$_2$e]	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***
Cumulative GHG Emissions [tCO$_2$e]	***0.96***	***1.93***	***2.89***	***3.86***	***4.82***	***5.79***	***6.75***	***7.72***	***8.68***	***9.65***
4.6 Mobile Combustion - Plant & equipment										
Road fuel [l]	29,718	29,718	29,718	29,718	29,718	29,718	29,718	29,718	29,718	29,718
Red diesel [l]	279,212	279,212	279,212	279,212	279,212	279,212	279,212	279,212	279,212	279,212
Red diesel used by contractors [l]	22,834	22,834	22,834	22,834	22,834	22,834	22,834	22,834	22,834	22,834
LPG [kg]	5,249	5,249	5,249	5,249	5,249	5,249	5,249	5,249	5,249	5,249
Kerosene [l]	31,333	31,333	31,333	31,333	31,333	31,333	31,333	31,333	31,333	31,333
Annual GHG Emissions [tCO$_2$e]	***1,257***	***1,257***	***1,257***	***1,257***	***1,257***	***1,257***	***1,257***	***1,257***	***1,257***	***1,257***
Cumulative GHG Emissions [tCO$_2$e]	***1,257***	***2,514***	***3,771***	***5,027***	***6,284***	***7,541***	***8,798***	***10,055***	***11,312***	***12,569***
5.5 Purchased Electricity - Buidings & infrastructure										
Agricultural electricity consumption [kWh]	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301
Annual GHG Emissions [tCO$_2$e]	***30***	***32***	***29***	***24***	***23***	***20***	***17***	***17***	***17***	***17***
Cumulative GHG Emissions [tCO$_2$e]	30	62	91	115	138	158	175	192	209	226
Annual Scope 1 & 2 GHG Emissions [tCO$_2$e]	***1,287***	***1,290***	***1,287***	***1,282***	***1,281***	***1,278***	***1,275***	***1,275***	***1,275***	***1,275***
Cumulative Scope 1 & 2 GHG Emissions [tCO$_2$e]	***1,287***	***2,577***	***3,864***	***5,146***	***6,427***	***7,705***	***8,980***	***10,254***	***11,529***	***12,804***
6.2 Process Emissions: Agrochemical production & use										
Pesticide production and use	244	244	244	244	244	244	244	244	244	244
Fertilizer production and use	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358	1,358
Annual GHG Emissions [tCO$_2$e]	***1,602***	***1,602***	***1,602***	***1,602***	***1,602***	***1,602***	***1,602***	***1,602***	***1,602***	***1,602***
Cumulative GHG Emissions [tCO$_2$e]	***1,602***	***3,204***	***4,805***	***6,407***	***8,009***	***9,611***	***11,212***	***12,814***	***14,416***	***16,018***
6.3 Fuel and energy related emissions (FERA)										
5.5 Electricity [kWh]	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301	307,301
Annual GHG Emissions [tCO$_2$e]	29	29	29	29	29	29	29	29	29	29
Annual GHG Emissions [tCO$_2$e]	29	58	87	116	145	174	203	231	260	289
Annual Scope 3 GHG Emissions [tCO$_2$e]	***1,631***	***1,631***	***1,631***	***1,631***	***1,631***	***1,631***	***1,631***	***1,631***	***1,631***	***1,631***
Cumulative Scope 3 GHG Emissions [tCO$_2$e]	***1,631***	***3,261***	***4,892***	***6,523***	***8,154***	***9,784***	***11,415***	***13,046***	***14,676***	***16,307***
Annual Baseline GHG Emissions [tCO$_2$e]	***2,918***	***2,921***	***2,918***	***2,912***	***2,911***	***2,909***	***2,905***	***2,905***	***2,905***	***2,905***
Cumulative Baseline GHG Emissions [tCO$_2$e]	***2,918***	***5,839***	***8,757***	***11,669***	***14,580***	***17,489***	***20,395***	***23,300***	***26,206***	***29,111***

Table A.3: Construction Phase Emissions (2019 – 2028) with Embedded Mitigation

Rail Central	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Construction Spend (£m)	19	26	51	54	43	39	52	67	33	1
Construction area (buildings)	0	25,441	17,761	116,286	84,879	90,405	109,753	124,667	77,030	0
4.9 Mobile combustion - Fuel use in mobile plant & equipment										
GHG Emissions per £100m turnover [CO2e/£100m]	27.335	26.788	26.253	25.728	25.213	24.709	24.215	23.730	23.256	22.791
Annual GHG Emissions [tCO2e]	***5***	***7***	***13***	***14***	***11***	***10***	***13***	***16***	***8***	***0***
Cumulative GHG Emissions [tCO2e]	***5***	***12***	***26***	***40***	***51***	***60***	***73***	***89***	***97***	***96.8***
5.7 Purchased Electricity: Buildings & infrastructure										
Site Electricity Emissions [kWh]	240,153	332,763	651,742	691,133	552,310	501,994	663,308	856,840	416,978	12,713
Annual GHG Emissions [tCO2e]	47	60	111	102	80	75	93	98	50	1
Cumulative GHG Emissions [tCO2e]	47	107	218	320	400	475	569	667	717	717.9
Scope 1 & 2 Annual GHG Emissions [tCO2e]	***52***	***67***	***125***	***116***	***91***	***85***	***106***	***114***	***57***	***2***
Cumulative Scope 1 & 2 GHG Emissions [tCO2e]	***52***	***119***	***244***	***360***	***451***	***536***	***642***	***756***	***813***	***815***
6.8 Mobile combustion: Transportation of materials										
Non-LCA materials moved by articulated truck [HGV-km]	9,912	156,305	598,142	788,580	645,330	621,940	838,380	968,899	585,596	0
LCA A4 Emissions [tCO2e]	133	173	280	377	316	304	421	489	307	9
Annual GHG Emissions [tCO2e]	***134***	***187***	***333***	***447***	***372***	***357***	***492***	***571***	***356***	***9***
Cumulative GHG Emissions [tCO2e]	***134***	***321***	***654***	***1,101***	***1,473***	***1,831***	***2,323***	***2,894***	***3,250***	***3,259***
6.9 Mobile combustion: Transportation of waste										
Construction waste generated (tonnes)	0	3,353	2,341	15,326	11,187	11,915	14,465	16,431	10,152	0
Waste moved [tonne.km]	0	33,530	23,408	153,260	111,866	119,150	144,650	164,306	101,522	0
Annual GHG Emissions [tCO2e]	***0***	***3***	***2***	***14***	***10***	***10***	***12***	***14***	***8***	***0***
Cumulative GHG Emissions [tCO2e]	***0***	***3***	***5***	***19***	***28***	***39***	***51***	***65***	***73***	***73***
6.17 Mobile combustion: Employee commuting										
Single occupancy vehicles: Distance travelled [km]	14,018	39,098	89,087	83,027	69,631	19,214	81,944	102,947	68,442	0
Shared vehicles: Distance travelled [passenger km]	1,558	4,344	9,899	9,225	7,737	2,135	9,105	11,439	7,605	0
Annual GHG Emissions [tCO2e]	***2,176***	***6,069***	***13,469***	***12,115***	***9,796***	***2,604***	***10,686***	***12,830***	***8,144***	***0***
Cumulative GHG Emissions [tCO2e]	***2,176***	***8,245***	***21,714***	***33,829***	***43,625***	***46,229***	***56,915***	***69,745***	***77,889***	***77,889***
6.12 Process emissions - Production of construction materials										
SRFI Quantity of materials used in buildings [tonnes]	0	0	31,026	209,613	174,161	165,913	229,169	270,541	161,948	0
SRFI Quantity of materials used in infrastructure [tonnes]	42,504	98,453	144,085	0	0	0	0	0	0	0
SRFI Total quantity of materials [tonnes]	42,504	98,453	175,111	209,613	174,161	165,913	229,169	270,541	161,948	0
J15a Quantity of materials used in infrastructure [tonnes]	11,021	11,021	11,021	11,021	11,021	11,021	11,021	11,021	11,021	11,021
Highway Works Quantity of materials used in infrastructure [tonnes]	1,858	1,858	1,858	1,858	1,858	1,858	1,858	1,858	1,858	1,858
Annual GHG Emissions [tCO2e]	***2,639***	***9,394***	***25,284***	***32,699***	***26,678***	***25,734***	***34,628***	***40,231***	***22,972***	***246***
Cumulative GHG Emissions [tCO2e]	***2,639***	***12,033***	***37,317***	***70,016***	***96,694***	***122,428***	***157,055***	***197,286***	***220,258***	***220,504***
6.19 Process Emissions: Fuel & energy related activity										
5.6 Related [kWh]	240,153	332,763	651,742	691,133	552,310	501,994	663,308	856,840	416,978	12,713
Annual GHG Emissions [tCO_2e]	***23***	***31***	***61***	***65***	***52***	***47***	***62***	***81***	***39***	***1***
Cumulative GHG Emissions [tCO_2e]	***23***	***54***	***115***	***180***	***232***	***280***	***342***	***423***	***462***	***463***
Scope 3 Annual GHG Emissions [tCO_2e]	***4,971***	***15,685***	***39,150***	***45,339***	***36,908***	***28,752***	***45,880***	***53,726***	***31,520***	***256***
Cumulative Scope 3 GHG Emissions [tCO2e]	***4,971***	***20,656***	***59,806***	***105,145***	***142,054***	***170,806***	***216,686***	***270,412***	***301,932***	***302,188***
Total Annual GHG Emissions [tCO_2e]	***5,023***	***15,752***	***39,275***	***45,455***	***36,999***	***28,837***	***45,986***	***53,840***	***31,577***	***258***
Cumulative GHG Emissions [tCO_2e]	***5,023***	***20,775***	***60,050***	***105,506***	***142,504***	***171,342***	***217,328***	***271,168***	***302,745***	***303,003***

Table A.4: Construction Phase Emissions (2019 – 2028) with Adaptive Mitigation

Rail Central	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Construction Spend (£m)	19	26	51	54	43	39	52	67	33	1
Construction area (buildings)	0	25,441	17,761	116,286	84,879	90,405	109,753	124,667	77,030	0
4.9 Mobile combustion - Fuel use in mobile plant & equipment										
GHG Emissions per £100m turnover [CO2e/£100m]	27.335	26.788	26.253	25.728	25.213	24.709	24.215	23.730	23.256	22.791
Annual GHG Emissions [tCO2e]	***5***	***7***	***13***	***14***	***11***	***10***	***13***	***16***	***8***	***0***
Cumulative GHG Emissions [tCO2e]	***5***	***12***	***26***	***40***	***51***	***60***	***73***	***89***	***97***	***96.8***
5.7 Purchased Electricity: Buildings & infrastructure										
Site Electricity Emissions [kWh]	240,153	332,763	651,742	691,133	552,310	501,994	663,308	856,840	416,978	12,713
Annual GHG Emissions [tCO2e]	47	60	111	102	80	75	93	98	50	1
Cumulative GHG Emissions [tCO2e]	47	107	218	320	400	475	569	667	717	717.9
Scope 1 & 2 Annual GHG Emissions [tCO2e]	***52***	***67***	***125***	***116***	***91***	***85***	***106***	***114***	***57***	***2***
Cumulative Scope 1 & 2 GHG Emissions [tCO2e]	***52***	***119***	***244***	***360***	***451***	***536***	***642***	***756***	***813***	***815***
6.8 Mobile combustion: Transportation of materials										
Non-LCA materials moved by articulated truck [tonne-km]	9,912	156,305	598,142	788,580	645,330	621,940	838,380	968,899	585,596	0
LCA A4 Emissions [tCO2e]	133	173	280	377	316	304	421	489	307	9
Annual GHG Emissions [tCO2e]	***134***	***187***	***333***	***447***	***372***	***357***	***492***	***571***	***356***	***9***
Cumulative GHG Emissions [tCO2e]	***134***	***321***	***654***	***1,101***	***1,473***	***1,831***	***2,323***	***2,894***	***3,250***	***3,259***
6.9 Mobile combustion: Transportation of waste										
Construction waste generated (tonnes)	0	852	594	3,892	2,841	3,026	3,674	4,173	2,578	0
Waste moved [tonne.km]	0	8,516	5,945	38,923	28,411	30,260	36,736	41,729	25,783	0
Annual GHG Emissions [tCO2e]	***0***	***1***	***1***	***3***	***2***	***3***	***3***	***4***	***2***	***0***
Cumulative GHG Emissions [tCO2e]	***0***	***1***	***1***	***5***	***7***	***10***	***13***	***16***	***19***	***19***
6.17 Mobile combustion: Employee commuting										
Single occupancy vehicles: Distance travelled [km]	14,018	39,098	89,087	83,027	69,631	19,214	81,944	102,947	68,442	0
Shared vehicles: Distance travelled [passenger km]	1,558	4,344	9,899	9,225	7,737	2,135	9,105	11,439	7,605	0
Annual GHG Emissions [tCO2e]	***2,176***	***6,069***	***13,469***	***12,115***	***9,796***	***2,604***	***10,686***	***12,830***	***8,144***	***0***
Cumulative GHG Emissions [tCO2e]	***2,176***	***8,245***	***21,714***	***33,829***	***43,625***	***46,229***	***56,915***	***69,745***	***77,889***	***77,889***
6.12 Process emissions - Production of construction materials										
Annual GHG Emissions [tCO2e]	***2,111***	***7,515***	***20,227***	***26,159***	***21,342***	***20,587***	***27,702***	***32,184***	***18,377***	***197***
Cumulative GHG Emissions [tCO2e]	***2,111***	***9,626***	***29,854***	***56,013***	***77,355***	***97,942***	***125,644***	***157,829***	***176,206***	***176,403***
6.19 Process Emissions: Fuel & energy related activity										
5.6 Related [kWh]	240,153	332,763	651,742	691,133	552,310	501,994	663,308	856,840	416,978	12,713
Annual GHG Emissions [tCO2e]	***23***	***31***	***61***	***65***	***52***	***47***	***62***	***81***	***39***	***1***
Cumulative GHG Emissions [tCO2e]	***23***	***54***	***115***	***180***	***232***	***280***	***342***	***423***	***462***	***463***
Scope 3 Annual GHG Emissions [tCO2e]	***4,443***	***13,804***	***34,092***	***38,789***	***31,565***	***23,598***	***38,946***	***45,669***	***26,919***	***207***
Cumulative Scope 3 GHG Emissions [tCO2e]	***4,443***	***18,247***	***52,339***	***91,128***	***122,694***	***146,292***	***185,237***	***230,907***	***257,826***	***258,033***
Total Annual GHG Emissions [tCO2e]	***4,495***	***13,871***	***34,217***	***38,905***	***31,656***	***23,683***	***39,052***	***45,783***	***26,976***	***209***
Cumulative GHG Emissions [tCO2e]	***4,495***	***18,366***	***52,583***	***91,488***	***123,144***	***146,827***	***185,879***	***231,662***	***258,639***	***258,847***

Table A.5: Construction Phase Operational Emissions (2018 – 2028) with Embedded Mitigation

Rail Central	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
B8 area completed in year [sqm]				116,811	86,179	80,147	110,531	104,883	122,229	
Proportion of year B8 is operational [%]				21%	19%	25%	20%	39%	34%	
Cumulative completed B8 area [sqm]				116,811	202,990	283,136	393,667	498,551	620,780	620,780
B8 area operational within year [sqm]				24,002	133,102	223,026	304,940	434,758	539,740	620,780
B1 area completed in year [sqm]			3,472							
Cumulative B1 area [sqm NIA]			3,472	3,472	3,472	3,472	3,472	3,472	3,472	3,472
B2 area complete in year [sqm NIA]			21,969							
Cumulative B2 area [sqm NIA]			21,969	21,969	21,969	21,969	21,969	21,969	21,969	21,969
Annual operating days			335	335	335	335	335	335	335	335
4.10 Stationary combustion: Production of heat and electricity										
B1 Building Gas Consumption (Part L Compliant) [kWh]			74,092	74,092	74,092	74,092	74,092	74,092	74,092	74,092
B2 Building Gas Consumption (Part L Compliant) [kWh]			463,766	463,766	463,766	463,766	463,766	463,766	463,766	463,766
B8 Building Gas Consumption (Part L Compliant) [kWh]			0	139,533	773,768	1,296,526	1,772,716	2,527,396	3,137,689	3,608,798
Total gas consumption [kWh]			537,858	677,391	1,311,626	1,834,384	2,310,574	3,065,254	3,675,547	4,146,656
Annual GHG Emissions [tCO2e]			***98***	***123***	***237***	***331***	***416***	***550***	***657***	***739***
Cumulative GHG Emissions [tCO2e]			***98***	***221***	***458***	***789***	***1,205***	***1,755***	***2,412***	***3,151***
5.7 Purchased Electricity: Buidings & infrastructure										
B1 Building Electricity Consumption (Part L Compliant) [kWh]			203,043	203,043	203,043	203,043	203,043	203,043	203,043	203,043
B2 Building Electricity Consumption (Part L Compliant) [kWh]			1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119
B8 Building Electricity Consumption (Part L Compliant) [kWh]			0	2,801,128	4,867,691	6,789,611	9,440,139	11,955,241	14,886,292	14,886,292
Site Electricity Emissions [kWh]			1,679,106	3,263,255	10,463,858	16,398,842	21,805,129	30,373,165	37,301,946	42,650,553
Infrastructure Electricity Emissions [kWh]			0	8,648	47,954	80,352	109,864	156,636	194,459	223,656
Total fuel consumption [kWh]			3,038,267	7,432,192	16,738,664	24,627,966	32,714,294	43,844,203	53,741,858	59,119,663
Annual GHG Emissions [tCO2e]			***519***	***1,099***	***2,415***	***3,697***	***4,606***	***5,008***	***6,415***	***6,408***
Cumulative GHG Emissions [tCO2e]			***519***	***1,618***	***4,032***	***7,729***	***12,335***	***17,343***	***23,758***	***30,166***
Scope 1 & 2 Annual GHG Emissions [tCO2e]	***0***	***0***	***617***	***1,222***	***2,652***	***4,028***	***5,022***	***5,558***	***7,072***	***7,147***
Cumulative Scope 1 & 2 GHG Emissions [tCO2e]	***0***	***0***	***617***	***1,839***	***4,491***	***8,518***	***13,540***	***19,097***	***26,170***	***33,317***
6.14 Mobile combustion: Transportation of freight										
Road HGV distance [000 tonne.km]	0	0	0	-25,324	-140,433	-235,310	-321,735	-458,704	-569,467	-654,970
Rail freight [000 tonne.km]	0	0	0	34,868	193,355	323,985	442,979	631,564	784,068	901,792
HGV GHG Emissions [tCO2e]	0	0	0	-1,680	-9,180	-15,160	-20,431	-28,713	-35,142	-39,851
Rail GHG Emissions [tCO2e]	0	0	0	1,078	5,861	9,649	12,889	17,774	21,627	24,140
Annual GHG Emissions [tCO2e]	***0***	***0***	***0***	***-602***	***-3,319***	***-5,511***	***-7,542***	***-10,939***	***-13,515***	***-15,711***
Cumulative GHG Emissions [tCO2e]	***0***	***0***	***0***	***-602***	***-3,921***	***-9,432***	***-16,974***	***-27,914***	***-41,428***	***-57,139***
6.15 Mobile combustion: Transportation of waste										
Waste generation [m^3or tonnes]			6,615	12,855	41,221	64,601	85,899	119,652	146,947	168,017
Goods moved [tonne.km]			66,147	128,552	412,213	646,015	858,990	1,196,519	1,469,471	1,680,173
Annual GHG Emissions [tCO_2e]			***6***	***11***	***36***	***56***	***73***	***101***	***123***	***139***
Cumulative GHG Emissions [tCO_2e]			***6***	***17***	***53***	***109***	***182***	***283***	***406***	***544***
6.17 Mobile combustion: Employee commuting										
Single occupancy vehicles: Distance travelled [km]			0	10,676,244	18,552,761	25,877,986	35,980,235	45,566,317	56,737,753	56,737,753
Shared vehicles: Distance travelled [passenger km]			0	340,403	591,539	825,097	1,147,199	1,452,843	1,809,035	1,809,035

Annual GHG Emissions [tCO2e]			***0***	***1,424***	***2,387***	***3,207***	***4,290***	***5,192***	***6,173***	***5,886***
Cumulative GHG Emissions [tCO2e]			***0***	***1,424***	***3,811***	***7,018***	***11,308***	***16,500***	***22,673***	***28,559***
6.19 Process Emissions: Fuel & energy related activity										
4.10 Related [kWh]			537,858	677,391	1,311,626	1,834,384	2,310,574	3,065,254	3,675,547	4,146,656
5.7 Related [kWh]			3,038,267	7,432,192	16,738,664	24,627,966	32,714,294	43,844,203	53,741,858	59,119,663
6.14 Road freight [000 tonne.km]	0	0	0	-25,324	-140,433	-235,310	-321,735	-458,704	-569,467	-654,970
6.14 Rail freight [000 tonne.km]	0	0	0	34,868	193,355	323,985	442,979	631,564	784,068	901,792
Annual GHG Emissions [tCO2e]	***0***	***0***	***302***	***429***	***5***	***-321***	***-532***	***-1,023***	***-1,332***	***-1,781***
Cumulative GHG Emissions [tCO2e]	***0***	***0***	***302***	***731***	***736***	***415***	***-117***	***-1,140***	***-2,472***	***-4,253***
Scope 3 Annual GHG Emissions [tCO2e]	***0***	***0***	***308***	***1,263***	***-892***	***-2,570***	***-3,711***	***-6,669***	***-8,551***	***-11,467***
Cumulative Scope 3 GHG Emissions [tCO2e]	***0***	***0***	***308***	***1,571***	***679***	***-1,891***	***-5,601***	***-12,270***	***-20,822***	***-32,289***
Total Annual GHG Emissions [tCO2e]	**0**	**0**	**925**	**2,485**	**1,760**	**1,458**	**1,311**	**-1,112**	**-1,479**	**-4,320**
	0	**0**	**925**	**3,409**	**5,170**	**6,628**	**7,939**	**6,827**	**5,348**	**1,028**

Table A.6: Construction Phase Operational Emissions (2018 – 2028) with Adaptive Mitigation

Rail Central	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
B8 area completed in year [sqm]				116,811	86,179	80,147	110,531	104,883	122,229	
Proportion of year B8 is operational [%]				21%	19%	25%	20%	39%	34%	
Cumulative completed B8 area [sqm]				116,811	202,990	283,136	393,667	498,551	620,780	620,780
B8 area operational within year [sqm]				24,002	133,102	223,026	304,940	434,758	539,740	620,780
B1 area completed in year [sqm]			3,472							
Cumulative B1 area [sqm NIA]			3,472	3,472	3,472	3,472	3,472	3,472	3,472	3,472
B2 area complete in year [sqm NIA]			21,969							
Cumulative B2 area [sqm NIA]			21,969	21,969	21,969	21,969	21,969	21,969	21,969	21,969
Annual operating days			335	335	335	335	335	335	335	335
4.10 Stationary combustion: Production of heat and electricity										
B1 Building Gas Consumption (Part L Compliant) [kWh]			74,092	74,092	74,092	74,092	74,092	74,092	74,092	74,092
B2 Building Gas Consumption (Part L Compliant) [kWh]			463,766	463,766	463,766	463,766	463,766	463,766	463,766	463,766
B8 Building Gas Consumption (Part L Compliant) [kWh]			0	128,409	712,080	1,193,161	1,631,387	2,325,900	2,887,537	3,321,088
Total gas consumption [kWh]			537,858	666,267	1,249,938	1,731,019	2,169,245	2,863,758	3,425,395	3,858,946
Annual GHG Emissions [tCO2e]			***98***	***121***	***226***	***312***	***390***	***514***	***613***	***688***
Cumulative GHG Emissions [tCO2e]			***98***	***219***	***445***	***757***	***1,148***	***1,661***	***2,274***	***2,962***
5.7 Purcahsed Electricity: Buidings & infrastructure										
B1 Building Electricity Consumption (Part L Compliant) [kWh]			203,043	203,043	203,043	203,043	203,043	203,043	203,043	203,043
B2 Building Electricity Consumption (Part L Compliant) [kWh]			1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119
B8 Building Electricity Consumption (Part L Compliant) [kWh]			0	554,584	3,075,395	5,153,134	7,045,785	10,045,312	12,470,963	14,343,421
Site Electricity Emissions [kWh]			1,679,106	3,263,255	10,463,858	16,398,842	21,805,129	30,373,165	37,301,946	42,650,553
Infrastructure Electricity Emissions [kWh]			0	8,648	47,954	80,352	109,864	156,636	194,459	223,656
Total fuel consumption [kWh]			3,038,267	5,185,648	14,946,368	22,991,490	30,319,939	41,934,274	51,326,529	58,576,791
Annual GHG Emissions [tCO2e]			***519***	***767***	***2,156***	***3,451***	***4,269***	***4,790***	***6,127***	***6,349***
Cumulative GHG Emissions [tCO2e]			***519***	***1,286***	***3,442***	***6,893***	***11,162***	***15,951***	***22,078***	***28,427***
Scope 1 & 2 Annual GHG Emissions [tCO2e]	***0***	***0***	***617***	***887***	***2,382***	***3,763***	***4,659***	***5,303***	***6,739***	***7,037***
Cumulative Scope 1 & 2 GHG Emissions [tCO2e]	***0***	***0***	***617***	***1,504***	***3,887***	***7,650***	***12,309***	***17,612***	***24,352***	***31,389***
6.14 Mobile combustion: Transportation of freight										
Road HGV distance [000 tonne.km]	0	0	0	-25,324	-140,433	-235,310	-321,735	-458,704	-569,467	-654,970
Rail freight [000 tonne.km]	0	0	0	34,868	193,355	323,985	442,979	631,564	784,068	901,792
HGV GHG Emissions [tCO2e]	0	0	0	-1,680	-9,180	-15,160	-20,431	-28,713	-35,142	-39,851
Rail GHG Emissions [tCO2e]	0	0	0	1,078	5,861	9,649	12,889	17,774	21,627	24,140
Annual GHG Emissions [tCO2e]	***0***	***0***	***0***	***-602***	***-3,319***	***-5,511***	***-7,542***	***-10,939***	***-13,515***	***-15,711***
Cumulative GHG Emissions [tCO2e]	***0***	***0***	***0***	***-602***	***-3,921***	***-9,432***	***-16,974***	***-27,914***	***-41,428***	***-57,139***
6.15 Mobile combustion: Transportation of waste										
Waste generation [m^3or tonnes]			6,615	12,855	41,221	64,601	85,899	119,652	146,947	168,017
Goods moved [tonne.km]			66,147	128,552	412,213	646,015	858,990	1,196,519	1,469,471	1,680,173
Annual GHG Emissions [tCO_2e]			***6***	***11***	***36***	***56***	***73***	***101***	***123***	***139***
Cumulative GHG Emissions [tCO_2e]			***6***	***17***	***53***	***109***	***182***	***283***	***406***	***544***
6.17 Mobile combustion: Employee commuting										
Single occupancy vehicles: Distance travelled [km]			0	10,676,244	18,552,761	25,877,986	35,980,235	45,566,317	56,737,753	56,737,753
Shared vehicles: Distance travelled [passenger km]			0	340,403	591,539	825,097	1,147,199	1,452,843	1,809,035	1,809,035

Turley

Annual GHG Emissions [tCO2e]			***0***	***1,424***	***2,387***	***3,207***	***4,290***	***5,192***	***6,173***	***5,886***
Cumulative GHG Emissions [tCO2e]			***0***	***1,424***	***3,811***	***7,018***	***11,308***	***16,500***	***22,673***	***28,559***
6.19 Process Emissions: Fuel & energy related activity											
4.10 Related [kWh]			537,858	677,391	1,311,626	1,834,384	2,310,574	3,065,254	3,675,547	4,146,656
5.7 Related [kWh]			3,038,267	7,432,192	16,738,664	24,627,966	32,714,294	43,844,203	53,741,858	59,119,663
6.14 Road freight [000 tonne.km]	0	0	0	-25,324	-140,433	-235,310	-321,735	-458,704	-569,467	-654,970
6.14 Rail freight [000 tonne.km]	0	0	0	34,868	193,355	323,985	442,979	631,564	784,068	901,792
Annual GHG Emissions [tCO2e]	***0***	***0***	***302***	***217***	***-165***	***-478***	***-761***	***-1,209***	***-1,567***	***-1,841***
Cumulative GHG Emissions [tCO2e]	***0***	***0***	***302***	***519***	***353***	***-125***	***-886***	***-2,095***	***-3,663***	***-5,503***
Scope 3 Annual GHG Emissions [tCO2e]	***0***	***0***	***308***	***1,051***	***-1,062***	***-2,727***	***-3,940***	***-6,855***	***-8,786***	***-11,527***
Cumulative Scope 3 GHG Emissions [tCO2e]	***0***	***0***	***308***	***1,359***	***297***	***-2,430***	***-6,371***	***-13,226***	***-22,012***	***-33,539***
Total Annual GHG Emissions [tCO2e]	**0**	**0**	**925**	**1,939**	**1,320**	**1,036**	**719**	**-1,552**	**-2,047**	**-4,490**
Total GHG Emissions [tCO2e]	**0**	**0**	**925**	**2,863**	**4,184**	**5,220**	**5,939**	**4,387**	**2,340**	**-2,150**

Table A.7: Short-term Operational Emissions (2029 – 2038) with Embedded Mitigation

Rail Central	2029	2020	2031	2032	2033	2034	2035	2036	2037	2038
B1 area [sqm]	3,472	3,472	3,472	3,472	3,472	3,472	3,472	3,472	3,472	3,472
B2 area [sqm]	21,969	21,969	21,969	21,969	21,969	21,969	21,969	21,969	21,969	21,969
B8 area [sqm]	620,780	620,780	620,780	620,780	620,780	620,780	620,780	620,780	620,780	620,780
Annual operating days	335	335	335	335	335	335	335	335	335	335
4.10 Stationary combustion: Production of heat and electricity										
B1 Building Gas Consumption (Part L Compliant) [kWh]	74,092	74,092	74,092	74,092	74,092	74,092	74,092	74,092	74,092	74,092
B2 Building Gas Consumption (Part L Compliant) [kWh]	463,766	463,766	463,766	463,766	463,766	463,766	463,766	463,766	463,766	463,766
B8 Building Gas Consumption (Part L Compliant) [kWh]	3,608,798	3,608,798	3,608,798	3,608,798	3,608,798	3,608,798	3,608,798	3,608,798	3,608,798	3,608,798
Total gas consumption [kWh]	4,146,656	4,146,656	4,146,656	4,146,656	4,146,656	4,146,656	4,146,656	4,146,656	4,146,656	4,146,656
Annual GHG Emissions [tCO_2e]	***737***	***735***	***659***	***659***	***659***	***659***	***659***	***659***	***659***	***659***
Cumulative GHG Emissions [tCO_2e]	***737***	***1,472***	***2,131***	***2,789***	***3,448***	***4,107***	***4,765***	***5,424***	***6,082***	***6,741***
5.7 Purchased Electricity: Buildings & infrastructure										
B1 Building Electricity Consumption (Part L Compliant) [kWh]	203,043	203,043	203,043	203,043	203,043	203,043	203,043	203,043	203,043	203,043
B2 Building Electricity Consumption (Part L Compliant) [kWh]	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119
B8 Building Electricity Consumption (Part L Compliant) [kWh]	14,886,292	14,886,292	14,886,292	14,886,292	14,886,292	14,886,292	14,886,292	14,886,292	14,886,292	14,886,292
Site Electricity Emissions [kWh]	42,650,553	42,650,553	42,650,553	42,650,553	42,650,553	42,650,553	42,650,553	42,650,553	42,650,553	42,650,553
Infrastructure Electricity Emissions [kWh]	223,656	223,656	223,656	223,656	223,656	223,656	223,656	223,656	223,656	223,656
Total Electricity Consumption [kWh]	**59,119,663**	**59,119,663**	**59,119,663**	**59,119,663**	**59,119,663**	**59,119,663**	**59,119,663**	**59,119,663**	**59,119,663**	**59,119,663**
Annual GHG Emissions [tCO_2e]	***5,679***	***6,162***	***5,646***	***4,591***	***4,403***	***3,933***	***3,249***	***3,249***	***3,249***	***3,249***
Cumulative GHG Emissions [tCO2e]	***5,679***	***11,842***	***17,487***	***22,079***	***26,481***	***30,414***	***33,663***	***36,911***	***40,160***	***43,409***
Scope 1 & 2 Annual GHG Emissions [tCO_2e]	***6,416***	***6,897***	***6,304***	***5,250***	***5,061***	***4,591***	***3,907***	***3,907***	***3,907***	***3,907***
Cumulative Scope 1 & 2 GHG Emissions [tCO_2e]	***6,416***	***13,314***	***19,618***	***24,868***	***29,929***	***34,521***	***38,428***	***42,335***	***46,242***	***50,150***
6.14 Mobile combustion: Transportation of freight										
Road HGV distance [tonne.km]	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970
Rail freight [tonne.km]	901,792	901,792	901,792	901,792	901,792	901,792	901,792	901,792	901,792	901,792
HGV GHG Emissions [tCO_2e]	-39,295	-38,752	-42,412	-41,651	-40,781	-39,803	-38,716	-37,521	-36,217	-34,804
Rail GHG Emissions [tCO_2e]	23,349	22,896	21,715	20,534	19,353	18,173	16,992	15,811	14,630	13,449
Annual GHG Emissions [tCO_2e]	***-15,947***	***-15,857***	***-20,697***	***-21,117***	***-21,428***	***-21,630***	***-21,724***	***-21,710***	***-21,587***	***-21,355***
Cumulative GHG Emissions [tCO_2e]	***-15,947***	***-31,803***	***-52,500***	***-73,617***	***-95,045***	***-116,676***	***-138,400***	***-160,110***	***-181,697***	***-203,052***
6.15 Mobile combustion: Transportation of waste										
Waste generation [tonnes]	168,017	168,017	168,017	168,017	168,017	168,017	168,017	168,017	168,017	168,017
Waste moved [tonne.km]	1,680,173	1,680,173	1,680,173	1,680,173	1,680,173	1,680,173	1,680,173	1,680,173	1,680,173	1,680,173
Annual GHG Emissions [tCO_2e]	***137***	***136***	***145***	***142***	***140***	***137***	***134***	***130***	***127***	***123***
Cumulative GHG Emissions [tCO_2e]	***137***	***273***	***417***	***560***	***699***	***836***	***970***	***1,101***	***1,228***	***1,350***
6.17 Mobile combustion: Employee commuting										
Single occupancy vehicles: Distance travelled [km]	56,737,753	56,737,753	56,737,753	56,737,753	56,737,753	56,737,753	56,737,753	56,737,753	56,737,753	56,737,753
Shared vehicles: Distance travelled [passenger km]	1,809,035	1,809,035	1,809,035	1,809,035	1,809,035	1,809,035	1,809,035	1,809,035	1,809,035	1,809,035
Annual GHG Emissions [tCO_2e]	***5,605***	***5,330***	***5,131***	***4,942***	***4,760***	***4,587***	***4,422***	***4,265***	***4,116***	***3,974***
Cumulative GHG Emissions [tCO_2e]	***5,605***	***10,935***	***16,066***	***21,007***	***25,768***	***30,355***	***34,777***	***39,042***	***43,158***	***47,132***
6.19 Process Emissions: Fuel & energy related activity										
4.10 Related [kWh]	4,146,656	4,146,656	4,146,656	4,146,656	4,146,656	4,146,656	4,146,656	4,146,656	4,146,656	4,146,656
5.7 Related [kWh]	59,119,663	59,119,663	59,119,663	59,119,663	59,119,663	59,119,663	59,119,663	59,119,663	59,119,663	59,119,663

6.14 Road HGV distance [tonne.km]	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970
6.14 Rail freight [tonne.km]	901,792	901,792	901,792	901,792	901,792	901,792	901,792	901,792	901,792	901,792
Annual GHG Emissions [tCO2e]	***-1,773***	***-1,766***	***-1,672***	***-1,609***	***-1,545***	***-1,482***	***-1,418***	***-1,355***	***-1,291***	***-1,227***
Cumulative GHG Emissions [tCO2e]	***-1,773***	***-3,539***	***-5,212***	***-6,821***	***-8,366***	***-9,848***	***-11,266***	***-12,620***	***-13,911***	***-15,139***
Scope 3 Annual GHG Emissions [tCO2e]	***-11,978***	***-12,157***	***-17,094***	***-17,642***	***-18,073***	***-18,388***	***-18,587***	***-18,669***	***-18,635***	***-18,485***
Cumulative Scope 3GHG Emissions [tCO2e]	***-11,978***	***-24,135***	***-41,229***	***-58,871***	***-76,944***	***-95,332***	***-113,919***	***-132,588***	***-151,223***	***-169,708***
Total Annual GHG Emissions [tCO2e]	**-5,562**	**-5,259**	**-10,790**	**-12,392**	**-13,012**	**-13,797**	**-14,679**	**-14,762**	**-14,728**	**-14,578**
Total GHG Emissions [tCO2e]	**-5,562**	**-10,821**	**-21,611**	**-34,003**	**-47,015**	**-60,811**	**-75,491**	**-90,253**	**-104,980**	**-119,559**

Table A.8: Short-term Operational Emissions (2029 – 2038) with Adaptive Mitigation

Rail Central	2029	2020	2031	2032	2033	2034	2035	2036	2037	2038
B1 area [sqm]	3,472	3,472	3,472	3,472	3,472	3,472	3,472	3,472	3,472	3,472
B2 area [sqm]	21,969	21,969	21,969	21,969	21,969	21,969	21,969	21,969	21,969	21,969
B8 area [sqm]	620,780	620,780	620,780	620,780	620,780	620,780	620,780	620,780	620,780	620,780
Annual operating days	335	335	335	335	335	335	335	335	335	335
4.10 Stationary combustion: Production of heat and electricity										
B1 Building Gas Consumption (Part L Compliant) [kWh]	74,092	74,092	74,092	74,092	74,092	74,092	74,092	74,092	74,092	74,092
B2 Building Gas Consumption (Part L Compliant) [kWh]	463,766	463,766	463,766	463,766	463,766	463,766	463,766	463,766	463,766	463,766
B8 Building Gas Consumption (Part L Compliant) [kWh]	3,321,088	3,321,088	3,321,088	3,321,088	3,321,088	3,321,088	3,321,088	3,321,088	3,321,088	3,321,088
Total gas consumption [kWh]	***3,858,946***	***3,858,946***	***3,858,946***	***3,858,946***	***3,858,946***	***3,858,946***	***3,858,946***	***3,858,946***	***3,858,946***	***3,858,946***
Annual GHG Emissions [tCO_2e]	***686***	***684***	***613***	***613***	***613***	***613***	***613***	***613***	***613***	***613***
Cumulative GHG Emissions [tCO_2e]	***686***	***1,370***	***1,983***	***2,596***	***3,209***	***3,822***	***4,435***	***5,047***	***5,660***	***6,273***
5.7 Purcahsed Electricity: Buildings & infrastructure										
B1 Building Electricity Consumption (Part L Compliant) [kWh]	203,043	203,043	203,043	203,043	203,043	203,043	203,043	203,043	203,043	203,043
B2 Building Electricity Consumption (Part L Compliant) [kWh]	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119	1,156,119
B8 Building Electricity Consumption (Part L Compliant) [kWh]	14,343,421	14,343,421	14,343,421	14,343,421	14,343,421	14,343,421	14,343,421	14,343,421	14,343,421	14,343,421
Site Electricity Emissions [kWh]	40,971,447	40,971,447	40,971,447	40,971,447	40,971,447	40,971,447	40,971,447	40,971,447	40,971,447	40,971,447
Infrastructure Electricity Emissions [kWh]	223,656	223,656	223,656	223,656	223,656	223,656	223,656	223,656	223,656	223,656
Total Electricity Consumption [kWh]	*56,897,685*	*56,897,685*	*56,897,685*	*56,897,685*	*56,897,685*	*56,897,685*	*56,897,685*	*56,897,685*	*56,897,685*	*56,897,685*
Annual GHG Emissions [tCO_2e]	***5,466***	***5,931***	***5,433***	***4,419***	***4,237***	***3,785***	***3,127***	***3,127***	***3,127***	***3,127***
Cumulative GHG Emissions [tCO2e]	***5,466***	***11,397***	***16,830***	***21,249***	***25,486***	***29,271***	***32,397***	***35,524***	***38,651***	***41,777***
Scope 1 & 2 Annual GHG Emissions [tCO_2e]	***6,152***	***6,615***	***6,046***	***5,032***	***4,850***	***4,398***	***3,739***	***3,739***	***3,739***	***3,739***
Cumulative Scope 1 & 2 GHG Emissions [tCO_2e]	***6,152***	***12,767***	***18,813***	***23,845***	***28,695***	***33,093***	***36,832***	***40,571***	***44,311***	***48,050***
6.14 Mobile combustion: Transportation of freight										
Road HGV distance [tonne.km]	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970
Rail freight [tonne.km]	901,792	901,792	901,792	901,792	901,792	901,792	901,792	901,792	901,792	901,792
HGV GHG Emissions [tCO_2e]	-39,295	-38,752	-42,412	-41,651	-40,781	-39,803	-38,716	-37,521	-36,217	-34,804
Rail GHG Emissions [tCO_2e]	23,349	22,896	21,715	20,534	19,353	18,173	16,992	15,811	14,630	13,449
Annual GHG Emissions [tCO_2e]	***-15,947***	***-15,857***	***-20,697***	***-21,117***	***-21,428***	***-21,630***	***-21,724***	***-21,710***	***-21,587***	***-21,355***
Cumulative GHG Emissions [tCO_2e]	***-15,947***	***-31,803***	***-52,500***	***-73,617***	***-95,045***	***-116,676***	***-138,400***	***-160,110***	***-181,697***	***-203,052***
6.15 Mobile combustion: Transportation of waste										
Waste generation [tonnes]	168,017	168,017	168,017	168,017	168,017	168,017	168,017	168,017	168,017	168,017
Waste moved [tonne.km]	1,680,173	1,680,173	1,680,173	1,680,173	1,680,173	1,680,173	1,680,173	1,680,173	1,680,173	1,680,173
Annual GHG Emissions [tCO_2e]	***137***	***136***	***145***	***142***	***140***	***137***	***134***	***130***	***127***	***123***
Cumulative GHG Emissions [tCO_2e]	***137***	***273***	***417***	***560***	***699***	***836***	***970***	***1,101***	***1,228***	***1,350***
6.17 Mobile combustion: Employee commuting										
Single occupancy vehicles: Distance travelled [km]	56,737,753	56,737,753	56,737,753	56,737,753	56,737,753	56,737,753	56,737,753	56,737,753	56,737,753	56,737,753
Shared vehicles: Distance travelled [passenger km]	1,809,035	1,809,035	1,809,035	1,809,035	1,809,035	1,809,035	1,809,035	1,809,035	1,809,035	1,809,035
Annual GHG Emissions [tCO_2e]	***5,605***	***5,330***	***5,131***	***4,942***	***4,760***	***4,587***	***4,422***	***4,265***	***4,116***	***3,974***
Cumulative GHG Emissions [tCO_2e]	***5,605***	***10,935***	***16,066***	***21,007***	***25,768***	***30,355***	***34,777***	***39,042***	***43,158***	***47,132***
6.19 Process Emissions: Fuel & energy related activity										
4.10 Related [kWh]	3,858,946	3,858,946	3,858,946	3,858,946	3,858,946	3,858,946	3,858,946	3,858,946	3,858,946	3,858,946
5.7 Related [kWh]	56,897,685	56,897,685	56,897,685	56,897,685	56,897,685	56,897,685	56,897,685	56,897,685	56,897,685	56,897,685

6.14 Road HGV distance [tonne.km]	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970	-654,970
6.14 Rail freight [tonne.km]	901,792	901,792	901,792	901,792	901,792	901,792	901,792	901,792	901,792	901,792
Annual GHG Emissions [tCO2e]	***-1,991***	***-1,984***	***-1,893***	***-1,829***	***-1,766***	***-1,702***	***-1,638***	***-1,575***	***-1,511***	***-1,448***
Cumulative GHG Emissions [tCO2e]	***-1,991***	***-3,976***	***-5,868***	***-7,697***	***-9,463***	***-11,165***	***-12,804***	***-14,378***	***-15,890***	***-17,338***
Scope 3 Annual GHG Emissions [tCO2e]	***-12,196***	***-12,375***	***-17,314***	***-17,862***	***-18,293***	***-18,608***	***-18,807***	***-18,889***	***-18,855***	***-18,706***
Cumulative Scope 3GHG Emissions [tCO2e]	***-12,196***	***-24,571***	***-41,886***	***-59,748***	***-78,041***	***-96,649***	***-115,456***	***-134,346***	***-153,201***	***-171,907***
Total Annual GHG Emissions [tCO2e]	**-6,045**	**-5,760**	**-11,268**	**-12,830**	**-13,443**	**-14,210**	**-15,068**	**-15,150**	**-15,116**	**-14,966**
Total GHG Emissions [tCO2e]	**-6,045**	**-11,805**	**-23,073**	**-35,903**	**-49,347**	**-63,557**	**-78,624**	**-93,774**	**-108,890**	**-123,857**

Appendix B: Emission Factors

Table B.1: Gas Grid Decarbonisation Effects

Fuel Proportion (%)	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Natural Gas	100%	100%	99%	99%	99%	98%	98%	98%	98%	97%	97%	97%
Biomethane	0%	0%	1%	1%	1%	2%	2%	2%	2%	3%	3%	3%
Hydrogen (produced by electrolysis)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Scope 1 Main Fuel Emission Factor [kgCO_2e/lWh]												
Natural Gas (Gross CV)	0.18416	0.18416	0.18416	0.18416	0.18416	0.18416	0.18416	0.18416	0.18416	0.18416	0.18416	0.18416
Biomethane	0.01121	0.01121	0.01121	0.01121	0.01121	0.01121	0.01121	0.01121	0.01121	0.01121	0.01121	0.01121
Hydrogen (produced by electrolysis)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Scope 3 Main Fuel Emission Factor [kgCO_2e/lWh]												
Natural Gas (Gross CV)	0.02785	0.02785	0.02785	0.02785	0.02785	0.02785	0.02785	0.02785	0.02785	0.02785	0.02785	0.02785
Biomethane	0.11379	0.11379	0.11379	0.11379	0.11379	0.11379	0.11379	0.11379	0.11379	0.11379	0.11379	0.11379
Hydrogen (produced by electrolysis)	0.10000	0.10000	0.10000	0.10000	0.10000	0.10000	0.10000	0.10000	0.10000	0.10000	0.10000	0.10000
Combined ‘Gas Grid’ Emission Factor [kgCO_2e/lWh]												
Scope 1	0.18416	0.18361	0.18308	0.18255	0.18202	0.18148	0.18095	0.18042	0.17989	0.17936	0.17882	0.17829
Scope 3 (WTT)	0.02785	0.02812	0.02839	0.02865	0.02892	0.02918	0.02945	0.02971	0.02997	0.03024	0.03050	0.03077

Fuel Proportion (%)	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Natural Gas	96%	96%	86%	86%	86%	86%	86%	86%	86%	86%
Biomethane	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Hydrogen (produced by electrolysis)	0%	0%	10%	10%	10%	10%	10%	10%	10%	10%
Scope 1 Main Fuel Emission Factor [kgCO_2e/lWh]										
Natural Gas (Gross CV)	0.18416	0.18416	0.18416	0.18416	0.18416	0.18416	0.18416	0.18416	0.18416	0.18416
Biomethane	0.01121	0.01121	0.01121	0.01121	0.01121	0.01121	0.01121	0.01121	0.01121	0.01121
Hydrogen (produced by electrolysis)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Scope 3 Main Fuel Emission Factor [kgCO_2e/lWh]										
Natural Gas (Gross CV)	0.02785	0.02785	0.02785	0.02785	0.02785	0.02785	0.02785	0.02785	0.02785	0.02785
Biomethane	0.11379	0.11379	0.11379	0.11379	0.11379	0.11379	0.11379	0.11379	0.11379	0.11379
Hydrogen (produced by electrolysis)	0.10000	0.10000	0.10000	0.10000	0.10000	0.10000	0.10000	0.10000	0.10000	0.10000
Combined ‘Gas Grid’ Emission Factor [kgCO_2e/lWh]										
Scope 1	0.17776	0.17725	0.15883	0.15883	0.15883	0.15883	0.15883	0.15883	0.15883	0.15883
Scope 3 (WTT)	0.03103	0.03103	0.03103	0.03103	0.03103	0.03103	0.03103	0.03103	0.03103	0.03103

Table B.2: Emission Factors applied in the GHG Assessment

Fuel/ Activity Data	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Grid ‘Gas’ [kgCO$_2$e/kWh]	0.18416	0.18361	0.18308	0.18255	0.18202	0.18148	0.18095	0.18042	0.17989	0.17936	0.17882	0.17829
Grid Electricity [kgCO$_2$e/kWh]	0.21337	0.20497	0.19466	0.18089	0.17088	0.14781	0.14426	0.15010	0.14079	0.11422	0.11937	0.10839
Road fuel [kgCO$_2$e/l]	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852
Red Diesel (aka 'Gas oil') [kgCO$_2$e/l]	3.47582	3.47582	3.47582	3.47582	3.47582	3.47582	3.47582	3.47582	3.47582	3.47582	3.47582	3.47582
LPG [kgCO$_2$e/kg]	2.94178	2.94178	2.94178	2.94178	2.94178	2.94178	2.94178	2.94178	2.94178	2.94178	2.94178	2.94178
Kerosene (aka 'Burning oil' and ‘kerosene’) [kgCO$_2$e/l]	3.16540	3.16540	3.16540	3.16540	3.16540	3.16540	3.16540	3.16540	3.16540	3.16540	3.16540	3.16540
Diesel (forecourt) [kgCO$_2$e/l]	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852
WTT Natural Gas	0.02785	0.02812	0.02839	0.02865	0.02892	0.02918	0.02945	0.02971	0.02997	0.03024	0.03050	0.03077
WTT Grid electricity (generation)	0.05605	0.05605	0.05605	0.05605	0.05605	0.05605	0.05605	0.05605	0.05605	0.05605	0.05605	0.05605
WTT Grid electricity (T&D)	0.00524	0.00524	0.00524	0.00524	0.00524	0.00524	0.00524	0.00524	0.00524	0.00524	0.00524	0.00524
T&D Grid electricity	0.03287	0.03287	0.03287	0.03287	0.03287	0.03287	0.03287	0.03287	0.03287	0.03287	0.03287	0.03287
WTT Gas Grid	0.02785	0.02812	0.02839	0.02865	0.02892	0.02918	0.02945	0.02971	0.02997	0.03024	0.03050	0.03077
Calculated >33t HGV Emissions [tonne.km]	0.07227	0.07099	0.06973	0.06848	0.06738	0.06633	0.06537	0.06443	0.06350	0.06260	0.06171	0.06084
Calculated >33t HGV WTT Emissions [tonne.km]	0.02234	0.02227	0.02219	0.02211	0.02205	0.02200	0.02194	0.02188	0.02182	0.02176	0.02170	0.02165
Rail Freight [tonne.km]	0.03231	0.03228	0.03224	0.03220	0.03162	0.03092	0.03031	0.02978	0.02910	0.02814	0.02758	0.02677
WTT Rail Freight [tonne.km]	0.00771	0.00771	0.00771	0.00771	0.00768	0.00764	0.00761	0.00757	0.00754	0.00750	0.00747	0.00743

Fuel/ Activity Data	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Grid ‘Gas’ [kgCO$_2$e/kWh]	0.17776	0.17725	0.15883	0.15883	0.15883	0.15883	0.15883	0.15883	0.15883	0.15883
Grid Electricity [kgCO$_2$e/kWh]	0.09606	0.10424	0.09550	0.07766	0.07447	0.06652	0.05495	0.05495	0.05495	0.05495
Road fuel [kgCO$_2$e/l]	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852
Red Diesel (aka 'Gas oil') [kgCO$_2$e/l]	3.47582	3.47582	3.47582	3.47582	3.47582	3.47582	3.47582	3.47582	3.47582	3.47582
LPG [kgCO$_2$e/kg]	2.94178	2.94178	2.94178	2.94178	2.94178	2.94178	2.94178	2.94178	2.94178	2.94178
Kerosene (aka 'Burning oil' and ‘kerosene’) [kgCO$_2$e/l]	3.16540	3.16540	3.16540	3.16540	3.16540	3.16540	3.16540	3.16540	3.16540	3.16540
Diesel (forecourt) [kgCO$_2$e/l]	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852	3.10852
WTT Natural Gas	0.03103	0.03129	0.03129	0.03129	0.03129	0.03129	0.03129	0.03129	0.03129	0.03129
WTT Grid electricity (generation)	0.05605	0.05605	0.05605	0.05605	0.05605	0.05605	0.05605	0.05605	0.05605	0.05605
WTT Grid electricity (T&D)	0.00524	0.00524	0.00524	0.00524	0.00524	0.00524	0.00524	0.00524	0.00524	0.00524
T&D Grid electricity	0.03287	0.03287	0.03287	0.03287	0.03287	0.03287	0.03287	0.03287	0.03287	0.03287
WTT Gas Grid	0.03103	0.03129	0.03850	0.03850	0.03850	0.03850	0.03850	0.03850	0.03850	0.03850
Calculated >33t HGV Emissions [tonne.km]	0.06000	0.05917	0.06475	0.06359	0.06226	0.06077	0.05911	0.05729	0.05530	0.05314
Calculated >33t HGV WTT Emissions [tonne.km]	0.02159	0.02153	0.02134	0.02114	0.02095	0.02075	0.02056	0.02037	0.02017	0.01998
Rail Freight [tonne.km]	0.02589	0.02539	0.02408	0.02277	0.02146	0.02015	0.01884	0.01753	0.01622	0.01491
WTT Rail Freight [tonne.km]	0.00740	0.00736	0.00729	0.00722	0.00715	0.00708	0.00701	0.00694	0.00687	0.00680

Appendix C: Life Cycle Assessment & Materials

Table C.1: Life Cycle Assessment Data by Declared Unit

Life Cycle Assessment Phase		A1	A2	A3	A4	A5	C1	C2	C3	C4	D
Material/ Product	Declared Unit	Raw Material Supply	Transport to Factory	Manufacturing	Transport to site	Construction - installation	Demolition	Transport	Waste Processing	Disposal	Reuse/ Recovery/ Recyling Potential
Gyproc - Plasterboard	kgCO$_2$/m^2	2.10E+00			7.70E-02	3.30E-01	0	1.90E-02	0	0	ND
Plasterboard - Knauf Generic GIPS	kgCO$_2$e/m^2	3.92E+00			2.10E-01	9.17E-02	ND	1.54E-01	7.77E-02	1.03E-02	-6.37E-01
UK CARES - Reinforcement	kgCO$_2$e/tonne	839			16.1	94.8	2.06	38.9	0	1.28	350
Bauforumstahl - Structural Steel	kgCO$_2$e/tonne	1735			ND	ND	ND	ND	ND	ND	-959
Brickwork	kgCO$_2$e/kg	0.16			ND	ND	0.0048	0.0015	0.0021	0.0016	-0.0207
Concrete Blockwork	kgCO$_2$e/kg	0.09			ND	ND	0.0048	0.0017	0.0024	0.0014	-0.0053
Tarmac - Readymix Concrete	kgCO2e/m^3	316			3.7	1.83	15.6	10.6	9.04	-0.416	-9.74
Hot rolled plate and structural sections (unfabricated)	kgCO$_2$e/kg	1.735			ND	ND	0.02	0.04	0	0	-0.0959
Hot formed structural hollow sections	kgCO$_2$e/kg	2.49			ND	ND	0.02	0.04	0	0	-1.38
Reinforcing steel	kgCO$_2$e/kg	1.27			ND	ND	0.019	0.042	0	0	-0.0426
Steel deck	kgCO$_2$e/kg	2.52			ND	ND	0.02	0.04	0	0	-1.45
Roofing - Twin-Therm Roof CA LT 17 1000S Liner Panel (U-Value 0.14W/m^{2}K)	kgCO$_2$e/m^2	43.01					ND	ND	ND	ND	-16.77
Twin-Therm Wall (U-Value 0.20W/m^{2}K)	kgCO$_2$e/m^2	34.59					ND	ND	ND	ND	-13.61
British Precast - Concrete Kerbs	kgCO$_2$e/tonne	131			6.62	1	-0.43	3.46	-1.6	1.31	ND
MPA - GEN I	kgCO$_2$e/tonne	77				ND	ND	ND	ND	ND	ND
MPA - RC25/30 with 100kg/m^3 reinforcement	kgCO$_2$e/tonne	133				ND	ND	ND	ND	ND	ND
MPA - RC28/35 with 30kg/m^3 reinforcement	kgCO$_2$e/tonne	134				ND	ND	ND	ND	ND	ND
RC32/40 with 100kg/m^3 reinforcement	kgCO$_2$e/tonne	154				ND	ND	ND	ND	ND	ND
RC40/50 with 100kg/m^3 reinforcement	kgCO$_2$e/tonne	178				ND	ND	ND	ND	ND	ND
Tarmac - Asphalt	kgCO$_2$e/tonne	70			6.87	6.04	4.54	4.35	4.07	0.0538	-14.6
Tarmac - Generic Aggregate	kgCO$_2$e/tonne	6.71			3.78	0	6.39	4.35	3.7	0.538	-3.99

ND – Not declared

Table C.2: Life Cycle Assessment Data by $kgCO_2e$/tonne of material/ product

Life Cycle Assessment Phase	A1	A2	A3	A4	A5	C1	C2	C3	C4	D
Material/ Product	Raw Material Supply	Transport to Factory	Manufacturing	Transport to site	Construction - installation	Demolition	Transport	Waste Processing	Disposal	Reuse/ Recovery/ Recyling Potential
Gyproc - Plasterboard	2.51E-01			9.22E-03	3.95E-02	ND	2.28E-03	ND	ND	ND
Plasterboard - Knauf Generic GIPS	3.06E-01			1.64E-02	7.15E-03	ND	1.20E-02	6.06E-03	8.03E-04	-4.97E-02
Plasterboard Average	***2.79E-01***			***1.28E-02***	***2.33E-02***	***ND***	***7.14E-03***	***6.06E-03***	***8.03E-04***	***-4.97E-02***
UK CARES - Reinforcement	8.39E-01			1.61E-02	9.48E-02	2.06E-03	3.89E-02	ND	1.28E-03	3.50E-01
Bauforumstahl - Structural Steel	1.74E+00			ND	ND	ND	ND	ND	ND	-9.59E-01
Tarmac - Readymix Concrete	1.30E-01			1.52E-03	7.50E-04	6.40E-03	4.35E-03	3.71E-03	-1.71E-04	-3.99E-03
Hot rolled plate and structural sections (unfabricated)	1.74E+00			ND	ND	2.00E-02	4.00E-02	ND	ND	-9.59E-02
Hot formed structural hollow sections	2.49E+00			ND	ND	2.00E-02	4.00E-02	ND	ND	-1.38E+00
Reinforcing steel	1.27E+00			ND	ND	1.90E-02	4.20E-02	ND	ND	-4.26E-02
Steel deck	2.52E+00			ND	ND	2.00E-02	4.00E-02	ND	ND	-1.45E+00
Roofing - Twin-Therm Roof CA LT 17 1000S Liner Panel (U-Value 0.14W/m2K)	2.83E+00					ND	ND	ND	ND	-16.77
Twin-Therm Wall (U-Value 0.20W/m^2K)	2.31E+00					ND	ND	ND	ND	-13.61
Cladding/ Roofing Average (30% roofing, 70% walls)	***2.47E+00***									
British Precast - Concrete Kerbs	1.31E-01				1.00E-03	-4.30E-04	3.46E-03	-1.60E-03	1.31E-03	ND
MPA - GEN I	7.70E-02				ND	ND	ND	ND	ND	ND
MPA - RC25/30 with 100kg/m^3 reinforcement	1.33E-01				ND	ND	ND	ND	ND	ND
MPA - RC28/35 with 30kg/m^3 reinforcement	1.34E-01				ND	ND	ND	ND	ND	ND
RC32/40 with 100kg/m^3 reinforcement	1.54E-01				ND	ND	ND	ND	ND	ND
RC40/50 with 100kg/m^3 reinforcement	1.78E-01				ND	ND	ND	ND	ND	ND
Tarmac - Asphalt	7.00E-02			6.87E-03	4.54E-03	4.35E-03	4.07E-03	5.38E-05	-1.46E-02	-14.6
Tarmac - Generic Aggregate	6.71E-03			3.78E-03	6.39E-03	4.35E-03	3.70E-03	5.38E-04	-3.99E-03	-3.99

ND = Not declared

Turley

Table C.3: Material Quantities for Buildings by Zone

Material Type	Weight [t]				
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
Steelwork	6,670	4,982	6,685	6,712	11,219
Claddings	1,497	1,120	1,523	1,517	2,387
Precast walls	1,035	774	1,673	1,051	1,560
M&E fittings	2,453	1,836	2,496	2,486	3,913
Concrete in-situ (RC28/30)	50,513	38,358	56,866	50,070	77,178
Concrete in-situ (RC32/40)	50,513	38,358	56,866	50,070	77,178
Aggregates	96,160	74,768	111,716	96,357	145,182
Reinforcement	614	470	726	597	912
Ceilings/Plasterboard	96	72	96	96	160
Kerbs	323	344	307	293	445
Tarmac	5,297	5,346	7,038	6,545	7,459
Pipes	1,113	1,113	742	742	1,113
Backfill	14,652	14,652	9,768	9,768	14,652
Manholes	231	231	154	154	231
Concrete in-situ (GEN I)	424	424	283	283	424
Fittings	56	56	37	37	56
Total	***231,646***	***182,903***	***256,975***	***226,778***	***344,068***

Table C.4: Material Quantities for Infrastructure Elements

Material Type	Estate Rds & Temp Access	Bridges on A43 & Northampton Rd	Intermodal	Express Freight Platform
Steelwork			1,158.00	
Cladding			379.00	
Precast decks		297.00		
Precast abutments		610.00		
Steel beams		586.00		
Concrete in-situ (RC40/50)	4,179.00	2,880.00	75,300.00	12,980.00
Aggregates	62,705.00	1,092.00	41,990.00	6,500.00
Reinforcement		165.00	1,114.00	2,350.00
Kerbs	984.00		290.00	60.00
Tarmac	62,705.00	480.00		
Pipes			1,100.00	300.00
M&E fittings			437.00	
Manholes	191.00			
Precast pit units			2,351.00	
Fencing	1,612.00	27.00	220.00	
Total	***132,376.00***		***124,339.00***	***6,137.00***

Turley

Table C.5: Profiled Material Quantities for Buildings & Infrastructure Elements [tonnes]

Buildings	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total
Steelwork			1,012	6,638	4,893	5,248	6,738	7,526	4,213		**36,268**
Cladding			215	1,424	1,089	1,138	1,520	1,697	960		**8,044**
Precast walls			141	939	745	758	1,053	1,403	1,054		**6,093**
M&E fittings			353	2,335	1,785	1,865	2,491	2,782	1,573		**13,184**
Concrete in-situ (RC28/30)			6,960	46,484	36,930	37,027	50,445	59,301	35,837		**272,983**
Concrete in-situ (RC32/40)			6,960	46,484	36,930	37,027	50,445	59,301	35,837		**272,983**
Aggregates			13,092	87,966	71,561	70,166	96,824	114,170	70,404		**524,183**
Reinforcement			82	553	450	439	604	734	458		**3,319**
Ceilings/Plasterboard			14	95	71	75	97	108	61		**520**
Kerbs			40	293	311	215	302	358	193		**1,712**
Tarmac			673	4,820	4,880	3,983	6,278	6,616	4,435		**31,685**
Pipes			100	782	980	539	836	1,118	468		**4,823**
Backfill			1,321	10,299	12,907	7,092	11,004	14,714	6,156		**63,492**
Manholes			21	162	203	112	173	232	97		**1,001**
Concrete in-situ (GEN I)			38	298	374	205	319	426	178		**1,838**
Fittings			5	39	49	27	42	56	23		**242**
Annual Total	***0***	***0***	***31,026***	***209,613***	***174,161***	***165,913***	***229,169***	***270,541***	***161,948***	***0***	***1,242,370***
Infrastructure	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**Total**
Steelwork	0	266	892								**1,158**
Cladding	0	87	292								**379**
Precast decks	91	139	67								**297**
Precast abutments	187	285	137								**610**
Steel beams	180	274	132								**586**
Concrete in-situ (RC40/50)	2,166	23,574	69,598								**95,339**
Aggregates	19,577	40,983	51,727								**112,287**
Reinforcement	51	873	2,706								**3,629**
Kerbs	302	541	491								**1,334**
Tarmac	19,389	29,562	14,234								**63,185**
Pipes	0	321	1,079								**1,400**
M&E fittings	0	100	337								437
Manholes	59	89	43								191
Precast pit units	0	540	1,811								2,351
Fencing	503	817	539								1,859
Annual Total	***42,504***	***98,453***	***144,085***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***285,042***

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Appendix D: Profiled Private Car Emission Factors

Table D.1: High Growth across electric only (cars), thousands

Vehicle stock	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Electric	-	300	740	1180	1620	2060	2500	3600	4700	5800	6900	8000	8850	9700	10550	11400	12250	13100	13950	14800	15650	16500	17350	18200	19050	19900	20750	21600	22450	23300	24150	25000
Hydrogen	-	2	37.6	73.2	108.8	144.4	180	280	380	480	580	680	856	1032	1208	1384	1560	1736	1912	2088	2264	2440	2616	2792	2968	3144	3320	3496	3672	3848	4024	4200
Liquid fuel	-	30,000	30,400	30,800	31,200	31,600	32,000	32,000	32,000	32,000	32,000	32,000	30,700	29,400	28,100	26,800	25,500	24,200	22,900	21,600	20,300	19,000	17,700	16,400	15,100	13,800	12,500	11,200	9,900	8,600	7,300	6000
TOTAL	**-**	**30,302**	**31,178**	**32,053**	**32,929**	**33,804**	**34,680**	**35,880**	**37,080**	**38,280**	**39,480**	**40,680**	**40,406**	**40,132**	**39,858**	**39,584**	**39,310**	**39,036**	**38,762**	**38,488**	**38,214**	**37,940**	**37,666**	**37,392**	**37,118**	**36,844**	**36,570**	**36,296**	**36,022**	**35,748**	**35,474**	**35,200**

Table D.2: Proportions of vehicle stock (cars)

Vehicle stock	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Electric %	0.99	0.99	2.22	3.47	4.71	5.96	7.21	9.78	12.27	14.76	17.25	19.67	22.30	24.87	27.44	30.01	32.58	35.14	37.71	40.28	42.85	45.42	47.98	50.55	53.12	55.69	58.26	60.82	63.39	65.96	68.53	71.02
Hydrogen %	0.01	0.01	0.10	0.20	0.31	0.41	0.52	0.73	0.96	1.19	1.42	1.67	2.20	2.72	3.23	3.74	4.25	4.77	5.28	5.79	6.31	6.82	7.33	7.85	8.36	8.87	9.38	9.90	10.41	10.92	11.44	11.93
Liquid fuel %	99.00	99.00	97.68	96.33	94.98	93.63	92.27	89.49	86.77	84.05	81.32	78.66	75.49	72.41	69.33	66.25	63.17	60.09	57.01	53.93	50.84	47.76	44.68	41.60	38.52	35.44	32.36	29.28	26.20	23.12	20.04	17.05

Table D.3: Assumed Well-to-Wheel CO2 emissions of different vehicle types (cars)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
HEV	105	105	102	99	96	93	90	87.2	84.4	81.6	78.8	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76
PHEV	36	36	35	34	33	32	31	30	29	28	27	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
ICE New	117	117	113.8	110.6	107.4	104.2	101	98	95	92	89	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86	86
Average ICE	140.4	140.4	137.70	133.83	129.95	126.08	122.21	118.58	114.95	111.32	107.69	104.06	101.82	99.56	97.30	95.045	92.79	90.53	88.27	86	86	86	86	86	86	86	86	86	86	86	86	86
Hydrogen	55	55	53	51	49	47	45	43	41	39	37	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35

Table D.4: Estimated Average gCO_2e emissions per km (cars)

Emissions [gCO_2e/km]	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Electric	0.70	0.70	1.52	2.31	3.04	3.72	4.36	5.73	6.96	8.09	9.13	10.03	11.38	12.69	13.99	15.30	16.61	17.92	19.23	20.54	21.85	23.16	24.47	25.78	27.09	28.40	29.71	31.02	32.33	33.64	34.95	36.22
Hydrogen	0.00	0.00	0.05	0.10	0.15	0.19	0.23	0.32	0.40	0.47	0.53	0.59	0.77	0.95	1.13	1.31	1.49	1.67	1.85	2.03	2.21	2.39	2.57	2.75	2.93	3.11	3.28	3.46	3.64	3.82	4.00	4.18
Liquid Fuel	139.00	139.00	134.50	128.91	123.43	118.05	112.77	106.12	99.74	93.56	87.58	81.86	76.86	72.09	67.46	62.97	58.61	54.40	50.32	46.38	43.73	41.08	38.43	35.78	33.13	30.48	27.83	25.18	22.53	19.88	17.23	14.66
Average	139.70	139.70	136.07	131.32	126.62	121.97	117.36	112.16	107.09	102.11	97.23	92.47	89.01	85.73	82.59	79.58	76.72	73.99	71.40	68.95	67.79	66.63	65.47	64.31	63.15	61.98	60.82	59.66	58.50	57.34	56.18	55.06

Appendix E: Profiled Freight Emissions

Table E.1 Profiled Road-only Emissions (2018 – 2028)

Road only Scenario	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
>33t Articulated Road load moved [tonne.km]	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97
Annual Scope 1 Road only GHG Emissions [tCO_2e]	**46,499**	**45,671**	**44,854**	**44,131**	**43,444**	**42,815**	**42,198**	**41,592**	**40,999**	**40,419**	**39,851**
Cumulative Scope 1 Road only GHG Emissions [tCO_2e]	**-**	**45,671**	**90,525**	**134,656**	**178,100**	**220,915**	**263,113**	**304,705**	**345,704**	**386,123**	**425,973**
Annual Scope 3 Road-only GHG Emissions [tCO_2e]	**14,584**	**14,533**	**14,483**	**14,444**	**14,406**	**14,368**	**14,330**	**14,292**	**14,254**	**14,216**	**14,178**
Cumulative Scope 3 Road-only Emissions [tCO_2e]	**-**	**14,533**	**29,016**	**43,461**	**57,867**	**72,235**	**86,565**	**100,857**	**115,111**	**129,327**	**143,504**
Annual Total Road only GHG Emissions [tCO_2e]	61,083	60,204	59,336	58,576	57,850	57,184	56,528	55,884	55,253	54,634	54,028
Cumulative Total Road only GHG Emissions [tCO_2e]	-	60,204	119,541	178,116	235,967	293,150	349,678	405,562	460,815	515,450	569,478

Table E.2 Profiled Rail Central Emissions (2018 – 2028)

Rail Central Scenario	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
>33t Articulated Road load moved [million tonne.km]	654.97	654.97	654.97	654.97	629.65	514.54	419.66	333.24	196.27	85.50	**0**
Rail load moved [million tonne.km]	0	0	0	0	34.87	193.35	323.99	442.98	631.56	784.07	**901.79**
>33t Articulated Road GHG Emissions [tCO_2e]	46,499	45,671	44,854	44,131	41,764	33,635	27,038	21,161	12,286	5,276	0
Rail GHG Emissions [tCO_2e]	0	0	0	0	1,078	5,861	9,649	12,889	17,774	21,627	24,140
Annual Scope 1 & 2 SRFI GHG Emissions [tCO_2e]	**46,499**	**45,671**	**44,854**	**44,131**	**42,842**	**39,496**	**36,687**	**34,050**	**30,060**	**26,904**	**24,140**
Cumulative Scope 1 & 2 SRFI GHG Emissions [tCO_2e]	**46,499**	**92,169**	**137,023**	**181,154**	**223,997**	**263,493**	**300,179**	**334,229**	**364,289**	**391,193**	**415,333**
>33t Articulated Road GHG Emissions [tCO_2e]	14,584	14,533	14,483	14,444	13,849	11,288	9,182	7,271	4,271	1,856	0
Rail GHG Emissions [tCO_2e]	0	0	0	0	267	1,471	2,454	3,339	4,739	5,855	6,703
Annual Scope 3 SRFI GHG Emissions [tCO_2e]	**14,584**	**14,533**	**14,483**	**14,444**	**14,116**	**12,759**	**11,635**	**10,611**	**9,010**	**7,711**	**6,703**
Cumulative Scope 3 SRFI GHG Emissions [tCO_2e]	**-**	**14,533**	**29,016**	**43,461**	**57,576**	**70,335**	**81,971**	**92,581**	**101,591**	**109,302**	**116,004**
Annual Total SRFI GHG Emissions [tCO_2e]	61,083	60,204	59,336	58,576	56,958	52,255	48,322	44,661	39,070	34,615	30,842
Cumulative Total SRFI GHG Emissions [tCO_2e]	-	106,703	166,039	224,615	281,573	333,828	382,150	426,811	465,880	500,495	531,337

Table E.3 Profiled Net Central Emissions (2018 – 2028)

Net Rail Central Emissions	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
>33t Articulated Road GHG Emissions [tCO_2e]	0	0	0	0	-1,680	-9,180	-15,160	-20,431	-28,713	-35,142	-39,851
Rail GHG Emissions [tCO_2e]	0	0	0	0	1,078	5,861	9,649	12,889	17,774	21,627	24,140
Annual Scope 1 & 2 Net GHG Emissions [tCO_2e]	**0**	**0**	**0**	**0**	**-602**	**-3,319**	**-5,511**	**-7,542**	**-10,939**	**-13,515**	**-15,711**
Cumulative Scope 1 & 2 Net GHG Emissions [tCO_2e]	**0**	**0**	**0**	**0**	**-602**	**-3,921**	**-9,432**	**-16,974**	**-27,914**	**-41,428**	**-57,139**
>33t Articulated Road GHG Emissions [tCO_2e]	0	0	0	0	-557	-3,081	-5,148	-7,021	-9,983	-12,360	-14,178
Rail GHG Emissions [tCO_2e]	0	0	0	0	267	1,471	2,454	3,339	4,739	5,855	6,703
Annual Scope 3 Net GHG Emissions [tCO_2e]	**0**	**0**	**0**	**0**	**-290**	**-1,610**	**-2,695**	**-3,681**	**-5,244**	**-6,505**	**-7,475**
Cumulative Scope 3 Net GHG Emissions [tCO_2e]	**0**	**0**	**0**	**0**	**-290**	**-1,900**	**-4,595**	**-8,276**	**-13,520**	**-20,025**	**-27,500**
Annual Total Net GHG Emissions [tCO_2e]	0	0	0	0	-892	-4,929	-8,206	-11,224	-16,183	-20,019	-23,186
Cumulative Net SRFI GHG Emissions [tCO_2e]	-	0	0	0	-892	-5,821	-14,027	-25,250	-41,434	-61,453	-84,639

Table E.4 Profiled Road-only Emissions (2029 – 2038)

Road only Scenario	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
>33t Articulated Road load moved [tonne.km]	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97	654.97
Annual Scope 1 Road only GHG Emissions [tCO_2e]	**39,295**	**38,752**	**42,412**	**41,651**	**40,781**	**39,803**	**38,716**	**37,521**	**36,217**	**34,804**
Cumulative Scope 1 Road only GHG Emissions [tCO_2e]	**39,295**	**78,048**	**120,460**	**162,111**	**202,892**	**242,695**	**281,411**	**318,932**	**355,149**	**389,953**
Annual Scope 3 Road-only GHG Emissions [tCO_2e]	**14,139**	**14,101**	**13,974**	**13,847**	**13,720**	**13,593**	**13,466**	**13,339**	**13,212**	**13,085**
Cumulative Scope 3 Road-only Emissions [tCO_2e]	**14,139**	**28,241**	**42,215**	**56,062**	**69,782**	**83,375**	**96,841**	**110,180**	**123,391**	**136,476**
Annual Total Road only GHG Emissions [tCO_2e]	53,435	52,854	56,386	55,498	54,501	53,396	52,182	50,860	49,429	47,889
Cumulative Total Road only GHG Emissions [tCO_2e]	53,435	106,289	162,675	218,173	272,674	326,070	378,252	429,112	478,540	526,429

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Table E.5 Profiled Rail Central Emissions (2019 – 2038)

Rail Central Scenario	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
>33t Articulated Road load moved [million tonne.km]	0	0	0	0	0	0	0	0	0	0
Rail load moved [million tonne.km]	901.792	901.792	901.792	901.792	901.792	901.792	901.792	901.792	901.792	901.792
>33t Articulated Road GHG Emissions [tCO_2e]	0	0	0	0	0	0	0	0	0	0
Rail GHG Emissions [tCO_2e]	23,349	22,896	21,715	20,534	19,353	18,173	16,992	15,811	14,630	13,449
Annual Scope 1 & 2 SRFI GHG Emissions [tCO_2e]	**23,349**	**22,896**	**21,715**	**20,534**	**19,353**	**18,173**	**16,992**	**15,811**	**14,630**	**13,449**
Cumulative Scope 1 & 2 SRFI GHG Emissions [tCO_2e]	**23,349**	**46,244**	**67,959**	**88,493**	**107,847**	**126,019**	**143,011**	**158,822**	**173,452**	**186,902**
>33t Articulated Road GHG Emissions [tCO_2e]	0	0	0	0	0	0	0	0	0	0
Rail GHG Emissions [tCO_2e]	6,671	6,639	6,575	6,512	6,448	6,385	6,321	6,258	6,194	6,131
Annual Scope 3 SRFI GHG Emissions [tCO_2e]	**6,671**	**6,639**	**6,575**	**6,512**	**6,448**	**6,385**	**6,321**	**6,258**	**6,194**	**6,131**
Cumulative Scope 3 SRFI GHG Emissions [tCO_2e]	**6,671**	**13,310**	**19,885**	**26,397**	**32,845**	**39,230**	**45,552**	**51,809**	**58,003**	**64,134**
Annual Total SRFI GHG Emissions [tCO_2e]	30,020	29,535	28,290	27,046	25,802	24,557	23,313	22,069	20,824	19,580
Cumulative Total SRFI GHG Emissions [tCO_2e]	30,020	59,554	87,844	114,890	140,692	165,249	188,563	210,631	231,456	251,036

Table E.6 Profiled Net Central Emissions (2019 – 2038)

Net Rail Central Emissions	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
>33t Articulated Road GHG Emissions [tCO_2e]	-39,295	-38,752	-42,412	-41,651	-40,781	-39,803	-38,716	-37,521	-36,217	-34,804
Rail GHG Emissions [tCO_2e]	23,349	22,896	21,715	20,534	19,353	18,173	16,992	15,811	14,630	13,449
Annual Scope 1 & 2 Net GHG Emissions [tCO_2e]	**-15,947**	**-15,857**	**-20,697**	**-21,117**	**-21,428**	**-21,630**	**-21,724**	**-21,710**	**-21,587**	**-21,355**
Cumulative Scope 1 & 2 Net GHG Emissions [tCO_2e]	**-73,086**	**-88,943**	**-109,640**	**-130,756**	**-152,184**	**-173,815**	**-195,539**	**-217,249**	**-238,836**	**-260,191**
>33t Articulated Road GHG Emissions [tCO_2e]	-14,139	-14,101	-13,974	-13,847	-13,720	-13,593	-13,466	-13,339	-13,212	-13,085
Rail GHG Emissions [tCO_2e]	6,671	6,639	6,575	6,512	6,448	6,385	6,321	6,258	6,194	6,131
Annual Scope 3 Net GHG Emissions [tCO_2e]	**-7,469**	**-7,462**	**-7,399**	**-7,335**	**-7,272**	**-7,208**	**-7,145**	**-7,081**	**-7,017**	**-6,954**
Cumulative Scope 3 Net GHG Emissions [tCO_2e]	**-7,469**	**-14,931**	**-22,330**	**-29,665**	**-36,937**	**-44,145**	**-51,289**	**-58,370**	**-65,388**	**-72,342**
Annual Total Net GHG Emissions [tCO_2e]	-23,415	-23,319	-28,096	-28,452	-28,700	-28,839	-28,869	-28,791	-28,604	-28,309
Cumulative Net SRFI GHG Emissions [tCO_2e]	-23,415	-46,734	-74,830	-103,282	-131,982	-160,820	-189,689	-218,480	-247,084	-275,393

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